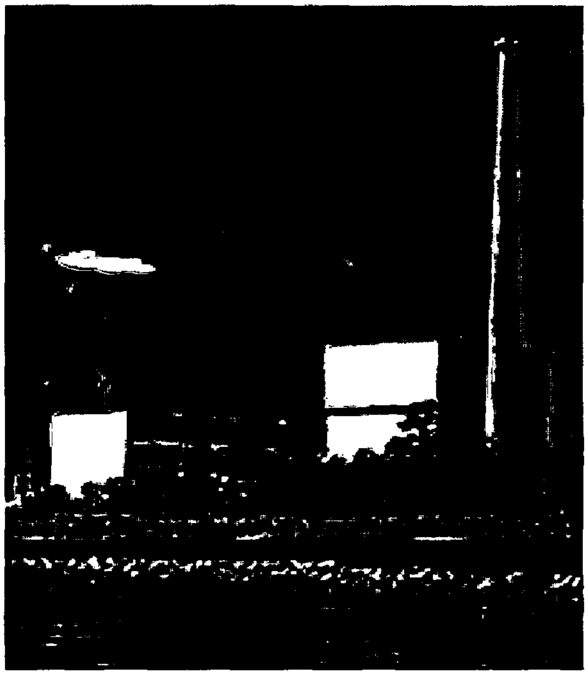
Oyster Creek
License Renewal Project
Drywell Monitoring Program



Information for ACRS Subcommittee

Reference Material

Volume 2

December 8, 2006

AY 113330

GPU Nuclear

SPECIFICATION

IS-402950-001

"NUCLEAR SAFETY RELATED"

INSTALLATION SPECIFICATION FOR

OYSTER CREEK

FUNCTIONAL REQUIREMENTS FOR

AUGMENTED DRYWELL INSPECTION

PREPARATION Peter Tamburro *Pete Tambu* DATE 9/30/90

ENGINEERING APPROVAL F.P.BARBIERI *Fred P. Barbieri* DATE 10/2/90

QA CONCURRENCE *Bob [signature]* DATE 10/4/90

REV. 0

FORM 5000-ADM-7350.02-1

TABLE OF CONTENTS

1.0 SCOPE

This specification establishes the minimum requirements for the augmented ultrasonic testing (examination) program of the Oyster Creek drywell containment vessel.

This specification requires UT examination of 57, 6" by 6" areas (grids) randomly chosen from all drywell plates above the sandbed elevation. Each 6" by 6" grid will be segmented into 9, 2" by 2" areas (cells). Acceptance criteria for each grid will be dependent upon the average thickness of each 2" by 2" cell and the average of the 9 cell thicknesses.

It may be necessary to expand an inspection location to an 18" by 18" area which will be segmented into 81, 2" by 2" cells. Figure #1 presents a schematic of the inspection logic for each of the 57 inspections locations.

1.1 Ultrasonic testing (UT) required by this specification is to be performed during refueling outage only.

1.2 All data shall be forwarded to Technical Functions for evaluation.

1.3 The inspections required by this specification are in addition to the inspections required by Reference 2.6. ROC shall coordinate all activities in the drywell associated with this specification and reference 2.6.

2.0 REFERENCES

2.1 ASME B&PV Code Section V, 1977 Edition through Addenda Summer, 1978.

2.2 ASME Section V, 1986 Edition.

2.3 ASME B&PV Code Section XI, 1977 Edition through Addenda Summer, 1978.

2.4 SNT-TC-1A, 1980 Edition, "American Society of Non-destructive Testing, Recommended Practice."

2.5 TDR 1027, "Design of a UT Inspection Plan for the Drywell Containment Using Statistical Inference Methods."

2.6 GPUN Specification IS-328227-004 "Functional Drywell Requirements for Drywell Containment Vessel Thickness Examination" (most recent revision).

SPEC 402950-001 INSPECTION LOGIC

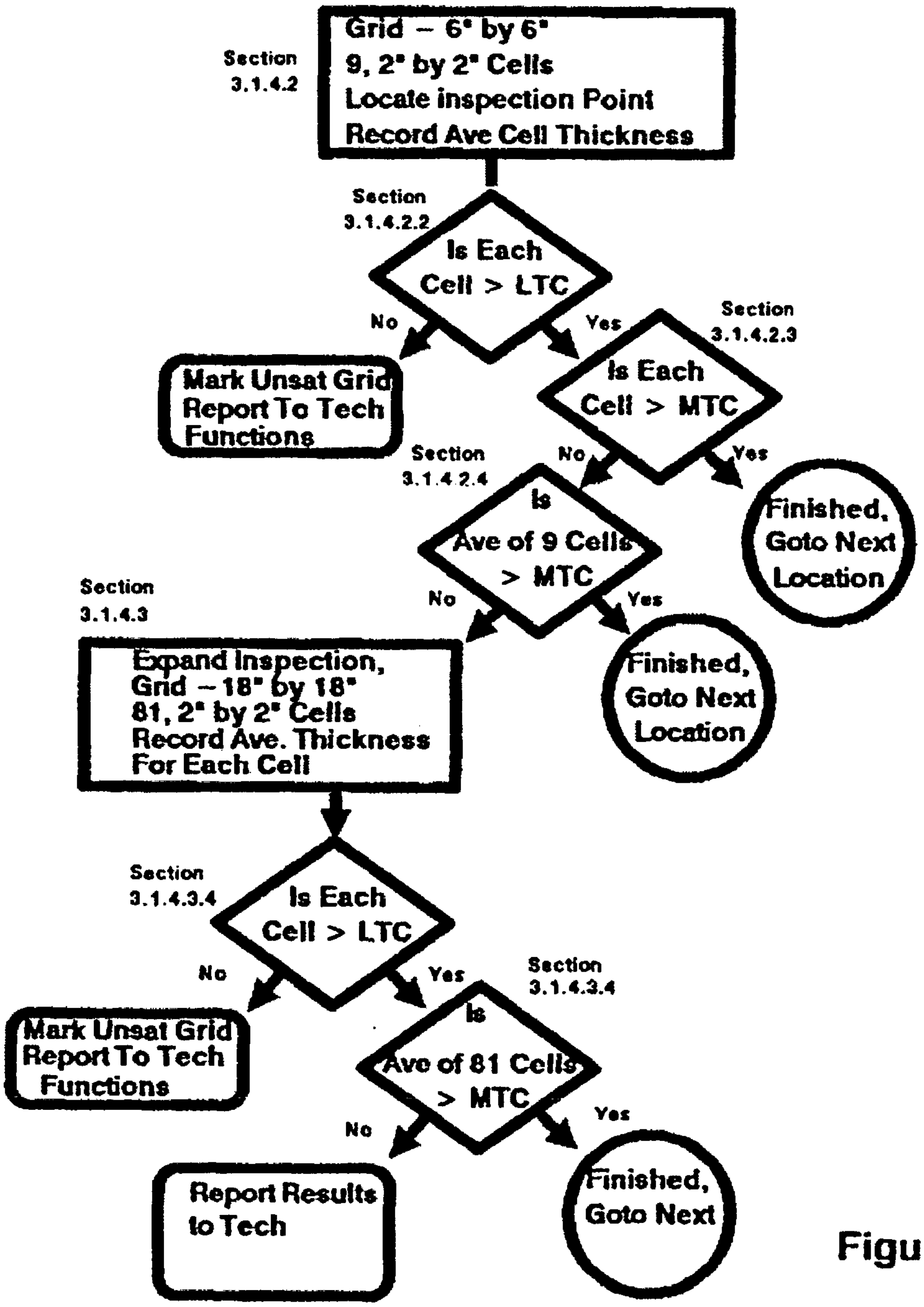


Figure 1

2.7 CBI Company Drawings 9-0971, Sheets 1 through 92.

2.8 GPUN Sketches 3E-SKM-339, Sheets 1 through 20.

2.9 GPUN Memo 5360-90-396, P. Tamburro to A. Baig

3.0 REQUIREMENTS

3.1 Non-Destructive Examinations

3.1.1 Personnel Qualification

3.1.1.1 Ultrasonic personnel shall be qualified and certified as a level 2 NDE Inspector in accordance with Reference 2.4.

3.1.2 Examination Equipment

3.1.2.1 Ultrasonic examination pulse-echo equipment capable of thickness measurement by the digital and/or A-scan on a CRT screen shall be utilized.

Digital readout equipment shall have printout capabilities and memory storage traceable to sequential readings.

3.1.2.2 Ultrasonic examination by use of robotic equipment may be performed; however, the performance of ultrasonic examination devices shall be in accordance with Sections 3.1.1.1 and 3.1.2.1. UT thickness examination through paint shall be performed per qualified techniques and procedures.

Qualification shall be performed to the satisfaction of the GPUN Manager of NDE/ISI. This qualification shall be documented.

3.1.3 Plate Number Scheme and Inspection Designation

3.1.3.1 To locate each inspection location, a series of drywell plate drawings have been developed (Reference 2.8).

Each inspection location will be numbered in the following format:

E - PN - GN

where:

E - Plate Elevation (6, 23, 50, and 71)

PN - Plate Number (per Exhibit #1)

GN - Grid Number

3.1.3.2 Inspection locations have been randomly chosen and are listed in Section 3.1.5 and are shown in Reference 2.8.

3.1.4 Inspections shall consist of the following for each inspection point.

3.1.4.1 The random locations have been chosen based on Reference 2.5. The inspection point shall be located by measuring first from the horizontal weld and then from the vertical welds as shown on the sketches in Reference 2.8.

Due to ALARA considerations and the random nature of these inspections it is not necessary to precisely verify the location of each inspection point. However, the robotic equipment operator or NDE Inspector shall ensure (the to best of their abilities) that each inspection point is properly located per Section 3.1.5 and Reference 2.8.

It is recognized that not all the randomly chosen locations may be accessible for inspection, or surface conditions may not allow for proper UT scan. In these instances, an alternate inspection location shall be chosen (as shown in Exhibit #2) with concurrence of Technical Functions.

3.1.4.2 <u>6" by 6" Inspection</u>

3.1.4.2.1

The UT Inspection shall be performed over a 6" by 6" area centered on each inspection point. Each 6" by 6" area (referred to as a "grid") shall be divided into 9, 2" by 2" areas (referred to as "cells"). As shown in Figure 2A.

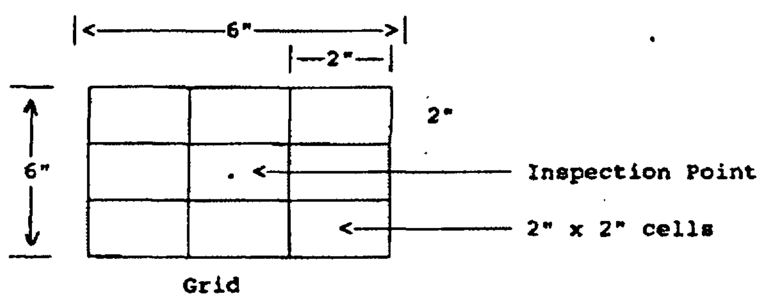
UT examination shall be performed in a manner which will result in a nominal thickness value for each 2" by 2" cell (for a total of 9 values).

3.1.4.2.2

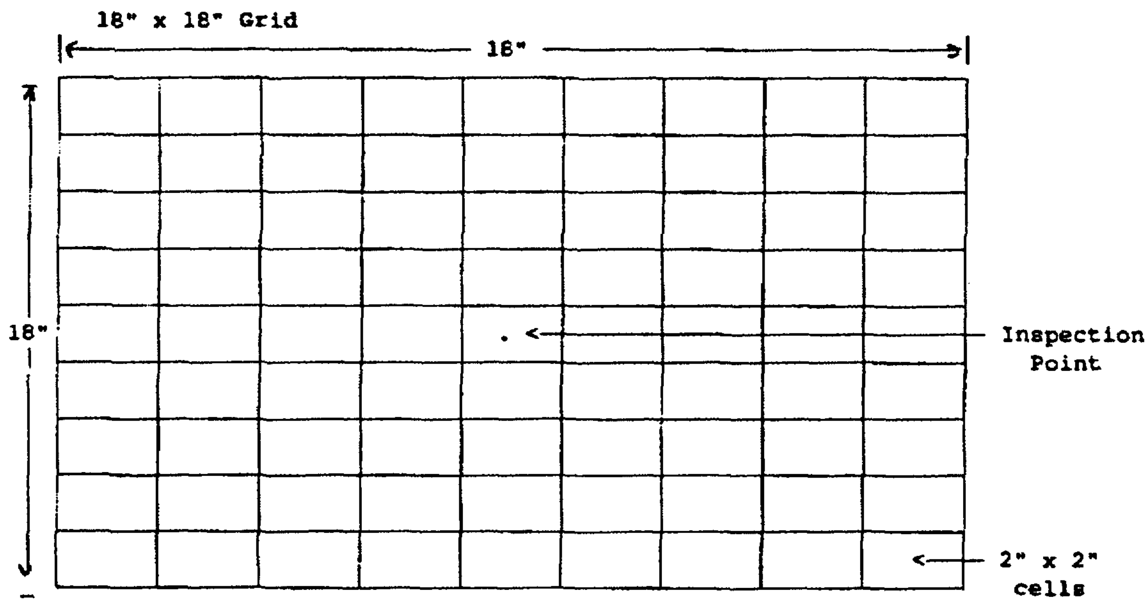
If one or more cell thickness values are less than LTC (Section 3.1.4.4), then this grid shall be marked and results reported to Technical Functions as soon as reasonable (approximately 12 hours). Additional inspections shall be determined following data evaluation.

If all 9 cell thickness values are greater than or equal to LTC then evaluate the data per Section 3.1.4.2.3.

Figure 2A



<u>Figure 2B</u>



3.1.4.2.3

If all 9 cell thickness values are greater than or equal to the MTC (Section 3.1.4.4), then no further inspections are required for this inspection point. Thickness values for all 9 cells shall be transmitted to Technical Functions (per Section 3.1.6.1).

If one or more of the 9 cell thickness values are less than the MTC, then data evaluation per Section 3.1.4.2.4 shall be performed.

3.1.4.2.4

The average of all 9 cell thickness values shall be calculated. If the average is greater than or equal to the MTC <u>and</u> the thickness value of all 9 cells is greater than or equal to the LTC, then no further inspections are required for this inspection point. Thickness data for the 9 cells shall be transmitted to Technical Functions (per Section 3.1.6.1).

If the average is less than MTC then an expanded inspection shall be performed per Section 3.1.4.3.

3.1.4.3 18" by 18" Expanded Inspection

3.1.4.3.1

An 18" by 18" expanded inspection shall be performed on all inspection points which do not meet the criteria in Section 3.1.4.2. Technical Functions shall be notified (as soon as reasonable) of all inspection points which require an 18" by 18" expanded inspection.

3.1.4.3.2

The 18" by 18" area shall be centered about the original inspection point and the 6" by 6" grid (Section 3.1.4.2). If the 18" by 18" area cannot be properly centered due to penetrations, welds, or surface conditions, the 18" by 18" area shall be placed and oriented in a manner in which the entire 18" by 18" area is located on the original vessel plate and overlaps the original 6" by 6" grid.

3.1.4.3.3

The 18" by 18" area shall be divided into 81, 2" by 2" cells, as shown in Figure 2B.

UT examination shall be performed in a manner which will result in a nominal thickness value for each 2" by 2" cell (total of 81 values).

3.1.4.3.4

If all 81 cell thickness values are greater than or equal to LTC and the average of the 81 cell thickness values is greater than or equal to MTC then no further inspections are required for this inspection point. Thickness data for all 81 cells shall be transmitted to Tech Functions.

If one or more cell thickness value(s) are less than LTC, then this expanded inspection area shall be marked, and results reported to Tech Functions as soon as reasonable (approximately 12 hours).

If the average of all 81 cell thickness values is less than MTC then results shall be reported to Technical Functions as soon as reasonable (approximately 12 hours).

Thickness data for all 81 cells shall be transmitted to Technical Functions (per section 3.1.6.1).

3.1.4.4 Thickness Criteria

3.1.4.4.1 (Reference 2.9)

The following Mean Thickness Criteria (MTC) shall be applied in Section 3.1.4.2 and 3.1.4.3:

Plate Evaluation	Nominal Delivered Thickness	MTC
11'-3" to 23'-6"	1.154"	.780"
23'-6" to 51'	.77"	.735"
51' to 65'	.722"	.695"
65' to 71'-6"	2.625"	TBD
71'-6" to 95'	0.64"	0.605"

3.1.4.4.2 (Reference 2.9)

The following Local Thickness Criteria (LTC) shall be applied in Sections 3.1.4.2 and 3.1.4.3.

Plate Evaluation	Nominal Delivered Thickness	LTC
11'-3" to 23'-6"	1.154"	.5"
23'-6" to 51'	.77"	.5"
51' to 65'	.722"	.470"
65' to 71'-6"	2.625"	TBD
71'-6" to 95'	0.64"	.435"

3.1.4.5 UT thickness examinations through paint shall be performed per qualified techniques and procedures. Qualification shall be performed to the satisfaction of the GPUN Manager of NDE/ISI.

3.1.5 13R Inspections Locations

For the 13R Outage, 57 inspection locations shall be examined (per Section 3.1.4). These locations shall be examined as follows:

Plate Elevation	Plate Number	Grid Number	Distance From Center Line of Vertical Weld (Right/Left)	Distance From Center Line of Horizontal Weld (Top/Bottom)
6'-10" to 23'-6"	6-7	99	Left 4'- 4"	Top 2'- 10"
6'-10" to 23'-6"	6-10	42	Left 1'- 0"	Top 1'- 5"
6'-10" to 23'-6"	6-12	149	Right 1'- 7"	Top 5'- 5"
6'-10" to 23'-6'	6-13	185	Left 0'- 5"	Top 6'- 10"
6'-10" to 23'-6"	6-14	31	Right 5'- 2"	Top 0'- 11"
6'-10" to 23'-6"	6-16	64	Left 2'- 5"	Top 1'- 11"
6'-10" to 23'-6"	6-18	155	Left 0'- 5"	Top 5'- 11"
6'-10" to 23'-6"	6-19	88	Right 1'- 4"	Top 2'- 2"
6'-10" to 23'-6"	6-20	196	Left 0'- 10"	Top 8'- 11"
23'-6" to 50'-11"	23-8	118	Left 3'- 1"	Top 4'- 0"
23'-6" to 50'-11"	23-11	629	Left 6'- 8"	Bottom 7'- 0"
23'-6" to 50'-11"	23-15	726	Right 0'- 6"	Bottom 1'- 6"
23'-6" to 50'-11"	23-17	368	Left 0'- 9"	Top 12'- 0"
23'-6" to 50'-11"	23-19	494	Right 0'- 8"	Bottom 12'- 0"
23'-6" to 50'-11"	23-20	190	Right 2'- 2"	Top 11'- 6"
23'-6" to 50'-11"	23-21	256	Left 4'- 3"	Top 11'- 6"
23'-6" to 50'-11"	23-22	311	Right 4'- 3"	Top 12'- 6"
23'-6" to 50'-11"	23-23	22	Left 2'-11"	Top 1'- 0"
23'-6" to 50'-11"	23-24	216	Right 3'- 1"	Top 6'- 6"

Plate Elevation	Plate Number	Grid Number	Distance From Center Line of Vertical Weld (Right/Left)	Distance From Center Line of Horizontal Weld (Top/Bottom)
50'-11" to 65'-2"	50-1	116	Left 1'- 3"	Bottom 8' - 11"
50'-11" to 65'-2"	50-3	277	Left 3'- 7"	Bottom 1' - 11
50'-11" to 65'-2"	50-4	2	Left 1'- 11"	Top 7' - 11"
50'-11" to 65'-2"	50-5	277	Right 2'- 3"	Bottom - 11"
50'-11" to 65'-2"	50-7	292	Left 3'- 8"	Bottom 1' - 5"
50'-11" to 65'-2"	50-8	597	Left 3'-11"	Bottom 2' - 5"
50'-11" to 65'-2"	50-10	442	Left 2'- 5"	Bottom 6' - 5"
50'-11" to 65'-2"	50-11	235	Left 3'- 3"	Bottom 3' - 5"
50'-11" to 65'-2"	50-12	114	Right 0'- 5"	Top 2' - 11"
50'-11" to 65'-2"	50-13	85	Left 0'- 6"	Top 7' - 11"
50'-11" to 65'-2"	50-14	492	Left 1'- 5"	Bottom 3' - 5"
50'-11" to 65'-2"	50-17	219	Left 1'- 8"	Bottom 3' - 11"
50'-11" to 65'-2"	50-18	359	Left 1'- 5"	Bottom 7' - 5"
50'-11" to 65'-2"	50-19	147	Right 1'- 0"	Bottom 7' - 5"
50'-11" to 65'-2"	50-21	190	Right 1'- 1"	Bottom 4' - 5"
50'-11" to 65'-2"	50-22	236	Left 3'- 11"	Top 6' - 5"

Plate Elevation	Plate Number	Grid Number	Distance From Center Line of Vertical Weld (Left/Right)	Distance From Center Line of Horizontal Weld (Top/Bottom)
65'- 2" to 71'-6'	65-2	35	Right 0'- 6"	Top 2' - 5"
65'- 2" to 71'-6"	65-5	49	Right 0'- 7"	Top 3' - 5"
65'- 2" to 71'-6"	65-6	22	Left 0'- 6"	Top 1' -11"
65'- 2" to 71'-6"	65-8	124	Right 0'- 6"	Bottom 0" - 5"
65'- 2" to 71'-6"	65-10	124	Right 0'- 6"	Bottom 0' - 5"
65'- 2" to 71'-6"	65-11	18	Right 2'- 0"	Top 1' - 5"
65'- 2" to 71'-6"	65-13	95	Right 1'- 4"	Bottom 1' -11"
65'- 2" to 71'-6'	65-14	112	Right 1'-11"	Bottom 0" -11"
65'- 2" to 71'-6"	65-16	85	Right 1'- 9"	Bottom 2' - 5"
65'- 2" to 71'-6"	65-17	113	Right 1'- 5"	Bottom 0" -11"
65'- 2" to 71'-6"	65-18	122	Right 1'- 5"	Bottom 0" - 5"
65'- 2" to 71'-6"	65-20	99	Left 0"- 10"	Bottom 1' - 5"
65'- 2" to 71'-6"	65-21	122	Right 1'- 5"	Bottom 0" - 5"
65'- 2" to 71'-6'	65-22	27	Left 1'- 0"	Top 1' -11"
65'- 2"	65-23	45	Right 2'- 1"	Top 3' - 5"
65'- 2"	65-24	82	Left 1'- 3"	Top 1' - 3"
65'- 2"	65-25	119	Left 1'- 11"	Bottom 2' - 11"
65'- 2"	65-26	32	Right 2'- 0"	Top 2' - 5"
71'- 6" to 83'	71-1	461	Left 4'- 6"	Bottom 5' - 1"
71' -6" to 83'	71-4	920	Right 3'- 0"	Bottom 0' - 7"
83' to 94'	83-1	482	Left 11'- 5"	Bottom 4' - 0"
83' to 94'	83-4	401	Left 1'- 11"	Top 4' - 0"

All Specific locations are shown on Reference 2.8.

3.1.6 Records

3.1.6.1 All data shall be recorded on data sheets which identify the inspection location number (per Section 3.1.5.1) as shown in Reference 2.8. Data sheet format shall be consistent with Figures 2A & 2B. Copies shall be transmitted to Technical Functions as soon as practical. Also, data shall be sent to Technical Functions on a floppy disk in an ASCII format.

3.2 Support Work

3.2.1 Work to be performed by the Refueling Outage Contractor (referred to as the ROC).

3.2.1.1 The ROC shall schedule and coordinate all activities necessary to perform the inspections.

3.2.1.2 When required, the ROC shall erect scaffolding.

4.0 QUALITY ASSURANCE

4.1 All work shall be performed in accordance with GPUN Operational QA Program. This work is classified Important to Safety/Nuclear Safety Related.

5.0 INFORMATION TO BE SUBMITTED

5.1 UT data sheets and calibration sheets in accordance with Reference 2.4.

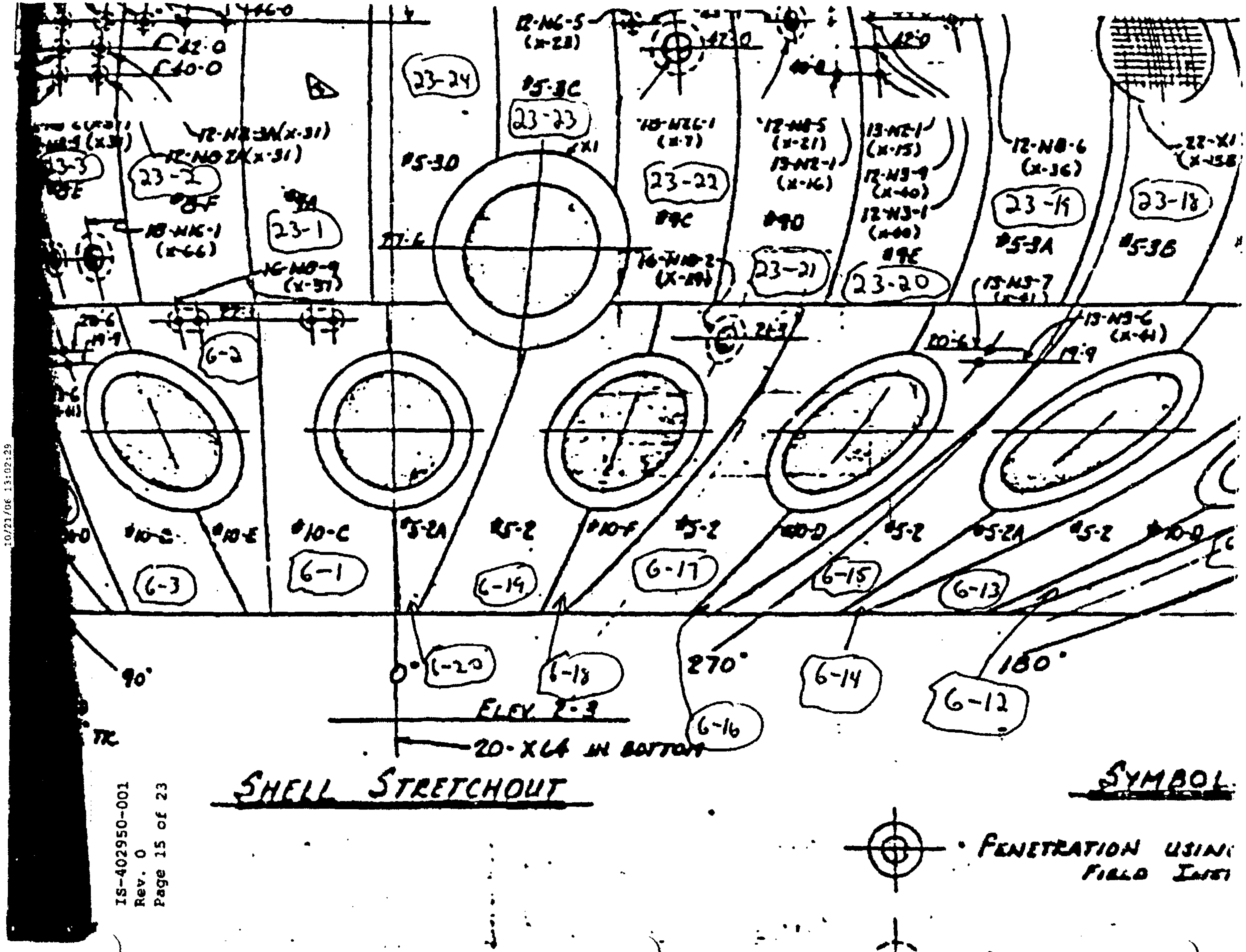
6.0 ATTACHMENTS

6.1 Exhibit 1 - Plate Numbering scheme shown on CBI drawing 9-0971, Sheet 2.

6.2 Exhibit 2 - Alternate Inspection Location Selection Scheme.

EXHIBIT #1

**Plate Numbering Scheme Shown on
CBI Drawing 9-0971 Sheet #2**



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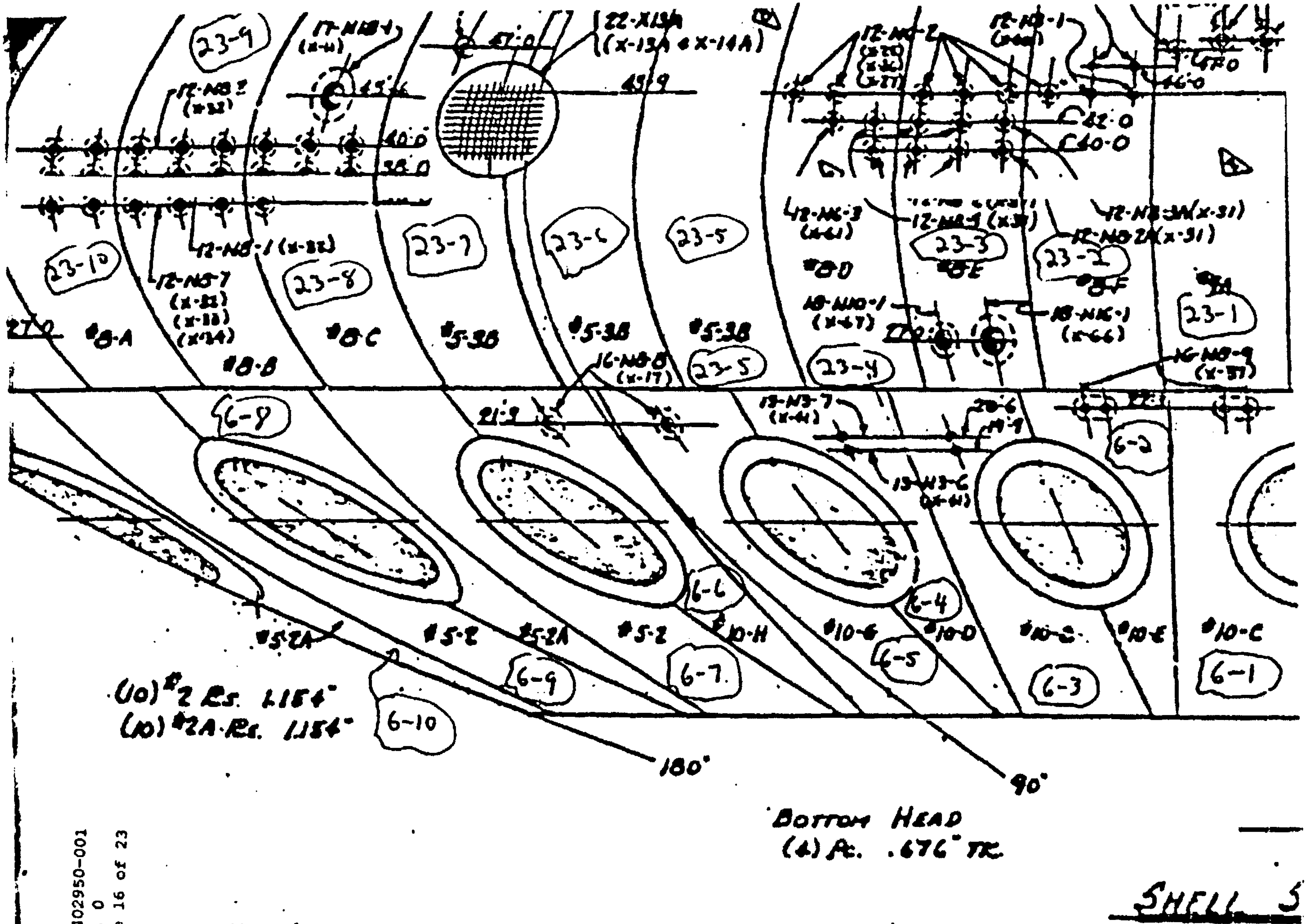
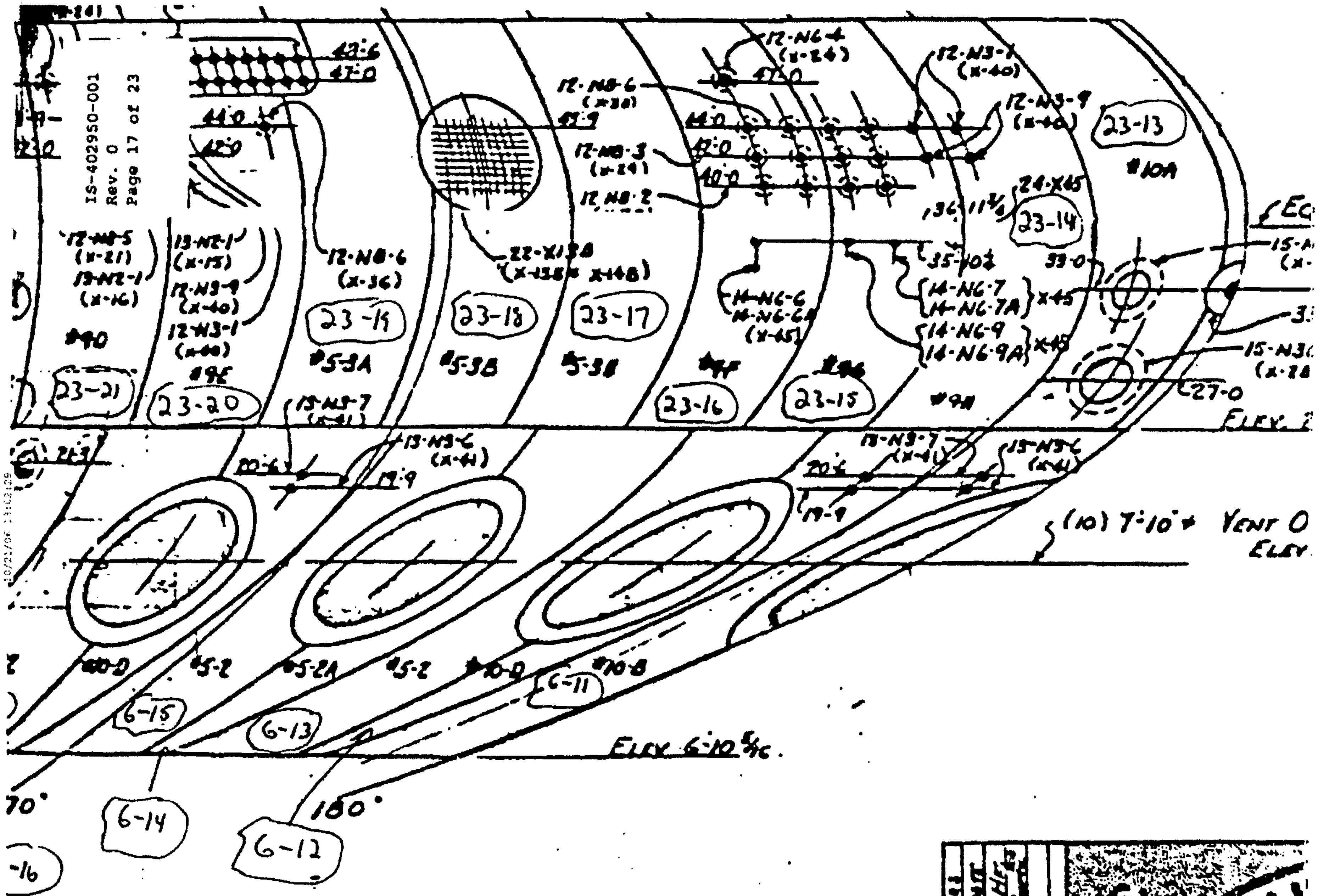
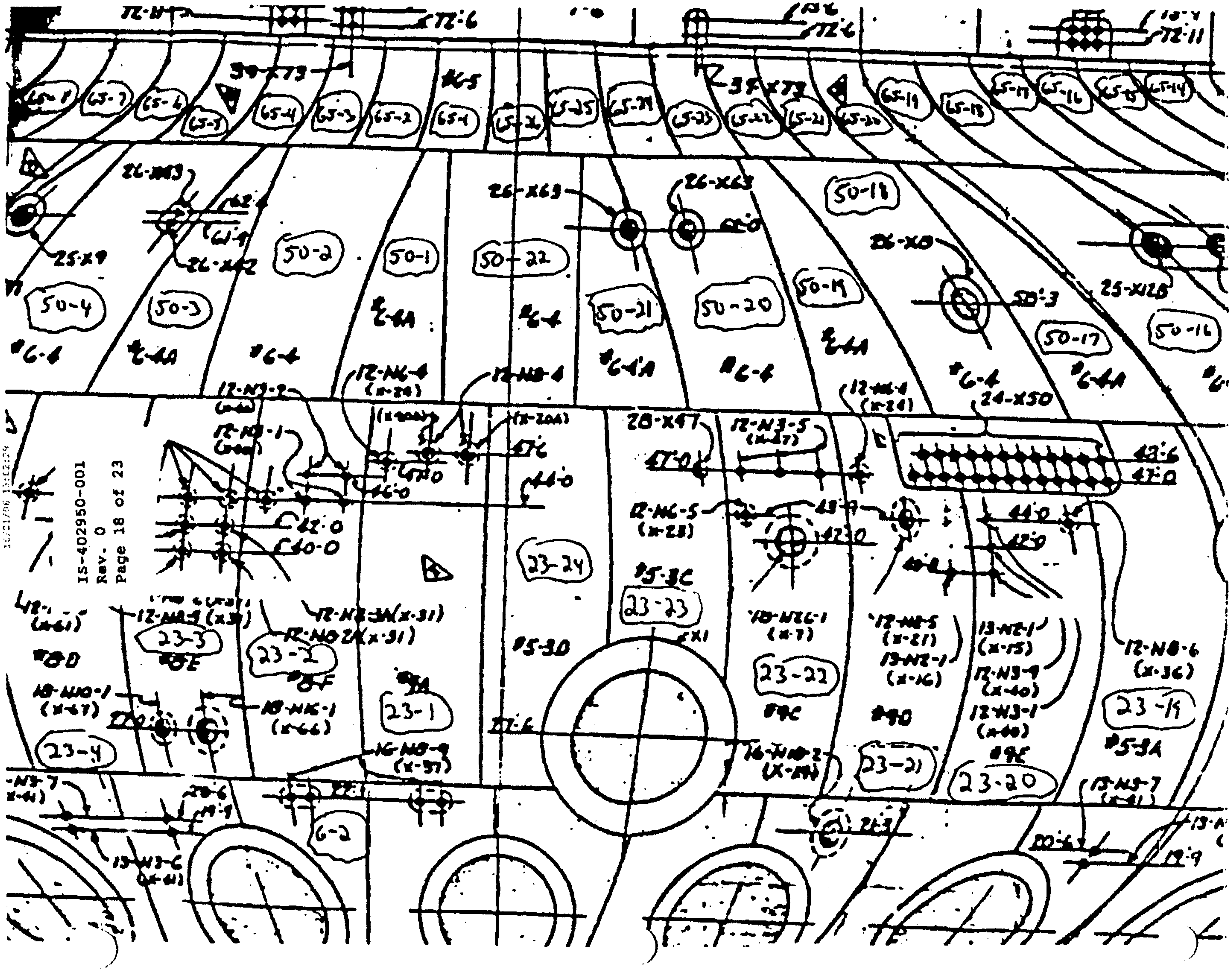

23-1
23-2
23-3
23-4
23-5
23-6
23-7
23-8
23-9
23-10
6-1
6-2
6-3
6-4
6-5
6-6
6-7
6-8
6-9
6-10
(10) #2 Rs. 1.154"
(10) #2A Rs. 1.154"
180°
90°
BOTTOM HEAD
(4) Pc. .676" TK.
SHELL 5

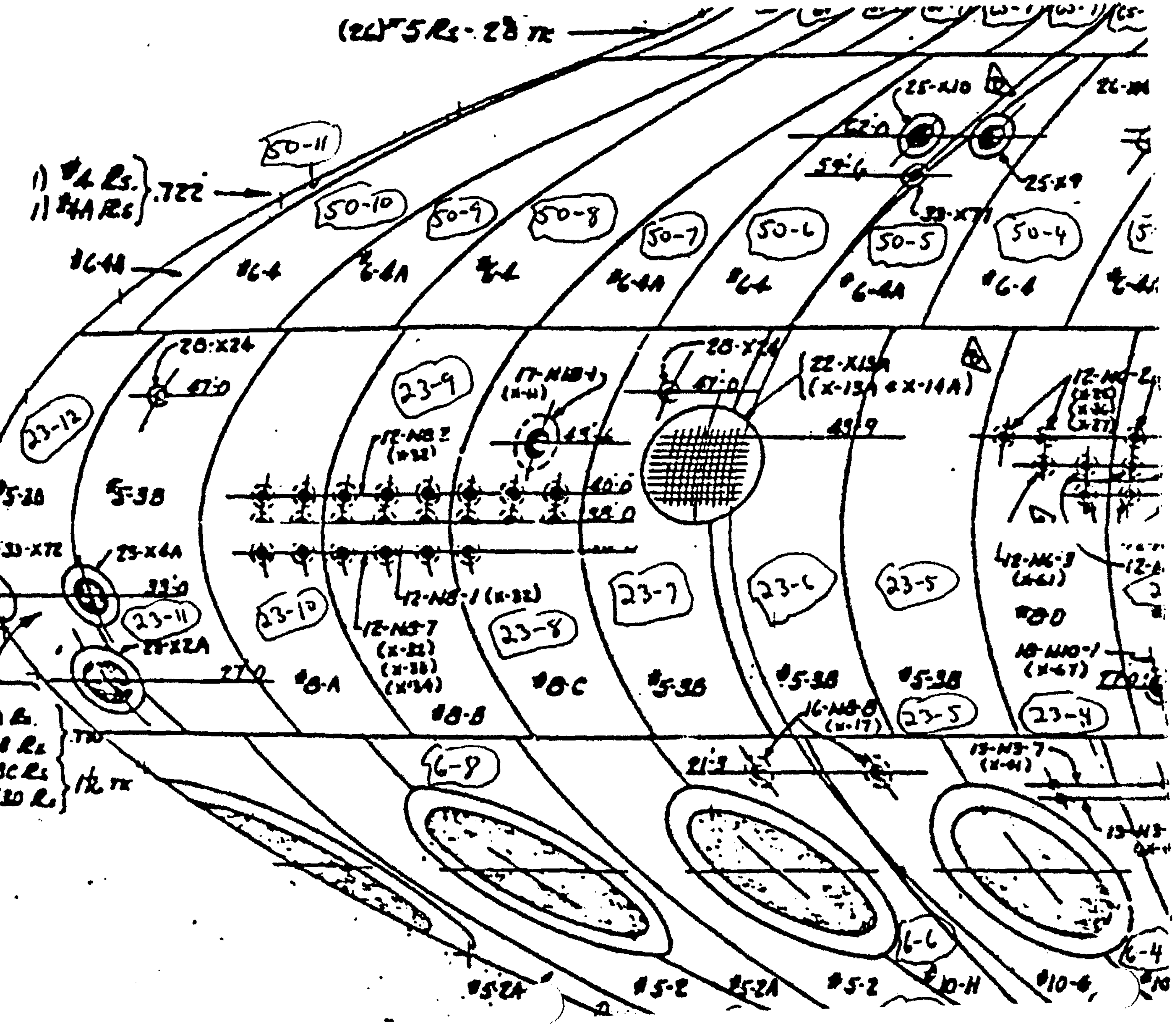


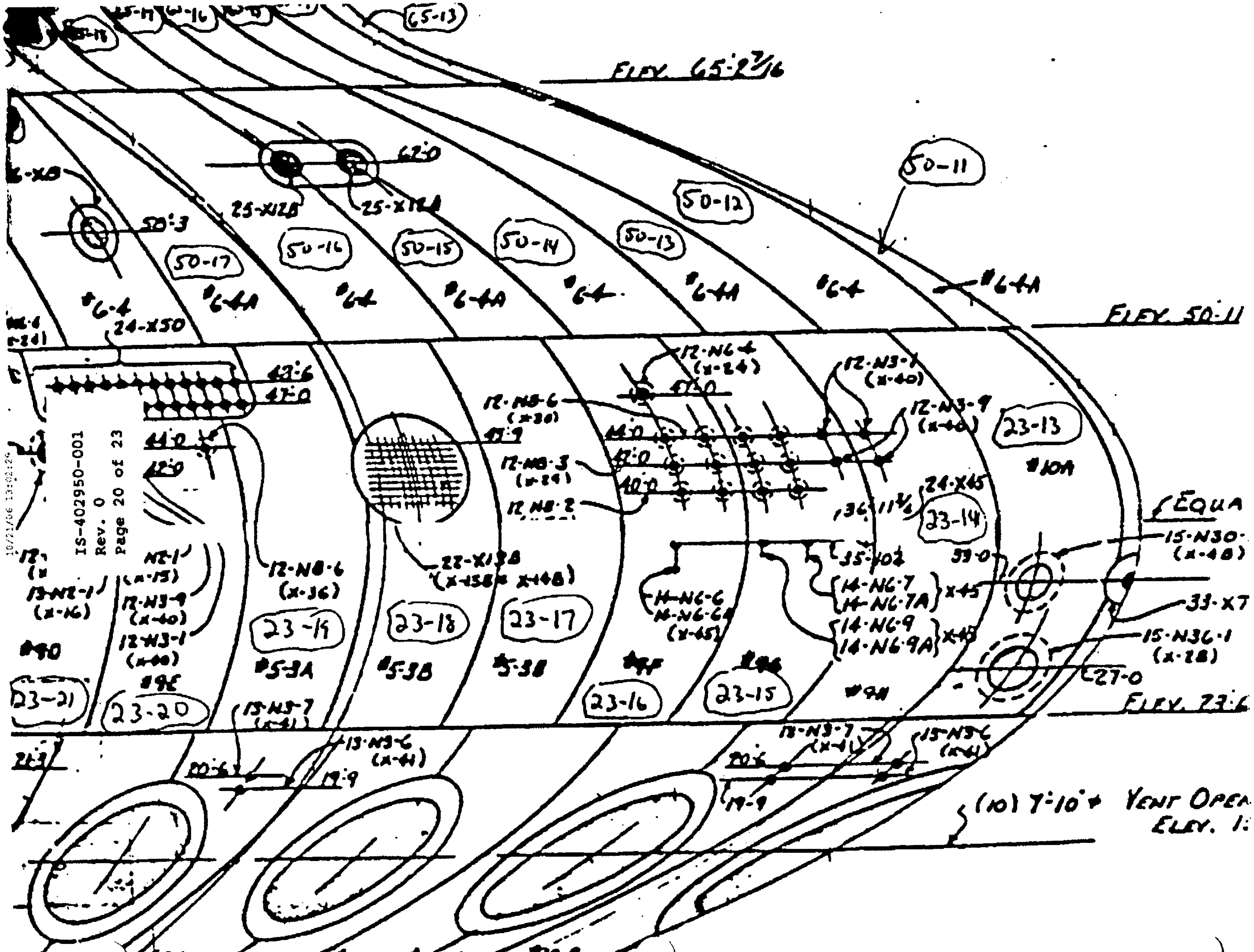
SYMBOLS

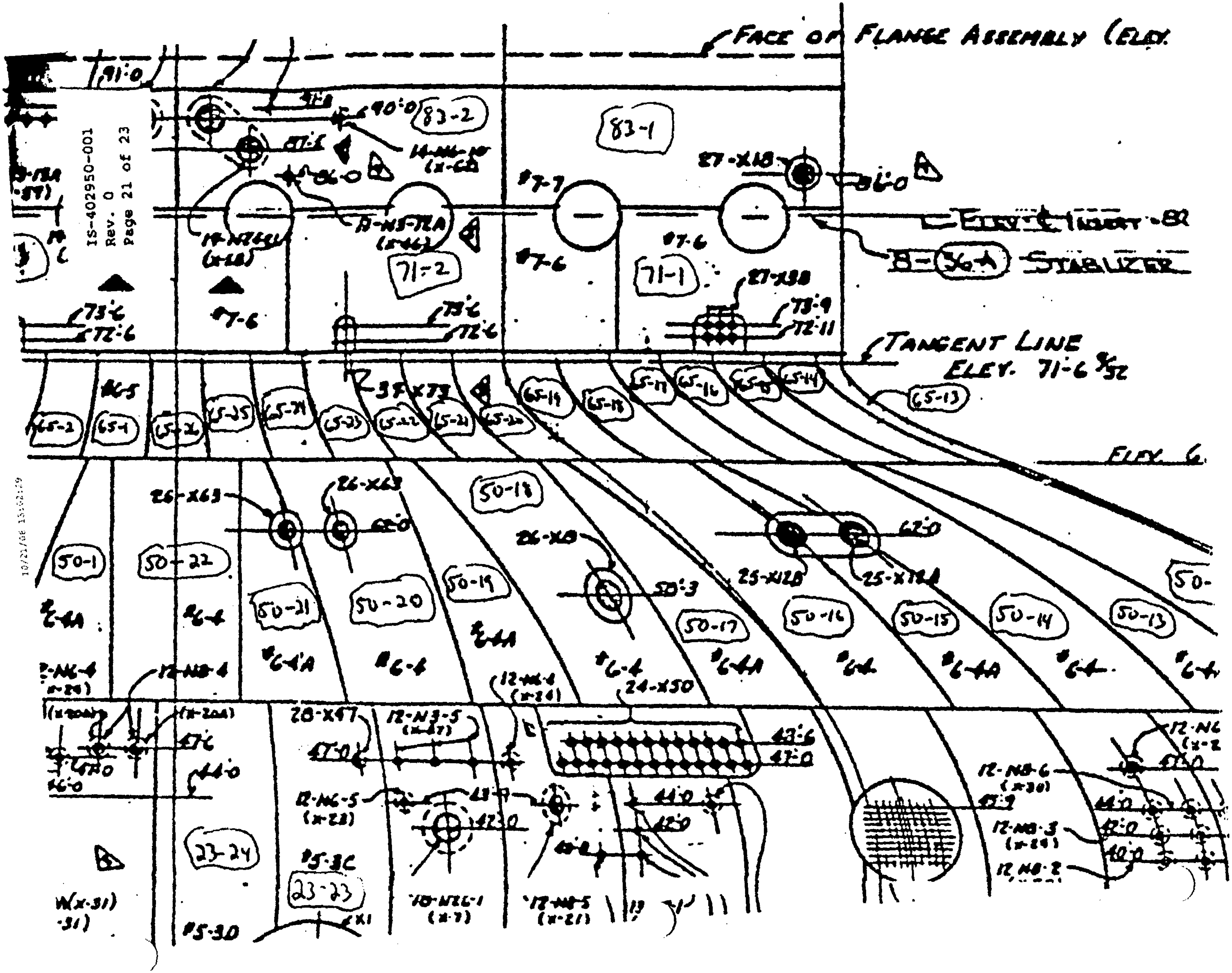
• FENESTRATION USING INSER PLATE


50-4
50-3
50-2
50-1
50-22
50-21
50-20
50-19
50-18
50-17
50-16
24-X50
23-24
23-23
23-3
23-2
23-1
23-22
23-21
23-20
23-19
23-4
6-2

SHEET NO. B-BO B-BO 9/16/80




65-13
ELEV. 65'-2 7/16
50-11
50-12
50-13
50-14
50-15
50-16
50-17
50'-3
25-X12B
25-X12A
#6-4
#6-4A
ELEV. 50-11
24-X50
43'-6
47'-0
44'-0
12-N6-4
(X-24)
12-N3-1
(X-40)
12-N3-9
(X-40)
12-N8-6
(X-30)
12-N8-3
(X-29)
12-N8-2
22-X13B
(X-15B & X-14B)
12-N8-6
(X-36)
23-13
23-14
23-15
23-16
23-17
23-18
23-19
23-20
23-21
#10A
24-X45
35-402
14-N6-7
14-N6-7A
14-N6-9
14-N6-9A
14-N6-6
14-N6-6A
(X-45)
15-N30-1
(X-48)
33-X7
15-N36-1
(X-28)
27-0
EQUA
ELEV. 23'-6
13-N2-1
(X-16)
12-N3-9
(X-40)
12-N3-1
(X-40)
#5-3A
#5-3B
13-N3-6
(X-41)
13-N3-7
(X-41)
15-N3-6
(X-41)
20'-6
19'-9
(10) 7'-10" Ø VENT OPEN
ELEV. 1


FACE OF FLANGE ASSEMBLY (ELEV.
91'-0
90'-0
83-2
83-1
87-X18
86'-0
71-2
71-1
87-X38
73'-6
72'-6
73'-9
72'-11
TANGENT LINE
ELEV. 71'-6 9/32
STABILIZER
65-2
65-1
65-26
65-25
65-24
65-23
65-22
65-21
65-20
65-19
65-18
65-17
65-16
65-15
65-14
65-13
ELEV. 6
26-X63
26-X62
26-X60
25-X12B
25-X12A
50-1
50-22
50-21
50-20
50-19
50-18
50-17
50-16
50-15
50-14
50-13
24-X50
28-X47
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12-N8-3
12-N6-5
23-24
23-23
43'-6
47'-0
44'-0

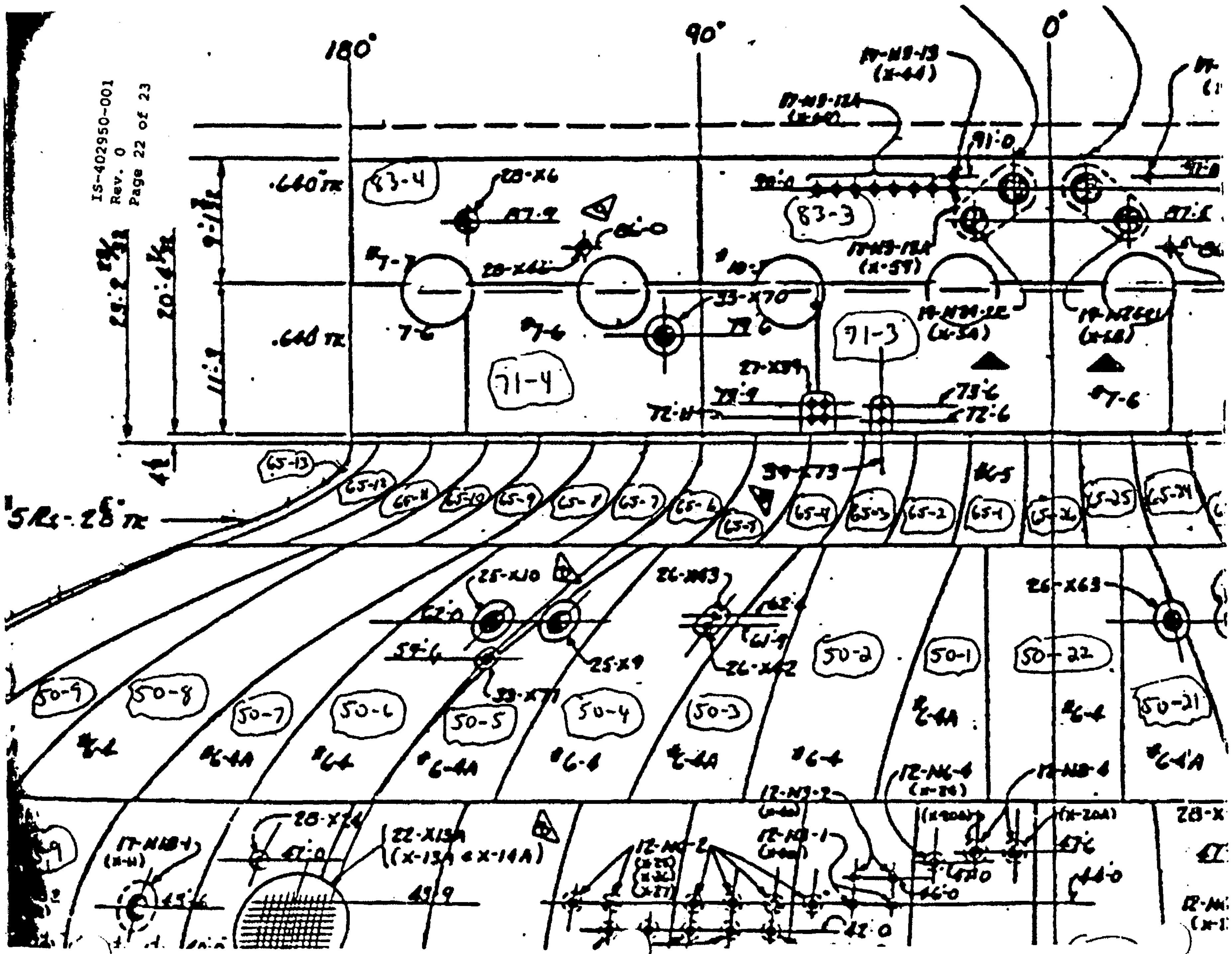
180°
90°
0°
83-4
83-3
71-4
71-3
28-X6
33-X70
34-X73
65-13
65-12
65-11
65-10
65-9
65-7
65-6
65-5
65-4
65-3
65-2
65-1
65-26
65-25
65-24
25-X10
25-X9
33-X71
26-X63
26-X62
50-9
50-8
50-7
50-6
50-5
50-4
50-3
50-2
50-1
50-22
50-21
28-X14
22-X13A
(X-13A & X-14A)

EXHIBIT #2

Alternate Inspection Location Selection Scheme

				9
	7	8	1	10
	6	original	2	11
↑	5	4	3	12
				13

Figure #3

Figure #3 illustrates the selection scheme in which an alternate inspection point shall be determined. The original inspection point, which is unaccessible, or cannot be scanned due to surface conditions, shall be located on the applicable sketch (Reference 2.8). If the original randomly chosen point is unaccessible, or cannot be scanned due to surface conditions, then per Figure #2 Grid #1 shall be the alternate location.

If Grid #1 is also unaccessible, or cannot be scanned due to surface conditions, then Grid 2, 3, 4, etc. shall be selected until a location is accessible.

If the original randomly chosen location borders a weld or penetration, and is unaccessible,then the grid which is accessible in the clockwise direction per Figure #3 shall be selected as the alternate inspection location. In all cases, the alternate inspection location shall be located on the original vessel plate.

GPU Nuclear

Technical Data Report

TDR No. 1027		Revision No. 1
	Budget Activity No. 402950	Page 1 of 38
Project: OYSTER CREEK DRYWELL CORROSION	Department/Section ENGINEERING & DESIGN	
	Release Date ______	Revision Date ______

Document Title: DESIGN OF A UT INSPECTION PLAN FOR THE DRYWELL CONTAINMENT USING STATISTICAL INFERENCE METHODS

Originator Signature	Date	Approval(s) Signature	Date
S. D. LESHNOFF		B. Elam	11/1/90
S. D. Leshnoff	10/31/90		
		Approval for External Distribution	Date

Does this TDR include recommendation(s)? ___Yes X No   If yes, TFWR/TR# ___

*	Distribution	Abstract:
	A. R. Baig F. P. Barbieri B. D. Elam, Jr. J. C. Flynn J. P. Moore, Jr. M. A. Orski D. G. Slear P. Tamburro	BACKGROUND: As a result of drywell corrosion at Oyster Creek, Ultrasonic Test (Ut) thickness measurements are periodically being taken. In the past these measurements have been utilized to identify locations whose thickness is reduced. By repeated measurements in these areas at the same location, statistically derived corrosion rates have been determined. A new UT inspection plan whose purpose was to provide a basis for statistical inference that the drywell thickness satisfies minimum required was developed. The drywell is statistically characterized using a limited number of plate thickness measurements. The purpose of this TDR is to document the basis for this inspection plan. (For Additional Space Use Side 2)

* Abstract Only

SOLUTION:

Using 6" x 6" grids for UT measurements, randomly choose 60 loctaions but do not include sand bed grids. Finding no unsatisfactory areas in remaining observations is the basis to conclude, with a 5% risk of error, that 95% of the drywell is free of such areas. A different sample is used each time that the assessment is made. Finding no repairable areas within grids provides a level of assurance of better than 99% that the drywell is free of such areas. Apply statistical inference methods as far as possible and where there are limitations use a judgement approach in order to determine whether corrosion is or is not occurring.

GPU Nuclear	DOCUMENT NO. TDR 1027		
TITLE	DESIGN OF A UT INSPECTION PLAN FOR THE DRYWELL CONTAINMENT USING STATISTICAL INFERENCE METHODS		
REV	SUMMARY OF CHANGE	APPROVAL	DATE
1	1. Add to both Background and Solution sections that there are limits to statistical inference which are overcome by judgement methods. 2. Change derived to estimated. 3. Change reference in text. 4. Add section for References. 5. Clarify Table 1. 6. Explain simulation notation and practice and number of units sampled. 7. Use Figure 1b for section distribution equal to 0.05. 8. Define stratification. 9. Use sand bed plates instead of sand bed when describing stratification. 10. Use estimate instead of failure and clarify multiple trials. 11. Add a statement showing that simulations demonstrate both accuracy and sensitivity of inspection plan. 12. Introduce insignificant change when using acutal number of plates per strata. 13. Add section addressing finding one or more unacceptable observations, including Figure 3. 14. Add statements to clarify approach to local low areas. 15. Correct equations for variance. 16. Add section on disposition of results.		

N0036 (03-90)

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BACKGROUND:

As a result of drywell corrosion at Oyster Creek, Ultrasonic Test (UT) thickness measurements are periodically being taken. In the past these measurements have been utilized to identify locations whose thickness is reduced. By repeated measurements in these areas at the same location, statistically estimabed corrosion rates have been determined. A new UT inspection plan whose purpose was to provide a basis for statistical inference that the drywell thickness satisfies minimum required was developed. The drywell is statistically characterized using a limited number of plate thickness measurements. The purpose of this TDR is to document the basis for this inspection plan.

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1

SOLUTION:

Using 6" X 6" grids for UT measurements, randomly choose 60 locations of a possible 60,000 but do not include sand bed grids. Finding no unsatisfactory areas in remaining observations is the basis to conclude, with a 5% risk of error, that 95% of the drywell is free of such areas. Therefore, this sampling plan will develop 95% confidence that 95% of the drywell is free of such areas. A different sample is used each time that the assessment is made. Finding no repairable areas within grids provides a level of assurance of better than 99% that the drywell is free of such areas. Apply statistical inference methods as far as possible and where there are limitations use a judgement approach in order to determine whether corrosion is or is not occurring.

1

TECHNICAL APPROACH:

A non-parametric statistical approach using attribute sampling that assumes no prior knowledge of the distribution of corrosion above the sand bed region is the basis for the augmented inspection plan. The acceptance criteria is that the mean and local thicknesses of the shell equals or exceeds a required minimum thickness plus a corrosion allowance necessary in order to reach the next inspection.

Statistically, a predicted value, A_u, of the maximum number of defects in the population, N, reflecting a selected level of risk can be used so that for this value "a" defects in sample "n" are expected at a low probability, α_u. The lower the probability, the larger the sample size. If "a" or less are found, then the selected risk is not exceeded. If ">a" are found, the selected risk is exceeded. Sample size "n" can be computed given A_u and α_u. For 5% of the surface as unacceptably degraded for A_u, then "n" is found to be 59 at $\alpha_u = 0.05$ and a = 0. That is, no observations which do not satisfy the acceptance criteria (i.e., grids) can be found in a sample of 59 with a 5% risk that the actual number of grids which would not satisfy the acceptance criteria exceeds A_u without rejecting the hypothesis. Using 60 grids, there is only a 5% chance of finding no grids whose thickness is below the acceptance criteria given 5% of the population below this thickness. Finding none in a sample of 60 is remote so that if none are found below this thickness, then the assumption about the defective proportion below the acceptance criteria thickness is probably an overestimate. Sixty observations is a good basis for a sampling plan. There is also the possibility that the actual number of defective grids is less than A_u and the hypothesis is rejected due to chance alone. This is evaluated in the discussion of finding one or more unacceptable observations (see below). The determination of the appropriate sample size is expressed formally by: (3)

$$\sum_{i=0}^{a} \Pr(i, n-i) \mid (A_u, N-A_u) =$$

$$({}_{A_u}C_a) \times ({}_{(N-A_u)}C_{(n-a)}) \,/\, {}_{N}C_n < \alpha_u \quad \text{(Ref. 1)}$$ (4)

Where ${}_{N}C_n$ is the number of combinations of n units chosen from N,

$${}_{N}C_n = \frac{N!}{n!\,(N-n)!}$$

Results as shown in Table 1

For a sample size n = 59 observations, it is evident from Table 1, that the probability for finding zero unsatisfactory observations is 0.0482, which is less than the assumed value of 0.05. Therefore, finding no occurrences in 59 observations satisfies the selected level of risk with only a .05 probability of error.

It is also evident from Table 1 that for a sample size n = 124 that the cumulative probability of finding up to two occurrences of failures, which is the sum of all three row entries, also satisfies .05. If, for this larger sample only one occurrence is observed, then this is the basis to conclude that the actual number of occurrences in the population is less than the assumed value. Furthermore, finding no occurrences is even more evidence of this. (5)

TABLE 1

PROBABILITY OF OCCURRENCES

N = 60,000

	NUMBER OF OCCURRENCES		
SAMPLE SIZE	0	1	2
2	---	---	---
-	---	---	---
58	0.0508	0.156	.234
59	0.0482	0.15	.230
-	---	---	---
123	0	0.0116	0.0374
124	0	0.0111	0.0361

Using this same method, it can be shown that for 10% of the total surface area as the selected risk, the sample size is reduced to 29 at a 5% risk. At n = 60, the risk is only 2%.

The results in Table 1, the work of Mr. J. P. Moore of GPUN, have been independently verified by Dr. D. G. Harlow, Associate Professor of Mechanics, Department of Mechanical Engineering and Mechanics, Lehigh University.

Simulation of Stratified Sampling:

The most severe corrosion has occurred in the sand bed region. This region may not always contain the most service limiting location, however, because of as-supplied local thickness. The previous measurement locations in this region will not be abandoned as part of this program since these are necessary in order to determine corrosion rate. It is appropriate to deliberately proportion the new observation locations in order to limit the total number of random grids that can fall in any one region. For purposes of assessing the performance of a random sampling, simulations will be performed.

Accuracy of Random Sampling Evaluated by Simulations:

A stratified sampling plan has been simulated by Professor Harlow. In Figure 1a, a total of 100 panels is used to represent the total number of plates used to fabricate the drywell. Consider the drywell divided into two strata without bias as to proportion of occurrences when the acceptance criteria is not met, the sand bed region and everywhere else. Ten plates, which are not necessarily contiguous, represent the lower strata, including portions of those plates which may be under the drywell floor and 90 comprise the upper strata. It is assumed that as much as five percent of the entire population does not meet the acceptance criteria. Assuming an equal probability of these observations in each strata (0.05), the actual proportion, P1, arrived at by simply counting the randomly simulated defective units in both strata is, P1 = 0.04833. The sample of the simulation is accomplished by randomly observing 15 units in the first stratum and 45 from the second stratum of a total of 60 observations, representing a one percent sample of available units. The measured characteristics are recorded as 1 if the unit does not meet the thickness criterion and as 0 otherwise. The estimated proportion p1, for sampling without replacement, is 0.047, a slight underestimate. 6 6 6

The simulation shows that the sampling plan is very promising. Figure 1b uses the same assumptions and proportion as for the first section distribution (0.05). The only difference is that a different random selection of 60 observations was made. The bottom line, however, changed. The overall estimated strata proportion, p1, has declined to 0.02. The simulation of the sampling plan no longer accurately reflects the reference proportions. A sampling plan is judged on satisfying this criteria. Repeated sampling using different grids each time will resolve this problem. The simulation studies show that the estimated proportions are more or less accurate depending on random selection of observations only. Based on the simulations it would be incorrect to conclude, using a single sample, that the overall risk assumption is not violated or that it is violated because of random selection. A number of selections of different samples will consistently provide a good estimate 7 of the actual number of defects in the population on average. A good, experimental design uses a different sample each time an estimate is made. It is proposed for this program that a different sample, each of the same size, be used each time an estimate of the defective proportion needs to be made so that the conclusion is not based on chance alone.

Finding no unacceptable occurrences after a number of repetitions of the sampling plan, using different samples, is evidence that the assumed risk is not exceeded. A single finding of no unacceptable occurrences is consistent with the assumed risk.

Simulations of larger populations with the sample assumed risk at the same probability for error show the same good overall performance, but with like sensitivity to random variation.

MORE COMPLICATED SIMULATIONS AND RECOMMENDED SAMPLING PLAN:

A five part stratified random sampling plan is proposed in order to make the most of 60 grids. The five strata represent five zones of the drywell (Figure 2). Stratification divides a heterogeneous population into subpopulation, each of which is internally homogeneous. Each strata is sampled at the same portion, considering plates, as for the total population of plates. Better precision should be obtained than by ignoring the differences in the population. Plates in each zone will be randomly selected with one grid selected randomly per plate. The simulation of this scheme is

(8)

included in Attachment 1, Part A. The stratification is based on relative proportions using existing qualitative knowledge of both material lost due to corrosion and rate of material lost. The sampling plan is summarized as follows:

ZONE	DESCRIPTION	NUMBER OF PLATES SAMPLED @ 1 GRID PER PLATE FROM TOTAL NUMBER OF PLATES PER STRATA (ESTIMATED)
I	Intersection of sand bed plates and drip zones	3
II	Drip zone	12
III	Sand bed plates	9
IV	All else	32
V	Cylinder	4

The sampling plan simulation shows satisfactory accuracy over 25 trials. No single estimate exceeding 5% is reason to reject the assumed level of risk. A single sample may be unrepresented due to chance alone. A different random sample is used each time this assessment is made.

Attachment 1, Part B, is an additional simulation of the same five part stratified sampling plan where 100 repeated random samplings of size 60 are considered. In this simulation the performance of sampling process is characterized by forming a distribution of the estimation results. At the 90% confidence limit, the estimate of defect proportion falls between 0.096 and 0.0037. This shows the risk, due to chance, that the structure is concluded to be unsatisfactory where, in fact, it is.

Using a one-sided t-score, an appropriate measure of the distribution of the estimates about the true mean, at = 0.05, the performance of the sampling process does not exceed 0.05, 95% of the time. This verifies the utility of the stratified sampling plan.

The confidence interval can be narrowed by increasing the proportion of the surface area that is scanned by UT. Using the grid location as a center, use of the A-scan on a best effort basis, will provide this process improvement. The A-scan device need only be set to the local minimum thickness as a threshold.

The sand bed condition with respect to material lost due to corrosion has already been characterized. About 67% of the sand bed zone perimeter has been surveyed by UT. By this means, the most severely corroded zones have been identified throughout the sand bed, including that portion below the drywell floor.

Attachment 2 is an additional simulation of the same five part stratified sampling plan, except that sand bed zone grids are excluded, if they are randomly selected. The saving of inspection time and exposure, the amount depending on chance for each sample, is justified by comparing mean estimates and standard deviations for 100 trials. Assuming 5% defective, the simulation including the sand bed zone grids as they are selected, shows a mean estimate of 0.046 with a standard deviation of 0.024 while the simulation excluding the sand bed zone grids as they are selected shows a mean estimate of 0.044 and standard deviation equal to 0.026 (using proportion P1 for comparison).

Also, using the t-score, as described above, this sampling process does not exceed 0.048, 95% of the time. By comparison, this is slightly less accurate.

Simulation of non-stratified sampling is shown in Attachment 3. This sampling plan does not use the accumulated corrosion information. This simulation shows that by ignoring what is already known about the degree of corrosion, the sampling process accuracy is reduced because of the increased standard deviation. The mean estimate is 0.047, but the standard deviation has increased to 0.030.

Also, using the t-score as above, the upper 95% confidence limit, U_{95}, is 0.052. This is slightly inaccurate, but in a nonconservative direction.

Table 2 summarizes the results of the simulations.

Simulation also shows that the random sampling plans are not only acceptably accurate but acceptably sensitive, as well. Simulation shows that finding no unacceptable observations occurs less than 5% of the time, as intended. (11)

Changing the simulation in Attachment 1b to reflect the actual number of plates per strata results in $U_{95} = 0.055$. The change is insignificant so that the estimates used in the above simulations are representative of the performance of the random sampling process. (12)

Finding One or More Unacceptable Observations:

In the simulations, finding one or more of the 60 observations to be less than the minimum thickness predominated. Finding one or more using this sample doesn't prove anything unique and conclusive about the level of structural assurance. For example, one or more unacceptable observations can occur at a 5% probability with 99.9% of the drywell free of unacceptable observations. A conclusion about drywell, structural adequacy with one such observation is not appropriate because a better condition can result in an unacceptable observation. Finding none does confirm the original hypothesis.

The probabilities of finding none (α) or finding one or more unacceptable observations using a sample of 60 observations for a number of populations containing different portions of unacceptable observations are shown in Figure 3. The probability of finding one or more, β, is $\beta = (1 - \alpha)$.

Use of Cells Within Grids:

Minimum required mean plate thickness and minimum required local plate thickness each must satisfy design basis stress criteria. In addition, minimum required mean plate thickness must satisfy ASME design basis stability criteria to prevent buckling. Minimum required mean plate thickness pertains to a shell course and minimum required local plate thickness pertains to a single local area or the sum of local areas within reference distances, if there are more than one local area.

TABLE 2

RESULTS OF SIMULATIONS

	5% DEFECTIVE				
	P1			P2	
	MEAN ESTIMATE	STANDARD DEVIATION	U_{95}	MEAN ESTIMATE	STANDARD DEVIATION
Five part stratification including sand bed	0.046	0.024	0.050	0.052	0.022
Five part stratification not including sand bed	0.044	0.026	0.048	0.043	0.026
No stratification, not including sand bed	0.047	0.030	0.052	---	---

NOTE: By simulation it can be shown that the mean estimate is less accurate for an assured 10% defective population using a sample size of = 30.

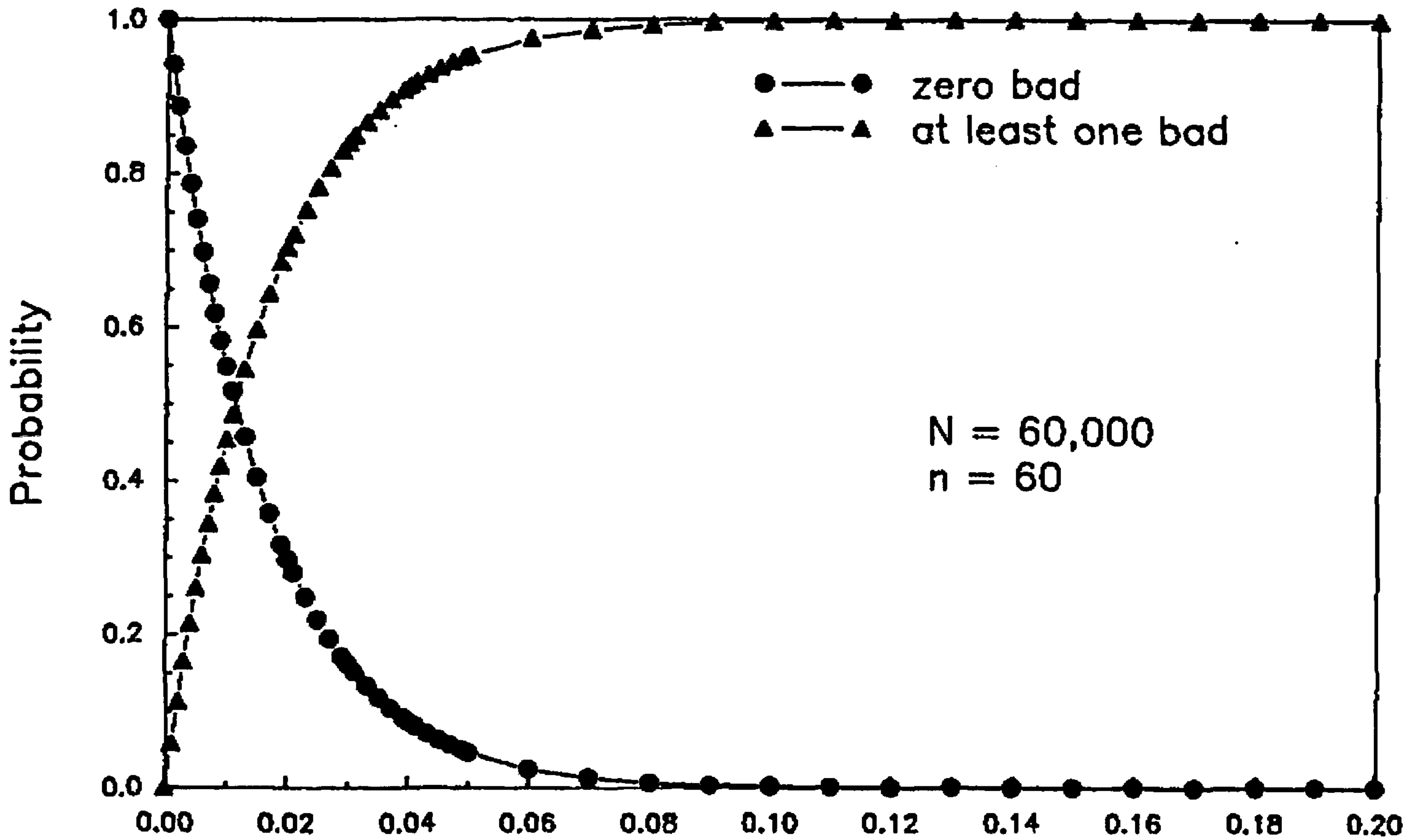

FIG. 3 Fraction of BAD Grids

A grid of individual measurements will be the basis for estimating the mean plate thickness. There is no code requirement for either the minimum or maximum grid size necessary to determine mean plate thickness. However, the grid size should be large enough to capture the local, minimum thickness in a 2.5" diameter or smaller circle and no larger than $2.5\sqrt{Rt}$, which is the distance that uniform shell thickness must extend around an unreinforced opening. Local minimum thickness must satisfy both local membrane stress criteria and code rules for unreinforced openings.

The grid size should be large enough to contain enough single observations to minimize the impact of a pit on the mean thickness while minimizing radiation exposure of personnel taking the measurements. A 6" X 6" grid of 49 data points on two inch centers fulfills these criteria. It conservatively captures a 2" diameter circle and is more conservative than a $2.5\sqrt{Rt}$ radius circle since there is less benefit from averaging. The 6" X 6" grids will also be used to establish that not more than 0.1% of the surface area satisfying the required mean thickness criteria contains locally low areas. That is, no more than one locally low area per reference circle. Therefore, equate the requirement that 99% of the area is free of holes to a 99% probability of finding no locally low area. (14)

Analysis of variance of 2" X 2" cells contained within a single 6" X 6" grid will show whether the difference between the required mean and local thickness is significantly more than the lower 99.9% tolerance limit one-sided, times the standard deviation for the 2" X 2" cells. The one percent probability is consistent with the one percent local reduction permitted by the code.

Statistical inference regarding the variance of the observed grid means about the true grid mean of the population is not important. The concern here is variance of reference 2" X 2" cell measurements about an assumed mean equal to the acceptance thickness for a particular plate.

As developed by Messrs. J. P. Moore and M. A. Orski of GPUN, with review and concurrence by Dr. J. Orsini, Professor of Management and System Design, Fordham University, the pooled variance of 49 cell measurements per grid, the average of four points per 2" X 2" cell, taken over 60 grids, totalling 540 observations, is the basis to establish the lower, single-sided tolerance limit for a single cell thickness.

The definition of X^2, the parameter characterizing a normal distribution, relates sample variance, s^2, and population variance, σ^2:

$$X^2 = s^2 \frac{(n-1)}{\sigma^2} \qquad \text{EQUATION 1}$$

Where n = sample size = 540 and

$$s^2 = \frac{\sum_{i=1}^{j} (n_i - 1) s_i^2}{\sum_{i=1}^{j} (n_i - 1)}, \qquad \text{for } j = 540 \text{ and } n_i = 4 \text{ for all } i$$

Where

$$s^2_i = \frac{\sum_{i=1}^{j} (x_i - \bar{x})^2}{(j - 1)}, \qquad \text{where } j = 4$$

15

Since n is large, σ^2 can be computed accurately using X^2 at a significance equal to 0.1.

Here the mean plate thickness is assumed and a tolerance limit is necessary to predict an individual observation. For a normal distribution of a large number of individual observations, the difference between the population mean, μ , and an individual observation, x, is given by the Z parameter,

$$Z = \frac{|x-\mu|}{\sigma} \qquad \text{EQUATION 2}$$

σ is obtained from Equation 1, above. The difference $|x-\mu|$ is the difference, Δ, between the assumed population mean and a local thickness of

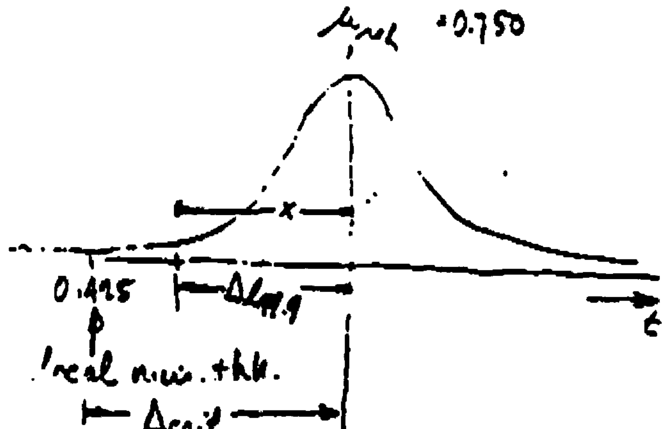

FIG.2 DIFFERENCE OF MEAN AND LOCAL THICKNESSES DOES NOT EXCEED CRITICAL VALUE

an individual cell. It is highly unlikely for a local cell thickness to be less than:

$$|x-\mu| = Z_{99.9} \cdot \sigma \qquad \text{EQUATION 3}$$

The distribution of results should show that the probability of an unacceptable local low area is very small. (14)

Using pooled variance, an individual cell thickness is estimated at the lower 99.9% confidence limit. Based on the distribution of local thicknesses, there is a high confidence that no repairable local areas will be found, i.e., that the critical differences are more than that shown by the measurements, ($\underline{\Delta}$ crit. < $\underline{\Delta}_{99.9}$) as shown in Figure 4.

SCOPE OF APPLICATION:

Since no portion of the drywell is purposely excluded on theoretical grounds, the inspection plan applies to the entire structure except welds, those areas over which a 6" X 6" simply won't fit, and penetrations.

Grids drawn at random falling in the sand bed region of the sphere will be disregarded because this zone is characterized in an ongoing manner by numerous grids and strip measurements. Previous measurements below the drywell floor in excavated trenches, showed that material loss due to corrosion was no worse than above the floor. This results in ALARA savings without sacrifice in sampling accuracy.

ACCEPTANCE CRITERIA:

A repairable grid is one that does not satisfy the local low spot minimum thickness. The 6" X 6" grid is a conservative gauge that could have been larger. Its utility is for corrosion rate assessment. Larger grids tend to drive the mean thickness upward. The use of pooled variance of grids with the reference mean thickness ensures that the local minimum thickness is obtained conservatively. Finding no repairable areas within grids provides a level of assurance of better than 99% that the drywell is free of such areas.

The corrosion allowance can be based on the estimated corrosion rate because nothing can be inferred about rate by this assessment. It is not appropriate to use a 95% confidence interval rate estimate based on other, routinely revisited grids.

Sampling Scheme Contingency Plan:

Should a randomly selected grid turn out to be inaccessible, consistent rules will be provided, in the inspection specification, to locate an alternate without introducing any biases.

Disposition of Results:

Finding an unacceptable mean thickness is reason to better characterize the area in order to show that the region is, in general, in much better condition. If a mean thickness, established using a 6" x 6" grid, does not meet minimum requirements, enlarge the inspection grid to an area one and a half feet on a side and obtain additional readings. Use the enlarged grid to compute a new mean thickness. This will improve accuracy, as well. 16

REFERENCES:

1. Personal, communication entitled "Sampling Plans for the Oyster Creek Drywell," D. G. Harlow to S. D. Leshnoff, 5/22/90. (4)

```
     STRAT2SIM
THE number ns OF SECTIONS. i.e. strata, IS 2.
ENTER THE number OF PANELS IN stratum 1
⎕:
     10
ENTER THE number OF PANELS IN stratum 2
⎕:
     90
THE total number OF PANELS = 100
ASSUME: TOTAL NUMBER OF UNITS IS identical FOR EACH PANEL.
ENTER THE number nu OF UNITS PER PANEL.
⎕:
     60
THE total number OF UNITS = 6000
THE number OF UNITS IN SECTIONS 1 TO 2 IS 600 5400
ENTER p = P(bad unit) WHICH DESCRIBES THE ENTIRE POPULATION.
⎕:
     .05

SECTION DISTRIBUTION no. 1: 0.05 0.05
SECTION DISTRIBUTION no. 2: 0.1538461538 0.03846153846
SECTION DISTRIBUTION no. 3: 0.25 0.02777777778

PROPORTION P1 = 0.04833333333
PROPORTION P2 = 0.049
PROPORTION P3 = 0.05133333333

 ENTER THE NUMBER n1 OF SAMPLES DESIRED FOR stratum 1
 ⎕:
      15
 ENTER THE NUMBER n2 OF SAMPLES DESIRED FOR stratum 2
 ⎕:
      45

 ENTER THE total number OF UNITS TO BE SAMPLED.
 ⎕:
      60

 sampling without replacement

 ESTIMATED STRATA PROPORTIONS p1 = 0.06666666667 0.04444444444
 ESTIMATED STRATA PROPORTIONS p2 = 0.06666666667 0.04444444444
 ESTIMATED STRATA PROPORTIONS p3 = 0.1333333333 0.02222222222

 ESTIMATED PROPORTION p1 = 0.04666666667
 ESTIMATED PROPORTION p2 = 0.04666666667
 ESTIMATED PROPORTION p3 = 0.03383333333

 ESTIMATED VARIANCE OF p1 = 7.9872644853E¯4
 ESTIMATED VARIANCE OF p2 = 7.9872644853E¯4
 ESTIMATED VARIANCE OF p3 = 4.6316019493E¯4
```

FIG. 1a SIMULATION OF RANDOM SAMPLING USING TWO STRATA

```
      STRAT2SIM
THE number ns OF SECTIONS, i.e. strata, IS 2.
ENTER THE number OF PANELS IN stratum 1
⎕:
      10
ENTER THE number OF PANELS IN stratum 2
⎕:
      90
THE total number OF PANELS = 100
ASSUME: TOTAL NUMBER OF UNITS IS identical FOR EACH PANEL.
ENTER THE number nu OF UNITS PER PANEL.
⎕:
      60
THE total number OF UNITS = 6000
THE number OF UNITS IN SECTIONS 1 TO 2 IS 600 5400
ENTER q = Pr(bad unit) WHICH DESCRIBES THE ENTIRE POPULATION.
⎕:
      .05

SECTION DISTRIBUTION no. 1: 0.15 0.05
SECTION DISTRIBUTION no. 2: 0.4567307692 4.807692308E¯3
SECTION DISTRIBUTION no. 3: 0.4583333333 4.629629631E¯3

PROPORTION P1 = 0.05033333333
PROPORTION P2 = 0.04816666667
PROPORTION P3 = 0.04833333333

ENTER THE NUMBER n1 OF SAMPLES DESIRED FOR stratum 1
⎕:
      15
ENTER THE NUMBER n2 OF SAMPLES DESIRED FOR stratum 2
⎕:
      45

ENTER THE total number OF UNITS TO BE SAMPLED.
⎕:
      60

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.02222222222
ESTIMATED STRATA PROPORTIONS p2 = 0.4666666667 0
ESTIMATED STRATA PROPORTIONS p3 = 0.4666666667 0

ESTIMATED PROPORTION p1 = 0.02
ESTIMATED PROPORTION p2 = 0.04666666667
ESTIMATED PROPORTION p3 = 0.04666666667

ESTIMATED VARIANCE OF p1 = 3.879236896E¯4
ESTIMATED VARIANCE OF p2 = 1.620478575E¯4
ESTIMATED VARIANCE OF p3 = 1.620478575E¯4
```

FIG. 1b SIMULATION OF RANDOM SAMPLING USING TWO STRATA.

DRYWELL

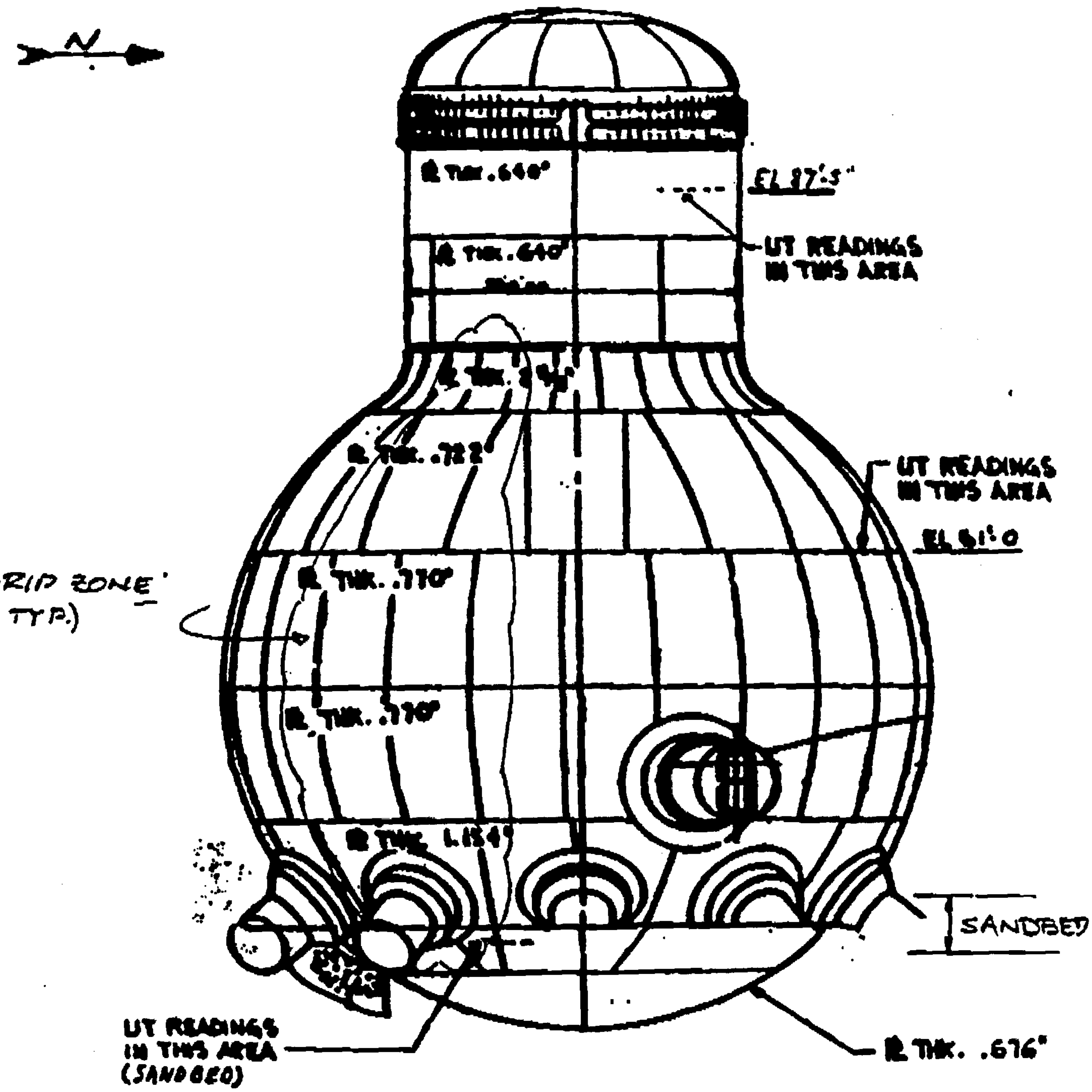

FIG. 2

ILLUSTRATION OF DRYWELL STRATA

ATTACHMENT 1a
SIMULATION OF 5 PART
STRATIFIED SAMPLING PLAN.

```
THE NUMBER OF SUBSETS ns = 5.
SUBSET 1 = drip zone and sandbed:  WORST
SUBSET 2 = drip zone only:  VERY BAD
SUBSET 3 = sand bed:  BAD
SUBSET 4 = rest of the sphere:  GOOD
SUBSET 5 = cylinder:  BEST
THE number OF PANELS IN SUBSETS 1.2.3.4.5 IS 5 20 15 52 8
THE total number OF PANELS = 100
ASSUME: TOTAL NUMBER OF 6'6 SAMPLE UNITS IS identical FOR EACH PANEL.
THE NUMBER OF UNITS PER PANEL nu = 600.
THE total number OF UNITS = 60.000.
THE number OF UNITS IN SUBSETS 1.2.3.4.5 IS 3000 12000 9000 31200 4800
ENTER q = Pr(bad unit):  A CHARACTERIZATION OF THE ENTIRE POPULATION.
]:
      0.05
SUBSET DISTRIBUTION no. 1: 0.2524487529 0.1262243765 0.06311218823
      5.048975059E¯3 5.048975058E¯4
SUBSET DISTRIBUTION no. 2: 0.3924646782 0.07849293564 0.03924646782
      0.01569858713 7.849293564E¯3

PROPORTION P1 = 0.05125
PROPORTION P2 = 0.0501

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.1666666667 0.1111111111 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0 0 0.1111111111 0 0

ESTIMATED PROPORTION p1 = 0.05
ESTIMATED PROPORTION p2 = 0.01666666667

ESTIMATED VARIANCE OF p1 = 7.092326222E¯4
ESTIMATED VARIANCE OF p2 = 2.466940771E¯4


THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.08333333333 0 0.03125 0
ESTIMATED STRATA PROPORTIONS p2 = 0 0.08333333333 0 0 0

ESTIMATED PROPORTION p1 = 0.03291666667
ESTIMATED PROPORTION p2 = 0.01666666667

ESTIMATED VARIANCE OF p1 = 5.099525677E¯4
ESTIMATED VARIANCE OF p2 = 2.543961997E¯4


THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0.3333333333 0.08333333333 0.1111111111 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.6666666667 0 0.1111111111 0.03125 0

ESTIMATED PROPORTION p1 = 0.05
ESTIMATED PROPORTION p2 = 0.06625
```

ESTIMATED VARIANCE OF p2 = 6.0731213232E¯4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0.3333333333 0.1666666667 0 0.03125 0
ESTIMATED STRATA PROPORTIONS p2 = 0 0 0 0 0

ESTIMATED PROPORTION p1 = 0.06625
ESTIMATED PROPORTION p2 = 0

ESTIMATED VARIANCE OF p1 = 9.0315660011E¯4
ESTIMATED VARIANCE OF p2 = 0

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.25 0.1111111111 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.3333333333 0 0 0.03125 0

ESTIMATED PROPORTION p1 = 0.06666666667
ESTIMATED PROPORTION p2 = 0.03291666667

ESTIMATED VARIANCE OF p1 = 8.7112111127E¯4
ESTIMATED VARIANCE OF p2 = 4.4061805532E¯4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0.3333333333 0.1666666667 0.3333333333 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.3333333333 0 0 0.03125 0

ESTIMATED PROPORTION p1 = 0.1
ESTIMATED PROPORTION p2 = 0.03291666667

ESTIMATED VARIANCE OF p1 = 1.2026619061E¯3
ESTIMATED VARIANCE OF p2 = 4.4061805532E¯4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.1666666667 0 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.6666666667 0.08333333333 0.1111111111
0.03125 0

ESTIMATED PROPORTION p1 = 0.03333333333
ESTIMATED PROPORTION p2 = 0.08291666667

ESTIMATED VARIANCE OF p1 = 4.6253854491E¯4
ESTIMATED VARIANCE OF p2 = 9.4170833321E¯4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

ATT 1a

0.03125 0

ESTIMATED PROPORTION p1 = 0.03333333333
ESTIMATED PROPORTION p2 = 0.08291666667

ESTIMATED VARIANCE OF p1 = 4.394578863E¯4
ESTIMATED VARIANCE OF p2 = 1.126723889E¯3

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.1666666667 0.2222222222 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.6666666667 0.1666666667 0 0 0.25

ESTIMATED PROPORTION p1 = 0.06666666667
ESTIMATED PROPORTION p2 = 0.08666666667

ESTIMATED VARIANCE OF p1 = 8.942531798E¯4
ESTIMATED VARIANCE OF p2 = 9.474126931E¯4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.1666666667 0 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.3333333333 0 0 0 0

ESTIMATED PROPORTION p1 = 0.03333333333
ESTIMATED PROPORTION p2 = 0.01666666667

ESTIMATED VARIANCE OF p1 = 4.625385449E¯4
ESTIMATED VARIANCE OF p2 = 1.850616872E¯4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.08333333333 0 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.6666666667 0.1666666667 0 0 0

ESTIMATED PROPORTION p1 = 0.01666666667
ESTIMATED PROPORTION p2 = 0.06666666667

ESTIMATED VARIANCE OF p1 = 2.543961997E¯4
ESTIMATED VARIANCE OF p2 = 6.476002321E¯4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0.3333333333 0.1666666667 0.2222222222 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.6666666667 0.08333333333 0 0.03125 0

ESTIMATED PROPORTION p1 = 0.08333333333
ESTIMATED PROPORTION p2 = 0.06625

ESTIMATED VARIANCE OF p1 = 1.079314867E¯3 sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0 0.1111111111 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.6666666667 0 0 0.03125 0

ESTIMATED PROPORTION p1 = 0.01666666667
ESTIMATED PROPORTION p2 = 0.04958333333

ATT. 14

ESTIMATED VARIANCE OF p1 = 2.466940771E¯4
ESTIMATED VARIANCE OF p2 = 4.406180552E¯4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0.6666666667 0.1666666667 0 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.6666666667 0.08333333333 0.1111111111
0.09375 0

ESTIMATED PROPORTION p1 = 0.06666666667
ESTIMATED PROPORTION p2 = 0.1154166667

ESTIMATED VARIANCE OF p1 = 6.476002321E¯4
ESTIMATED VARIANCE OF p2 = 1.403358545E¯3

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0.3333333333 0.08333333333 0.2222222222 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0 0.08333333333 0.1111111111 0.03125 0

ESTIMATED PROPORTION p1 = 0.06666666667
ESTIMATED PROPORTION p2 = 0.04958333333

ESTIMATED VARIANCE OF p1 = 8.711725219E¯4
ESTIMATED VARIANCE OF p2 = 7.566466448E¯4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0.3333333333 0.08333333333 0 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0 0.1666666667 0.1111111111 0 0

ESTIMATED PROPORTION p1 = 0.03333333333
ESTIMATED PROPORTION p2 = 0.05

ESTIMATED VARIANCE OF p1 = 4.394578869E¯4
ESTIMATED VARIANCE OF p2 = 7.092326221E¯4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0.3333333333 0.1666666667 0.1111111111 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.3333333333 0.1666666667 0 0 0

ESTIMATED PROPORTION p1 = 0.06666666667

ATT. 1a

[illegible]
ESTIMATED VARIANCE OF p2 = 6.476002321E^-4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.1666666667 0.3333333333 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0 0.08333333333 0 0.03125 0

ESTIMATED PROPORTION p1 = 0.08333333333
ESTIMATED PROPORTION p2 = 0.02291666667

ESTIMATED VARIANCE OF p1 = 1.017500216E^-3
ESTIMATED VARIANCE OF p2 = 5.095525677E^-4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.08333333333 0 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0 0.25 0 0 0

ESTIMATED PROPORTION p1 = 0.01666666667
ESTIMATED PROPORTION p2 = 0.05

ESTIMATED VARIANCE OF p1 = 2.543961997E^-4
ESTIMATED VARIANCE OF p2 = 6.244270356E^-4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.08333333333 0 0 0
ESTIMATED STRATA PROPORTIONS p2 = 1 0 0 0 0

ESTIMATED PROPORTION p1 = 0.01666666667
ESTIMATED PROPORTION p2 = 0.05

ESTIMATED VARIANCE OF p1 = 2.543961997E^-4
ESTIMATED VARIANCE OF p2 = 0

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.08333333333 0 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0 0.25 0 0.03125 0

ESTIMATED PROPORTION p1 = 0.01666666667
ESTIMATED PROPORTION p2 = 0.06625

ESTIMATED VARIANCE OF p1 = 2.543961997E^-4
ESTIMATED VARIANCE OF p2 = 8.799834036E^-4

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ATT. 1a

```
ESTIMATED PROPORTION p1 = 0.01666666667
ESTIMATED PROPORTION p2 = 0.06666666667

ESTIMATED VARIANCE OF p1 = 2.466940771E¯4
ESTIMATED VARIANCE OF p2 = 2.543961997E¯4


THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0 0.25 0.2222222222 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.6666666667 0.08333333333 0 0.0625 0

ESTIMATED PROPORTION p1 = 0.08333333333
ESTIMATED PROPORTION p2 = 0.0625

ESTIMATED VARIANCE OF p1 = 1.056141671E¯3
ESTIMATED VARIANCE OF p2 = 9.340831153E¯4


THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0.6666666667 0.25 0 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.6666666667 0 0.1111111111 0 0

ESTIMATED PROPORTION p1 = 0.08333333333
ESTIMATED PROPORTION p2 = 0.05

ESTIMATED VARIANCE OF p1 = 8.094887228E¯4
ESTIMATED VARIANCE OF p2 = 4.317557643E¯4


THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

sampling without replacement

ESTIMATED STRATA PROPORTIONS p1 = 0.3333333333 0.08333333333 0.1111111111 0 0
ESTIMATED STRATA PROPORTIONS p2 = 0.3333333333 0.1666666667 0 0 0

ESTIMATED PROPORTION p1 = 0.05
ESTIMATED PROPORTION p2 = 0.05

ESTIMATED VARIANCE OF p1 = 6.861519641E¯4
ESTIMATED VARIANCE OF p2 = 6.476002321E¯4
```

ATTACHMENT 1b
SIMULATION OF 5 PART
STRATIFIED SAMPLING PLAN.

SUBSET2SIM
THE NUMBER OF SUBSETS ns = 5.
SUBSET 1 = drip zone and sandbed: WORST
SUBSET 2 = drip zone only: VERY BAD
SUBSET 3 = sand bed: BAD
SUBSET 4 = rest of the sphere: GOOD
SUBSET 5 = cylinder: BEST
THE number OF PANELS IN SUBSETS 1,2,3,4,5 IS 5 20 15 52 8
THE total number OF PANELS = 100
ASSUME: TOTAL NUMBER OF 6X6 SAMPLE UNITS IS identical FOR EACH PANEL.
THE NUMBER OF UNITS PER PANEL nu = 600.
THE total number OF UNITS = 60,000.
THE number OF UNITS IN SUBSETS 1,2,3,4,5 IS 3000 12000 9000 31200 4800
ENTER q = Pr(bad unit): A CHARACTERIZATION OF THE ENTIRE POPULATION.
D:
0.05

SUBSET DISTRIBUTION no. 1:
0.2524487529
0.1262243765
0.0631121882
0.0050489751
0.0005048975
SUBSET DISTRIBUTION no. 2:
0.3924646782
0.0784929356
0.0392464678
0.0156985871
0.0078492936

PROPORTION P1 = 0.04735
PROPORTION P2 = 0.0515

sampling without replacement

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.

MAXIMUM OF THE ESTIMATES: 0.1166666667 0.03726821082 1 1 0.1325 0.03469665474 1 1
MINIMUM OF THE ESTIMATES: 0 0 0 0 0 0 0 0
AVERAGE OF THE ESTIMATES: 0.045925 0.02282403069 0.91 0.99 0.05165 0.02247775817 0.88 0.98
STD DEV OF THE ESTIMATES: 0.02409039543 7.305016591E¯3 0.2876234913 0.1 0.02850819482 8.331828116E¯3 0.3265986324 0.1407052941

UPPER TWO-SIDED NORMAL 0.90 AND 0.95 CONFIDENCE LIMIT = 0.09628466044 0.1051476805
LOWER TWO-SIDED NORMAL 0.90 AND 0.95 CONFIDENCE LIMIT = 3.715339564E¯3 ¯5.147680519E¯3

p1(hat)	s1(hat)	TEST90	TEST95	p2(hat)	s2(hat)	TEST90	TEST95
0.0333333	0.0209633	1	1	0.0829167	0.0300526	1	1
0.0500000	0.0261937	1	1	0.0162500	0.0159861	1	1
0.0658333	0.0305628	1	1	0.0333333	0.0209633	1	1
0.0333333	0.0215067	1	1	0.0333333	0.0209633	1	1
0.0500000	0.0261945	1	1	0.0829167	0.0306873	1	1
0.0000000	0.0000000	0	1	0.0662500	0.0300526	1	1
0.0333333	0.0209633	1	1	0.0500000	0.0207787	1	1
0.0829167	0.0339088	1	1	0.1162500	0.0296645	0	0
0.0495833	0.0263631	1	1	0.0829167	0.0306873	1	1
0.1000000	0.0324990	0	1	0.0333333	0.0209633	1	1
0.0666667	0.0284515	1	1	0.1000000	0.0266314	0	1
0.0333333	0.0223650	1	1	0.0662500	0.0300526	1	1
0.0166667	0.0159498	1	1	0.0333333	0.0207787	1	1
0.0000000	0.0000000	0	1	0.0500000	0.0261937	1	1
0.0166667	0.0126037	1	1	0.0662500	0.0263631	1	1

ATT. 1b.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1
[illegible]	[illegible]	1	1	0.0491667	0.0272272	1	1
0.0500000	0.0254480	1	1	0.0166667	0.0136037	1	1
0.0166667	0.0159498	1	1	0.0829167	0.0225821	1	1
0.0495833	0.0263631	1	1	0.0833333	0.0294515	1	1
0.0166667	0.0159499	1	1	0.0500000	0.0209633	1	1
0.0500000	0.0261945	1	1	0.0495833	0.0209909	1	1
0.0500000	0.0254480	1	1	0.0829167	0.0225821	1	1
0.0333333	0.0207787	1	1	0.0333333	0.0136037	1	1
0.0829167	0.0215534	1	1	0.0000000	0.0000000	0	1
0.0500000	0.0286314	1	1	0.1000000	0.0324990	0	1
0.0333333	0.0223850	1	1	0.0662500	0.0306873	1	1
0.0333333	0.0215067	1	1	0.0666667	0.0254480	1	1
0.0333333	0.0207787	1	1	0.0829167	0.0300526	1	1
0.0166667	0.0136037	1	1	0.0495833	0.0263631	1	1
0.0333333	0.0215067	1	1	0.0662500	0.0300526	1	1
0.0333333	0.0223850	1	1	0.0662500	0.0306873	1	1
0.0666667	0.0254480	1	1	0.0162500	0.0159861	1	1
0.0662500	0.0263631	1	1	0.0662500	0.0310611	1	1
0.0829167	0.0300526	1	1	0.0666667	0.0159498	1	1
0.0495833	0.0209909	1	1	0.0162500	0.0159861	1	1
0.0991667	0.0372622	0	1	0.0491667	0.0273683	1	1
0.0166667	0.0159498	1	1	0.0495833	0.0263631	1	1
0.0500000	0.0249885	1	1	0.0333333	0.0223850	1	1
0.1000000	0.0261937	0	1	0.0495833	0.0263631	1	1
0.0666667	0.0157065	1	1	0.0833333	0.0324990	1	1
0.0333333	0.0207787	1	1	0.0000000	0.0000000	0	1
0.0500000	0.0254480	1	1	0.0491667	0.0272272	1	1
0.0500000	0.0207787	1	1	0.0162500	0.0159861	1	1
0.0500000	0.0249885	1	1	0.0700000	0.0271895	1	1
0.0500000	0.0254480	1	1	0.0825000	0.0337968	1	1
0.0000000	0.0000000	0	1	0.0162500	0.0159861	1	1
0.1166667	0.0342318	0	0	0.0833333	0.0207777	1	1
0.0500000	0.0254480	1	1	0.0500000	0.0207787	1	1
0.0666667	0.0299041	1	1	0.0329167	0.0224109	1	1
0.0166667	0.0159498	1	1	0.0000000	0.0000000	0	1
0.0166667	0.0136037	1	1	0.0162500	0.0159861	1	1
0.0333333	0.0209633	1	1	0.0333333	0.0223850	1	1
0.0333333	0.0207787	1	1	0.0333333	0.0207787	1	1
0.0500000	0.0254480	1	1	0.0495833	0.0263631	1	1
0.0666667	0.0295156	1	1	0.0500000	0.0261945	1	1
0.0333333	0.0209633	1	1	0.0833333	0.0299048	1	1
0.0333333	0.0209633	1	1	0.0500000	0.0209633	1	1
0.0500000	0.0254480	1	1	0.0000000	0.0000000	0	1
0.0500000	0.0254480	1	1	0.1325000	0.0346967	0	0
0.0333333	0.0215067	1	1	0.0166667	0.0159498	1	1
0.0333333	0.0136037	1	1	0.0333333	0.0136037	1	1
0.0166667	0.0136037	1	1	0.0333333	0.0209633	1	1
0.0166667	0.0136037	1	1	0.0829167	0.0306873	1	1
0.0666667	0.0295148	1	1	0.0500000	0.0254480	1	1
0.0166667	0.0157065	1	1	0.0825000	0.0304365	1	1
0.0333333	0.0215067	1	1	0.0825000	0.0222402	1	1
0.0333333	0.0207777	1	1	0.0491667	0.0272272	1	1
0.0833333	0.0295156	1	1	0.0500000	0.0254480	1	1
0.0000000	0.0000000	0	1	0.0666667	0.0159498	1	1
0.0166667	0.0157065	1	1	0.0166667	0.0159498	1	1
0.0833333	0.0324990	1	1	0.0333333	0.0209633	1	1
0.0500000	0.0261945	1	1	0.0833333	0.0299048	1	1
0.0500000	0.0261945	1	1	0.0495833	0.0275072	1	1
0.0662500	0.0295353	1	1	0.0000000	0.0000000	0	1
0.0166667	0.0157065	1	1	0.0833333	0.0215067	1	1
0.0500000	0.0254480	1	1	0.0829167	0.0335668	1	1
0.0333333	0.0136037	1	1	0.0166667	0.0157065	1	1
0.0333333	0.0215067	1	1	0.0666667	0.0333775	1	1

0.0333333	0.0215067	1	1	0.0333333	0.0209633	1	1
0.0666667	0.0299048	1	1	0.0495833	0.0262166	1	1
0.0662500	0.0300526	1	1	0.0000000	0.0000000	0	1
0.0333333	0.0209633	1	1	0.0991667	0.0333377	0	1
0.0666667	0.0295156	1	1	0.0166667	0.0136037	1	1
0.0166667	0.0159498	1	1	0.0500000	0.0207787	1	1
0.0500000	0.0266314	1	1	0.0829167	0.0335668	1	1
0.0500000	0.0209633	1	1	0.0658333	0.0260708	1	1
0.0495833	0.0262166	1	1	0.0495833	0.0209909	1	1
0.0995833	0.0362179	0	1	0.0662500	0.0300526	1	1
0.0666667	0.0284515	1	1	0.0666667	0.0159498	1	1
0.0333333	0.0223850	1	1	0.0658333	0.0260708	1	1
0.0500000	0.0266314	1	1	0.0325000	0.0222402	1	1
0.0500000	0.0207787	1	1	0.0495833	0.0267973	1	1
0.0333333	0.0207787	1	1	0.0333333	0.0207787	1	1
0.0662500	0.0306873	1	1	0.0829167	0.0300526	1	1
0.0500000	0.0254480	1	1	0.0166667	0.0159498	1	1
0.0829167	0.0335660	1	1	0.0166667	0.0136037	1	1
0.0500000	0.0266314	1	1	0.0000000	0.0000000	0	1

ATT. 2
SAND BED EXCLUDED

SUBSET4SIM
THE NUMBER OF SUBSETS ns = 5.
SUBSET 1 = drip zone and sandbed: WORST
SUBSET 2 = drip zone only: VERY BAD
SUBSET 3 = sand bed: BAD
SUBSET 4 = rest of the sphere: GOOD
SUBSET 5 = cylinder: BEST
THE number OF PANELS IN SUBSETS 1,2,3,4,5 IS 5 20 15 52 8
THE total number OF PANELS = 100
ASSUME: TOTAL NUMBER OF 6X6 SAMPLE UNITS IS identical FOR EACH PANEL.
THE NUMBER OF UNITS PER PANEL nu = 600.
THE total number OF UNITS = 60,000.
THE number OF UNITS IN SUBSETS 1,2,3,4,5 IS 3000 12000 9000 31200 4800
ENTER q = Pr(bad unit): A CHARACTERIZATION OF THE ENTIRE POPULATION.
0:
0.05

SUBSET DISTRIBUTION no. 1:
0.2524487529
0.1262243765
0.0631121882
0.0050489751
0.0005048975
SUBSET DISTRIBUTION no. 2:
0.3924646782
0.0784929356
0.0392464678
0.0156985871
0.0078492936

PROPORTION P1 = 0.05015
PROPORTION P2 = 0.05103333333

sampling without replacement

THE NUMBER OF PANELS TO BE SAMPLED FOR subsets 1 - 5 = 3,12,9,32,4.
THE BOTTOM HALF OF THE PANELS IN subsets 1 AND 5 ARE EXCLUDED,
IF AND ONLY IF THEY ARE RANDOMLY SELECTED.

CONDITIONAL PROPORTION P1 = 0.04312962963
CONDITIONAL PROPORTION P2 = 0.04181481481

MAXIMUM OF THE ESTIMATES: 0.1203703704 1 1 58 0.1226851852 1 1
MINIMUM OF THE ESTIMATES: 0 0 0 49 0 0 0
AVERAGE OF THE ESTIMATES: 0.04425562169 0.94 0.97 53.9 0.04344973545 0.94 0.95
STD DEV OF THE ESTIMATES: 0.02582932443 0.2386832566 0.171446608 1.702642035 0.02656310082 0.2386832566 0.2190429136

UPPER TWO-SIDED NORMAL 0.90 AND 0.95 CONFIDENCE LIMIT FOR CASE 1 =
0.08627206874 0.09453338687
LOWER TWO-SIDED NORMAL 0.90 AND 0.95 CONFIDENCE LIMIT FOR CASE 1 =
¯1.280948283E¯5 ¯8.274127611E¯3
UPPER TWO-SIDED NORMAL 0.90 AND 0.95 CONFIDENCE LIMIT FOR CASE 2 =
0.08492373684 0.09246374318
LOWER TWO-SIDED NORMAL 0.90 AND 0.95 CONFIDENCE LIMIT FOR CASE 2 =
¯6.941072068E¯4 ¯8.034113331E¯3

p1(hat)	TEST90	TEST95	no. sampled	p2(hat)	TEST90	TEST95
0.0689815	1	1	54	0.0685185	1	1
0.0365741	1	1	54	0.0185185	1	1
0.0365741	1	1	55	0.0370370	1	1
0.0000000	1	1	51	0.0180556	1	1
0.0643519	1	1	53	0.1226852	0	0
0.0759259	1	1	53	0.0185185	1	1

ATT. 2

0.0351852	1	1	55	0.0685185	1	1
0.0555556	1	1	51	0.0277778	1	1
0.0995370	0	0	53	0.0462963	1	1
0.0629630	1	1	54	0.0921296	0	1
0.0638889	1	1	51	0.0828704	1	1
0.0370370	1	1	56	0.0277778	1	1
0.0629630	1	1	53	0.0277778	1	1
0.0856481	1	1	52	0.0277778	1	1
0.0000000	1	1	52	0.0736111	1	1
0.0736111	1	1	50	0.0643519	1	1
0.0185185	1	1	54	0.0370370	1	1
0.0324074	1	1	55	0.0490741	1	1
0.0509259	1	1	55	0.0458333	1	1
0.0462963	1	1	54	0.0185185	1	1
0.0324074	1	1	55	0.0361111	1	1
0.0393519	1	1	53	0.0361111	1	1
0.0555556	1	1	55	0.0550926	1	1
0.0185185	1	1	54	0.0555556	1	1
0.0370370	1	1	53	0.0643519	1	1
0.0370370	1	1	55	0.0462963	1	1
0.0138889	1	1	56	0.0365741	1	1
0.0550926	1	1	54	0.0365741	1	1
0.0277778	1	1	49	0.1009259	0	0
0.0648148	1	1	54	0.0277778	1	1
0.0416667	1	1	52	0.0462963	1	1
0.0393519	1	1	53	0.0638889	1	1
0.0000000	1	1	54	0.0689815	1	1
0.0319444	1	1	55	0.0555556	1	1
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0.0578704	1	1	54	0.0324074	1	1
0.0643519	1	1	54	0.0462963	1	1
0.0925926	0	1	54	0.0458333	1	1
0.0717593	1	1	54	0.0504630	1	1
0.0740741	1	1	54	0.0277778	1	1
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0.0555556	1	1	57	0.0185185	1	1
0.0648148	1	1	57	0.0601852	1	1
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0.0555556	1	1	54	0.0277778	1	1
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0.0185185	1	1	55	0.0138889	1	1
0.0277778	1	1	52	0.0833333	1	1
0.0555556	1	1	54	0.0185185	1	1
0.0185185	1	1	54	0.0555556	1	1
0.0185185	1	1	54	0.0833333	1	1
0.0767196	1	1	55	0.0458333	1	1
0.0347222	1	1	54	0.0319444	1	1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ATT. 2

0.0347222	1	1	54	0.0319444	1	1
0.0185185	1	1	53	0.0000000	1	1
0.0787037	1	1	55	0.1046296	0	0
0.0578704	1	1	54	0.0319444	1	1
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0.0166667	1	1	54	0.0000000	1	1
0.0185185	1	1	53	0.0185185	1	1
0.0740741	1	1	51	0.0458333	1	1
0.0185185	1	1	54	0.0000000	1	1
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0.0537037	1	1	55	0.0370370	1	1
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0.0370370	1	1	52	0.0185185	1	1
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0.0324074	1	1	54	0.0324074	1	1
0.0000000	1	1	55	0.0000000	1	1
0.0555556	1	1	53	0.0615741	1	1
0.0370370	1	1	54	0.0833333	1	1
0.0925926	0	1	52	0.0689815	1	1
0.0289352	1	1	58	0.0319444	1	1
0.0388889	1	1	55	0.0185185	1	1
0.0458333	1	1	54	0.0462963	1	1
0.1203704	0	0	51	0.0185185	1	1
0.0722222	1	1	54	0.0458333	1	1
0.0000000	1	1	53	0.0939815	0	0
0.0324074	1	1	54	0.0324074	1	1
0.0000000	1	1	51	0.0462963	1	1
0.0555556	1	1	53	0.0185185	1	1
0.0509259	1	1	52	0.0000000	1	1

ATT. 3

NON-STRATIFIED

SIMPSIM
ASSUME: TOTAL NUMBER OF 6x6 SAMPLE UNITS IS identical FOR EACH PANEL.
THE NUMBER OF UNITS PER PANEL nu = 600.
THE total number OF UNITS = 60,000.
ENTER ε = Pr(bad unit): A CHARACTERIZATION OF THE ENTIRE POPULATION.
0:
0.05

PROPORTION P1 = 0.05061666667

sampling without replacement

THE NUMBER OF PANELS TO BE SAMPLED IS 60.
THE BOTTOM HALF OF THE PANELS IN THE SAND BED (20 PANELS) ARE EXCLUDED, IF AND ONLY IF THEY ARE RANDOMLY SELECTED.

CONDITIONAL PROPORTION P1 = 0.05096296296

MAXIMUM OF THE ESTIMATES: 0.1346153846 1 1 55
MINIMUM OF THE ESTIMATES: 0 0 0 44
AVERAGE OF THE ESTIMATES: 0.0470419326 0.83 0.95 49.77
STD DEV OF THE ESTIMATES: 0.03059222548 0.3775251681 0.2190429136 2.407291113

UPPER TWO-SIDED NORMAL 0.90 AND 0.95 CONFIDENCE LIMIT FOR CASE 1 =
0.09766751304 0.1066109375
LOWER TWO-SIDED NORMAL 0.90 AND 0.95 CONFIDENCE LIMIT FOR CASE 1 =
4.258412886E¯3 ¯4.685011597E¯3

p1(hat)	TEST90	TEST95	no. sampled
0.0000000	0	1	51
0.0196078	1	1	51
0.0576923	1	1	52
0.0212766	1	1	47
0.0000000	0	1	49
0.0196078	1	1	51
0.0392157	1	1	51
0.0188679	1	1	53
0.0377358	1	1	53
0.0000000	0	1	48
0.0196078	1	1	51
0.0200000	1	1	50
0.0612245	1	1	49
0.0566038	1	1	53
0.0408163	1	1	49
0.0980392	0	1	51
0.0600000	1	1	50
0.0833333	1	1	48
0.1346154	0	0	52
0.0408163	1	1	49
0.0000000	0	1	52
0.0425532	1	1	47
0.0600000	1	1	50
0.0425532	1	1	47
0.0384615	1	1	52
0.0208333	1	1	48
0.0588235	1	1	51
0.0784314	1	1	51
0.0566038	1	1	53
0.1086957	0	0	46
0.0384615	1	1	52
0.0392157	1	1	51
0.0576923	1	1	52
[illegible]	[illegible]	[illegible]	[illegible]

ATT. 1

[illegible]	1	1	51
0.0377358	1	1	53
0.0576923	1	1	52
0.0833333	1	1	48
0.0800000	1	1	50
0.0400000	1	1	50
0.0416667	1	1	48
0.0639298	1	1	47
0.[illegible]200000	1	1	50
0.0384615	1	1	52
0.0612245	1	1	49
0.[illegible]41667	[illegible]	1	48
0.0576923	1	1	52
0.0196078	1	1	51
0.0566038	1	1	53
0.0370370	1	1	54
0.0217391	1	1	46
0.0000000	0	1	50
0.0188679	1	1	53
0.0384615	1	1	52
0.0612245	1	1	49
0.0400000	1	1	50
0.0851064	1	1	47
0.1200000	0	0	50
0.0588235	1	1	51
0.0638298	1	1	47
0.0000000	0	1	49
0.0612245	1	1	49
0.0384615	1	1	52
0.0833333	1	1	48
0.0196078	1	1	51
0.0566038	1	1	53
0.0555556	1	1	54
0.0204082	1	1	49
0.0425532	1	1	47
0.0000000	0	1	54
0.0444444	1	1	45
0.0833333	1	1	48
0.0888889	1	1	45
0.0192308	1	1	52
0.0212766	1	1	47
0.0638298	1	1	47
0.0625000	1	1	48
0.0566038	1	1	53
0.0784314	1	1	51
0.0816327	1	1	49
0.1224490	0	0	49
0.0227273	1	1	44
0.0000000	0	1	49
0.0600000	1	[illegible]	50
0.0833333	1	1	48
0.0000000	0	[illegible]	50
0.0196078	1	1	51
0.0000000	0	1	47
0.0769231	1	1	52
0.0196078	1	1	51
0.0222222	1	1	45
0.0434783	1	1	46
0.0208333	1	1	48
0.0400000	1	1	50
0.0181818	1	1	55
0.0212766	1	1	47
0.0384615	1	1	52
0.1111111	0	0	45
0.0816327	1	1	49
0.0638298	1	1	47

Nuclear

GPU Nuclear Corporation
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Parsippany, New Jersey 07054
201-316-7000
TELEX 136-482
Writer's Direct Dial Number:

December 5, 1990
5000-90-1995
C320-90-302

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

Gentlemen:

Subject: Oyster Creek Nuclear Generating Station (OCNGS)
Docket No. 50-219
License No. DPR-16
Oyster Creek Drywell Containment

References: (1) NRC Letter dated October 16, 1990 - Requested Clarifications.
(2) GPUN Letter dated November 26, 1990 - Drywell Inspection/Sampling Plan.

This letter, together with the Reference (2) submittal, completes the response to the Reference (1) request for clarifications on the drywell corrosion issue.

The attachments to this letter address Reference (1), Items ii to iv, which correspond to Reference (2), Items (2) to (4).

Attachment I to this letter provides the information requested by the NRC for Item (2). This attachment consists of GE/Teledyne Report TR-7377-1 "Justification for Use of Section III Subsection NE Guidance in Evaluating the Oyster Creek Drywell." This report provides the technical justification for using ASME Section III NE guidance for the evaluation of membrane stress intensities which are between 1.0Smc and 1.1Smc.

Attachment II to this letter provides the information requested by the NRC for Item (3). This attachment consists of GE Reports Index No. 9-1 and 9-2, "An ASME Section VIII Evaluation of the Oyster Creek Drywell Stress and Stability Analysis." This two part report covers the structural analysis of the Oyster Creek drywell through the 14R outage with the current sand-in-place configuration and the sandbed portion of the drywell conservatively assumed corroded to 0.700". This report confirms the adequacy of the Oyster Creek drywell shell utilizing ASME Section III guidance to demonstrate ASME Section VIII Code compliance.

Attachment III to this letter provides the information requested by the NRC for Item (4). This attachment consists of a detailed summary of the actions GPUN has undertaken to identify and prevent water intrusion into the drywell gap and addresses the effects of leakage on structures and equipment other than the drywell.

In addition to providing the requested Reference (1) clarification documentation, GPUN is proceeding with the analysis, engineering and planning to support removal of sand from the drywell sandbed region. Since our meeting with you on September 19, 1990, corrosion testing studies have reinforced our conviction that this will be a key step in arresting corrosion in that region. The technical evaluation supporting sand removal is well underway and the structural calculations are expected to be completed in December. Assuming satisfactory results, we plan to submit this structural analysis to you by December 31, 1990.

If you have any questions on this submittal or the overall drywell corrosion program, please contact Mr. Michael Laggart, Manager, Corporate Nuclear Licensing at (201) 316-7968.

Very truly yours,

J. C. DeVine, Jr.
Vice President, Technical Functions

JCD/RZ/plp
Attachments

cc: Administrator, Region I
NRC Resident Inspector
Mr. Alex Dromerick, Jr.

LIST OF ATTACHMENTS

ATTACHMENT I	GE/Teledyne Report TR-7377-1, "Justification for use of Section III Subsection NE Guidance in Evaluating the Oyster Creek Drywell."
ATTACHMENT II	GE Reports Index No. 9-1 and 9-2, "An ASME Section VIII Evaluation of the Oyster Creek Drywell Stress and Stability Analysis."
ATTACHMENT III	GPUN Detailed Summary Addressing Water Intrusion and Leakage Effects.

C320302

ATTACHMENT III

GPUN Detailed Summary Addressing Water Intrusion and Leakage Effects Related to the Oyster Creek Drywell

C320302

WATER INTRUSION

The following describes GPUN past actions to investigate, identify, and correct leak paths into the drywell gap, as well as our planned future actions to prevent and survell potential leakage. The issues discussed below occurred from 1985 to date. Actions taken to address the impact of leakage on other structures and equipment are also described.

1. **REFUELING CAVITY**

a) Liner

The stainless steel liner was inspected both by visual and dye penetrant methods. A significant number of cracks were found as well as some through-wall damage, most probably caused by mechanical impact. As a result, an analysis was performed for determining the failure mechanism (i.e., IGSCC, fatigue, etc.) and it was determined that the cracking was mechanically induced and not IGSCC induced. The most probable cause was thermal fatigue. (A sample was removed from the liner and metallurgically examined.)

To prevent leakage through these cracks during refueling, we install an adhesive type stainless steel tape to bridge any large cracks observed, and subsequently, apply a strippable coating. Both the tape and the coating have been qualified by GPUN and vendor for use in the environment that they normally see. This method of repair is temporary (refueling only) and both the tape and coating are removed prior to the end of the outage. No leakage concerns exist at any other times since the cavity is dry.

b) Bellows

The bellows allow for expansion between the drywell and the refueling cavity and are made of stainless steel. They were repeatedly tested using helium (external) and air (internal) without any indication of leakage. Any leaks from the refueling bellows would wind up in the concrete trough, which has a leakage detection/collection system. No leakage has been observed for the last two refuelings.

c) Piping Drains

There are two drain lines from the cavity that allow for water removal from the cavity and trough. They have been pressure tested with no evidence of leakage.

d) Metal Trough

The metal trough is located between the drywell and the reactor building. It was tested visually and with helium without any positive leaks identified.

A gasket at the drain line from the trough was replaced. However, no clear leakage path was identified from this source. This portion of the cavity is coated during refueling with strippable coating.

e) Concrete Trough

The concrete trough is located under the metal trough and is designed to collect any leakage from the bellow area and direct it to a drain. This area was inspected by removing the drain plate attachment to the metal trough and visually inspected, using remote video. An area where concrete was found to be chipped was repaired and the drainage capability restored. No further problems are known to exist.

f) Steps (Stainless Steel Liner)

These are the steps that receive the shield plugs and plugs from the fuel pool to the cavity and cavity to equipment pool gates. These steps were examined visually and by PT with no indications of cracking. These steps will also be periodically coated during refueling.

g) Skimmer

The skimmer system is designed to maintain water clarity in the cavity. It consists of ducts and piping connected to the liner with most of the ducting and piping encased in concrete. A pressure test was performed in the skimmer system and as a result, some skimmers are removed from service by plugging them prior to each refueling.

In conclusion, we believe that all potential water leakage pathways from the refueling cavity into the drywell gap have been thoroughly checked and the continuation of our current tape/strippable coating method during future refueling outages is adequate for prevention of leakage from this source.

2. EQUIPMENT POOL

a) Liner

The liner was inspected both visually and dye penetrant tested, with any PT indications vacuum box checked. No through wall leakage was found. Additionally, the equipment pool has a leak detection system under the welds in the plate which is routed to drains. Any leaks into the collection system would not reach the drywell. While the leak detection system indicated leakage, no liner leaks were found.

Preventively, the equipment pool will be taped using the SS tape and then coated with a strippable coating prior to the refueling outage, further reducing the probability of leakage.

b) Drain

The drain was checked for leaks via pressure test and found to be leak free.

c) Support Pad

Concerns with the pad to liner welds arose. As a result, the pad was removed and the liner weld area checked prior to replacing the pad. No leakage was identified.

In conclusion, no leaks have been found related to the equipment pool. Preventively, the equipment pool will be protectively coated similar to the refueling cavity. Drains from the leak detection system are monitored on a periodic basis to detect any changes.

3. FUEL POOL

The fuel pool has a leak detection system similar to the equipment pool. The leak detection is for all welded joints in the stainless steel liner. Minor leakage (dripping) has been noted over the years at infrequent intervals, even though the pool is continuously flooded. Leakage or condensation has been postulated as the source. Additionally, in 1985 while reracking the pool, a leak was found. As a result, vacuum testing was performed to find the leak and underwater divers were used to confirm the leak location and to repair the leak. No further problems were encountered. Ongoing monitoring of the leak detection ensures early leakage detection.

4. PIPING PENETRATIONS

Piping that is buried in concrete and whose leakage could become a leak path to the drywell gap was investigated. The piping penetrating the drywell was not investigated since it was either tested as part of 10 CFR 50 Appendix J or any significant leakage would be detected as part of operability/system operation.

Other piping such as the drains from the cavity and equipment pool are discussed above.

In conclusion, no leakage is expected from the buried piping or piping penetrating the drywell.

5. WALKDOWNS FOR VISUAL LEAKAGE

Walkdowns are periodically conducted to identify any leakage in the Reactor Building wall, under the two pools, and on the drywell wall. While minor staining can be seen, samples of water were obtained (sand bed, drywell wall, etc.) and analyzed without being conclusive as being reactor refueling water.

6. SAND BED DRAINS

In the sand bed region of the drywell, there are five sand bed drains equally spaced around the drywell. Some of these drains were known to drip/leak. When cathodic protection was installed, water was observed coming out of the CP holes. As a result, every effort to remove any water entrapped in the sand bed was initiated. The five drains were cleared using a "roto-rooter" approach and approximately 500 gallons of water were removed. Presently, the drains are not leaking and preventive maintenance to clear the drains periodically has been initiated. A routine walkdown to identify changes in leakage is in place.

In conclusion, while the sand was retaining water due to blockage of the drains, after clearing the drains, the sand bed area appears to be free of water.

As a result of the above described approach to identify and correct potential water source leak paths and our ongoing program for surveillance for water intrusions, as discussed in the presentations made to the NRC on September 19, 1990 and the NRC site visit and inspection on October 29-31, 1990, we believe we have a thorough program for managing leakage that could affect drywell integrity.

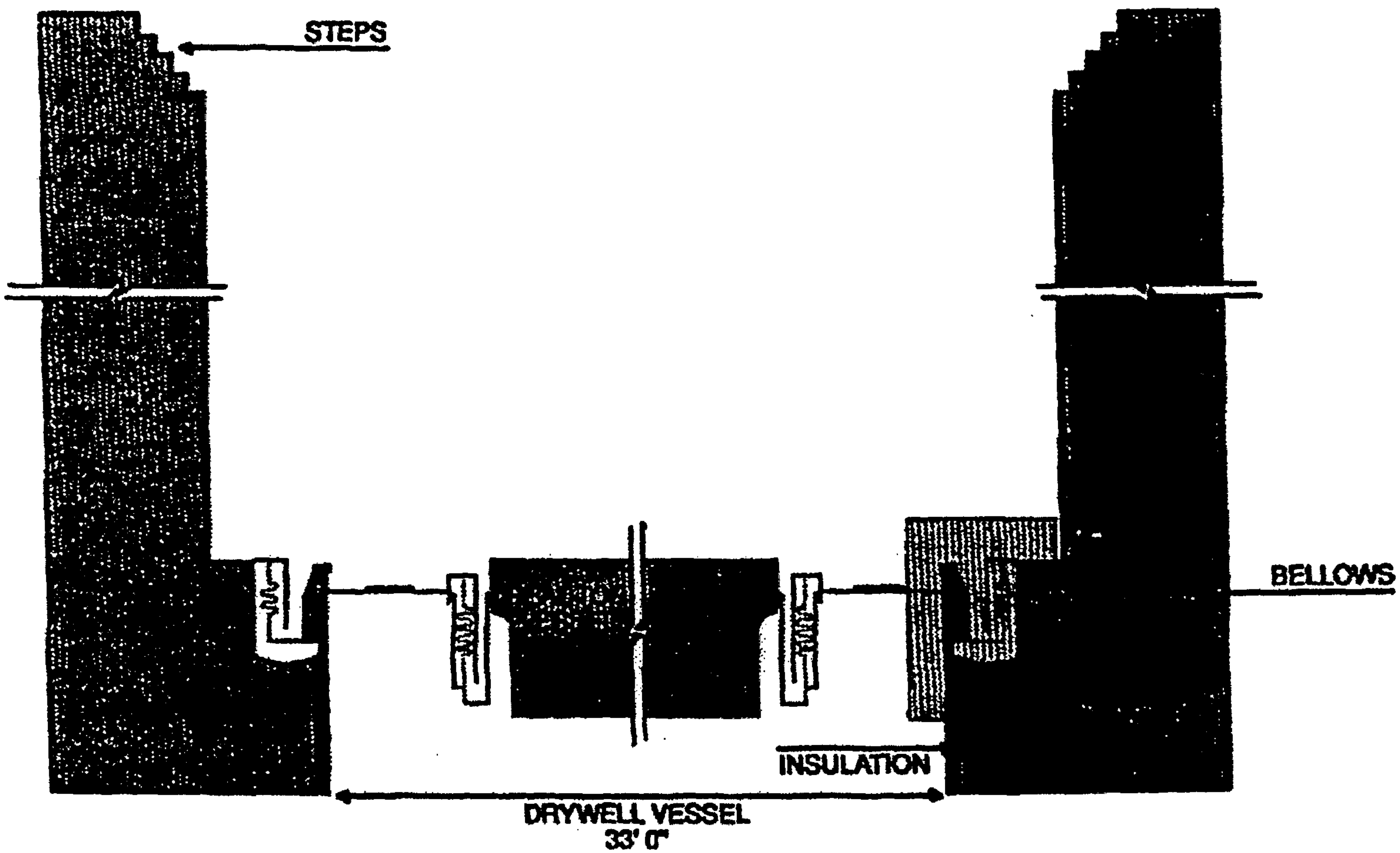
In addition to the efforts described above, actions have also been taken to address the potential impact of leakage on other structures and equipment. These actions are described below.

Cracks have been identified in the concrete walls and floor of the spent fuel pool and equipment pool. These cracks are routinely inspected and monitored for changes in size and condition. Numerous analyses have been performed which conclude that the identified cracking does not degrade the ability of the building to perform its intended function.

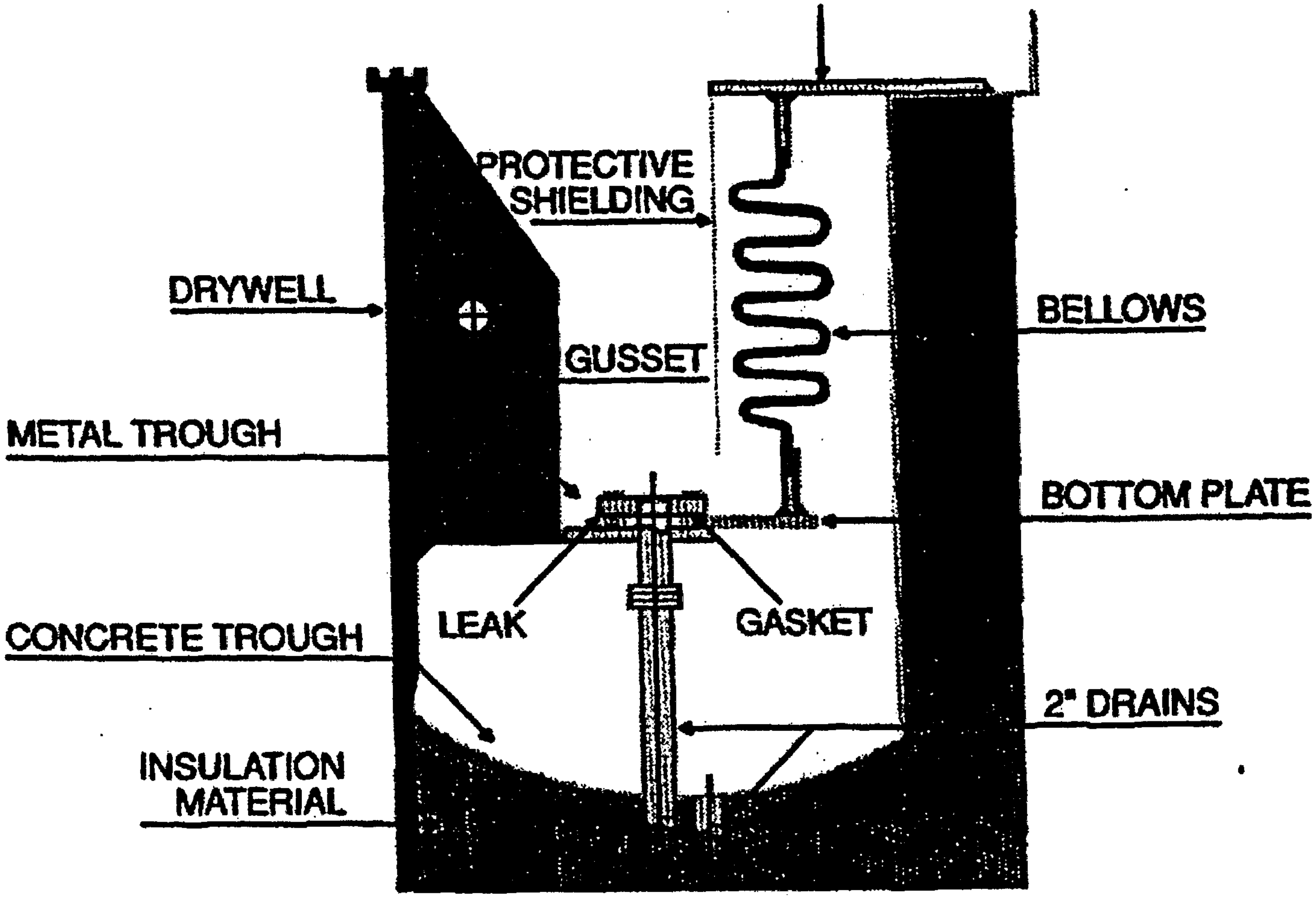
Inspections of these cracks indicate no evidence of leakage around or under the spent fuel pool. Evidence of leakage has been observed in both the floor and wall of the equipment pool and in the reactor cavity wall above elevation 95'-0". Based on visual inspections, this leakage has not affected any equipment. The water stains observed on the underside of the equipment pool contain no evidence which would indicate reinforcing bar corrosion. In addition, visual inspections indicate no general concrete degradation associated with these cracks.

Stains on the equipment pool and reactor cavity walls above elevation 95'-0" do indicate slight corrosion of the reinforcing bar. To determine the potential effect of this corrosion, a compositional analysis of a representative concrete core sample was performed in October, 1989. This analysis indicates that the diameter of a typical reinforcing bar could be expected to be reduced by 0.002 inch/year. The walls in question are reinforced with #8 and #11 reinforcing bar. Therefore, if the corrosion continues, the diameter of the reinforcing bar would be reduced by 8% and 6% respectively over a 40-year period. Since the corrosion is localized, this reduction has no impact on concrete integrity.

TOP OF REACTOR VESSEL



DRYWELL TO CAVITY SEAL



Nuclear

GPU Nuclear Corporation
One Upper Pond Road
Parsippany, New Jersey 07054
201-316-7000
TELEX 136-482
Writer's Direct Dial Number:

November 26, 1990
5000-90-1993
C320-90-264

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

Gentlemen:

Subject: Oyster Creek Nuclear Generating Station (OCNGS)
Docket No. 50-219
License No. DPR-16
Oyster Creek Drywell Containment

References: (1) NRC letter dated October 3, 1990 - Summary of September 19, 1990 meeting

(2) NRC letter dated October 16, 1990 - Requested Clarifications

On Wednesday, September 19, 1990, a meeting was held with the NRC at the NRC offices, One White Flint North, Rockville, Maryland. The purpose of this meeting was to discuss GPUN's overall plan to address the drywell corrosion issue at the Oyster Creek Nuclear Generating Station. The Reference (1) letter documents the participants, morning and afternoon presentations and summarizes the significant items discussed.

The NRC requested detailed supplemental information supporting GPUN's assessment be submitted no later than December 31, 1990.

The requested information specified by Reference (2) consists of the following four (4) items:

(1) Drywell Inspection Plan Details (original and augmented) which includes justification of Sampling Techniques and Statistical Methodology.

(2) Point-By-Point Code Comparison justifying ASME Section III, NE Methodology for the ASME Section VIII Drywell/Containment Vessel.

(3) Structural Design Report justifying operation to 14R refueling outage based on ASME Section III, NE Methodology using 62 psig as drywell design pressure.

(4) GPUN Actions to prevent leakage into the drywell gap and the effects of leakage on other structures or equipment.

In order to expedite NRC review of the requested information, individual submittals will be provided as the documentation of each item is finalized.

Attachment I to this letter provides the information requested by the NRC for Item (1) and includes a brief summary of the overall drywell inspection plan and the following technical documentation.

- GPUN TDR 948, Rev. 1, "Statistical Analysis of Drywell Thickness Data."
- GPUN Specification IS-328227-004, Rev. 8, "Functional Requirements for Drywell Containment Vessel Thickness Examination."
- GPUN Calculation C-1302-187-5300-011, Rev. 0, "Statistical Analysis of Drywell Thickness Data from 4/24/90" (Appendices 6.1 to 6.3 not attached).
- GPUN TDR 1027, Rev. 1, "Design of a UT Inspection Plan for the Drywell Containment Using Statistical Inference Methods."
- GPUN Specification IS-402950-001, Rev. 0, "Functional Requirement for Augmented Drywell Inspection."

It is GPUN's goal to provide submittal items (2) through (4) as they become available but no later than December 31, 1990. GPUN will, of course, inform the NRC of any changes to the corrosion assessment which would compromise our technical justification for continued operation of the OCNGS.

If you have any questions on this submittal or the overall drywell corrosion program, please contact Mr. Michael Laggart, Manager, Corporate Nuclear Licensing at (201) 316-7968.

Sincerely,

J. C. DeVine, Jr.
Vice President, Technical Functions

JCD/RZ/plp
Attachment
cc's on next page

RZ:C320264

cc: Administrator
Region 1
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

NRC Resident Inspector
Oyster Creek Nuclear Generating Station
Forked River, NJ 08731

Project Manager
U.S. Nuclear Regulatory Commission
Mail Station P1-137
Washington, DC 20555

RZ:C320264

ATTACHMENT I

SUMMARY OF GPUN OVERALL

DRYWELL INSPECTION PLAN

The GPUN drywell inspection plan is separated in two portions. The first portion is an inspection program intended to determine corrosion rates which are utilized to develop conservative projections.

In this portion of the program, UT inspections are performed over time at the same specific locations. The inspections are performed during outages of opportunity when a drywell entry is made for reasons other than program inspections. 20 priority #1 locations are inspected not more frequently than 3 months, and 7 priority #2 locations are inspected not more frequently than 18 months. These inspection locations were identified during detailed inspection of elevations 11'-3", 50'-2", 51'-10" and 87-5" conducted in 1986, 1987 and 1990. During the 13R outage, GPUN will perform inspection of all priority #1 locations, once at the beginning of the outage and once at the end of the outage. Included in this attachment are copies of the GPUN internal reports which provide details of data collection and data reduction, as well as the most recent results for inspection up to April 1990. Also provided is Specification IS-328227-004, Rev. 8 which presents functional requirements for inspection implementation.

The second portion of the program will be implemented for the first time during the 13R outage and is intended to statistically confirm required drywell thicknesses. This portion of the program relies on UT inspection of 57, 6 x 6 inch randomly chosen locations. The resulting inspection data will characterize the condition of the upper elevations of the drywell.

As part of this Attachment are copies of a GPUN Report which provides details of how the amount and the location of the 57 inspection locations were determined and Specification IS-402950-001 which presents functional requirements for this augmented inspection implementation in 13R.

ATTACHMENT I (CONTINUED)
TECHNICAL DOCUMENTATION

- GPUN TDR 948, Rev. 1, "Statistical Analysis of Drywell Thickness Data."
- GPUN Specification IS-328227-004, Rev. 8, "Functional Requirements for Drywell Containment Vessel Thickness Examination."
- GPUN Calculation C-1302-187-5300-011, Rev. 0, "Statistical Analysis of Drywell Thickness Data from 4/24/90" (Appendices 6.1 to 6.3 not attached).
- GPUN TDR 1027, Rev. 1, "Design of a UT Inspection Plan for the Drywell Containment Using Statistical Inference Methods."
- GPUN Specification IS-402950-001, Rev. 0, "Functional Requirement for Augmented Drywell Inspection."

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AN ASME SECTION VIII EVALUATION OF OYSTER CREEK DRYWELL FOR WITHOUT SAND CASE PART I STRESS ANALYSIS

February 1991

prepared for

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AN ASME SECTION VIII EVALUATION OF OYSTER CREEK DRYWELL FOR WITHOUT SAND CASE

PART I

STRESS ANALYSIS

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1. INTRODUCTION

1.1 Background

The Oyster Creek Nuclear Generating Station utilizes a GE BWR Nuclear Steam Supply System and a steel Mark I pressure suppression type containment vessel system. The pressure suppression system consists of a drywell, a pressure suppression chamber (torus) which stores a large volume of water and a connecting vent system between the drywell and the water pool. The drywell, sometimes referred to as the containment vessel or containment structure, houses the reactor vessel, reactor coolant recirculation loops, and other components associated with the reactor system.

Figure 1-1 shows the drywell along with the pertinent dimensions. The drywell is a combination of a sphere, cylinder and 2:1 ellipsoidal dome and it resembles an inverted light bulb. The spherical portion of drywell near the base includes a sandbed region that provides an elastic transition zone which is intended to ameliorate abrupt thermal and mechanical discontinuities. The pressure suppression system was designed, analyzed and constructed by Chicago Bridge & Iron Company (CBI).

A recent inspection of the steel shell (November 1986) prior to restart from the 11R outage in the sandbed region revealed that some degradation of the shell had taken place during the years since completion of construction. Subsequent inspections also indicated minor thickness degradations in the upper spherical and cylindrical sections of the drywell.

A detailed description of the previous analyses pertaining to Oyster Creek drywell is given in Reference 1-1. An ASME Code stress analysis addressing the drywell thickness degradation is documented in Reference 1-2. The analyses in Reference 1-2 are based on the present configuration in the sandbed region, i.e., it is assumed that the sand is present. One of the option GPUN is exploring to mitigate further corrosion in the sandbed region, is to remove the sand. The purpose of the stress analyses presented in this report is to evaluate the drywell per ASME Section VIII for this modification.

1.2 Supplementary Code Stress Analyses

The Code of record for the stress analysis of Oyster Creek drywell is Section VIII, 1962 Edition and Nuclear case interpretations 1270 N-5, 1274 N-5 and 1272 N-5. The CBI stress report (Reference 1-3) augmented by the recent GE report (Reference 1-2) constitutes the Section VIII Code stress report of record for the drywell. The GE report is a supplementary stress report to the CBI stress report and addresses aspects of Code compliance as they relate to the local wall thinning observed in the Oyster Creek drywell. The stress analyses in this report as in the previous GE report [1-2] are guided by GPUN Technical Specification for primary containment analysis [1-4].

Based on the ultrasonic (UT) inspection results, the projected 95% confidence thickness value for the drywell shell in the sandbed region is 0.736 inch. However, in several previous Oyster Creek drywell analyses, as discussed in Reference 1-1, a conservative thickness value of 0.700 inch was used. A shell thickness of 0.700 inch in the sandbed region was used in the stress analyses documented in Reference 1-2.

In the first part of the stress analysis report of Reference 1-2, the nominal or as-designed thicknesses were assumed everywhere except in the sand bed region. The thickness in the sand bed region was assumed as 0.700 inch compared to the as-designed thickness of 1.154 inch. Later, the local thinning in areas other than the sand bed region of drywell was addressed. The second part of Reference 1-2 report addressed the buckling evaluation of drywell shell.

1.3 Scope of Present Analysis

The stress analyses described in this report address the case when the sand has been removed from the sandbed region (called the 'without sand case'). A companion report [1-5] addresses the buckling evaluation for this case.

The finite element models used in the Reference 1-2 analyses were modified for this case by removing the spring elements representing sand stiffness. It will be shown that this change affects only the stresses in the sandbed and adjacent region. The stresses in the other regions of the drywell are essentially unaffected.

1.4 Report Outline

Section 2 of the report describes the drywell geometry, materials, ASME Code allowables and load combinations used in the evaluation of applied stresses. Also discussed is the temperature gradient definition in the sand bed region under DBA conditions. Section 3 includes the details of drywell finite element analysis. Seismic load analyses are covered in Section 4.

Section 5 presents the Code stress evaluation results to meet the Code criteria. Finally, the summary and conclusions are discussed in Section 6. The Appendix includes calculated stresses from some of the unit load cases.

1.5 References

1-1 Yekta, M., "OC Drywell Structural Evaluations," GPUN Technical Data Report No. 926, Rev. 1, February 6,1989.

1-2 a. "An ASME Section VIII Evaluation of the Oyster Creek Drywell - Part 1 - Stress Analysis," GE Index # 9-1, DRF # 00664 (November 1990).

b. "An ASME Section VIII Evaluation of the Oyster Creek Drywell - Part 2 - Stability Evaluation," GE Index # 9-2, DRF # 00664 (November 1990).

1-3 "Structural Design of the Pressure Suppression Containment Vessels," by Chicago Bridge & Iron Co..Contract # 9-0971, 1965.

1-4 GPUN Specification SP-1302-53-044, Technical Specification for Primary Containment Analysis - Oyster Creek Nuclear Generating Station; Rev. 2, October 1990.

1-5 "An ASME Section VIII Evaluation of the Oyster Creek Drywell for Without Sand Case - Part 2 - Stability Evaluation," GE Index # 9-4, DRF # 00664 (February 1991).

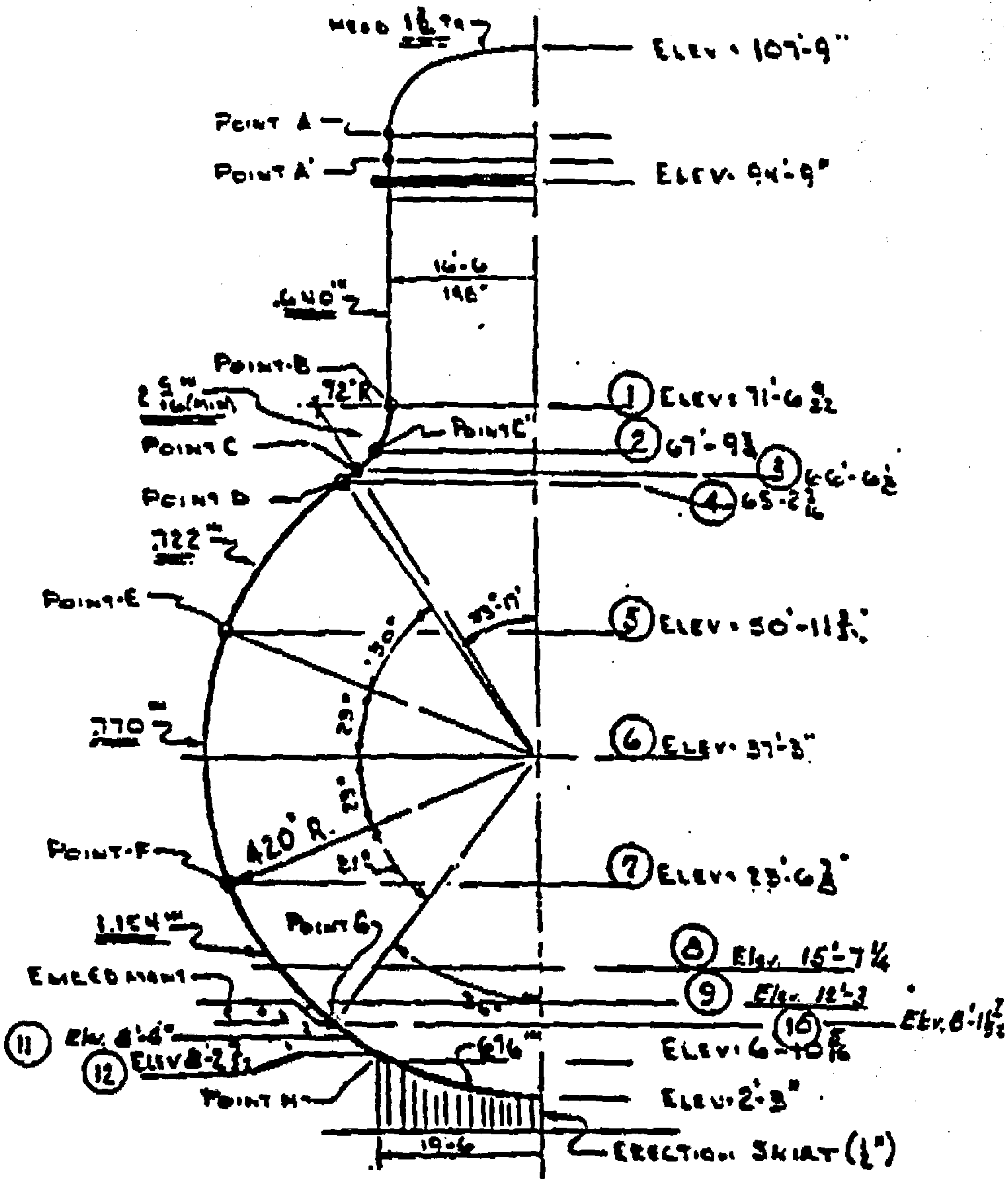

Figure 1-1 Drywell Configuration

2. ANALYSIS BASES

2.1 Drywell Geometry and Materials

The spherical section has an inside diameter of 70 ft. which intersects the 33 ft. diameter cylindrical portion. A transition knuckle is provided at the connection of the sphere to the cylinder (Figure 1-1). The drywell is 105'-6" high. The plate thicknesses vary from a maximum of 2.625 in. at the transition between the sphere and the cylinder down to a minimum of 0.640 in. in the cylinder. The head wall thickness is 1.188 in.

The head, which is 33 ft. in diameter, is made with a double tongue and groove seal which permits periodic checks for tightness. Ten vent pipes, 6'-6" in diameter, are equally spaced around the circumference to connect the drywell to the vent header inside the pressure suppression chamber.

The drywell interior is filled with concrete to elevation 10'-3" to provide a level floor. Concrete curbs follow the contour of the vessel up to elevation 12'-3" with cutouts around the vent lines.

On the exterior, the drywell is encapsulated in concrete of varying thickness from the base elevation up to the elevation of the top head. From there, the concrete continues vertically to the level of the top of the spent fuel pool.

The base of the drywell is supported on a concrete pedestal conforming to the curvature of the vessel. A structural steel skirt was first installed to provide interim support for the vessel during erection. A portion of the steel skirt was left in place which serves as one of the shear rings that provides horizontal restraint for the drywell during an earthquake.

The proximity of the biological shield concrete surface to the steel shell varies with the elevation. The concrete is in full contact with the shell over the bottom of the sphere at its invert elevation 2'-3" up to elevation 8'-11 1/4". At that point, the concrete is stepped back 15 inches radially to form a pocket which continues up to elevation 12'-3". That pocket is currently filled with sand which forms a cushion which is intended to smooth the transition of the shell plate from a condition of fully clamped between two concrete masses to a free standing condition. This sand filled pocket is referred to here as the sandbed. In the analyses described in this report it is assumed that the sand has been removed. Up from elevation 12'-3" there is a 3-inch gap between the drywell and the concrete biological shield wall which is filled with foam material that provides insulation but no structural support.

An upper lateral seismic restraint, attached to the cylindrical portion of the drywell at elevation 82'-6", allows for thermal, deadweight, and pressure radial deflection, but not for lateral movement due to seismic excitation. All penetrations for piping, instrumentation lines, vent ducts, electrical lines, equipment accesses, and personnel entrance have expansion joints and double seals where applicable.

The materials of construction for the drywell are given in Specification S-2299-4 [2-1]. The drywell shell, i.e., the sphere, cylinder, dome, and transitions, was constructed from SA-212, Grade B High Tensile Strength Carbon-Silicon Steel Plates for Boilers and other Pressure Vessels ordered to SA-300 specification.

The following steels were used in the construction of penetrations, reinforcements, and appurtenances:

SA-300 Steel Plates for Pressure Vessels for Service at Low Temperatures.

SA-333 Seamless and Welded Steel Pipe for Low Temperature Service.

SA-350 Forged or Rolled Carbon and Alloy Steel Flanges, Forged Fittings, and Valves and Parts for Low Temperature Service.

ASTM A-36 Structural Steel.

Table 2-1 shows the as-designed thicknesses used in the Code stress evaluation of the drywell shell [1-2]. Also shown in the same Table are the projected 95% confidence thickness values in the locally corroded areas [2-2]. These latter thicknesses are used in the primary stress evaluation presented in Subsection 5.2.

2.2 ASME Code Allowable Values

The Oyster Creek drywell vessel was designed, fabricated and erected in accordance with the 1962 Edition of ASME Code, Section VIII and Code Cases 1270N-5, 1271N and 1272N-5.

The Code Case 1272 N-5 limits the general membrane stresses to 1.1 times the allowable stress values given in Table UCS-23 of Section VIII. The combined general membrane, general bending, and local membrane stresses are limited to 1.5 times the general membrane stress allowables. Finally, the Code Case limits the sum of the primary plus secondary stresses to three times the allowable stresses given in Table UCS-23. The allowable stress value given in Table UCS-23 for SA 212, Grade B is 17500 psi. Accordingly, the allowable stress values for various categories of stresses are shown in Table 2-2.

The original Code of record and the Code Cases do not provide specific guidance in two areas. The first relates to the size of a region of increased membrane stress due to thickness reductions from local or general corrosion effects, and the second pertains to the allowable stresses for service level C or post-accident conditions. In the first case, guidance was sought from Subsection NE of Section III. The justification for the use of this guidance is provided in a report prepared by Dr. W.E. Cooper of Teledyne [2-5]. In the latter case, the Standard Review Plan document was used as guidance with details discussed in Reference 2-6. The allowable limits obtained are discussed next.

2.2.1 Thickness Reductions from Local Corrosion Effects

Consideration of local corrosion effects can be achieved by application of the requirements for Local Primary Membrane Stresses. A thorough discussion of this is presented in Reference 2-5. The discussion presented here is extracted from that reference.

The NE-3213.10 definition of Local Primary Membrane Stress is:

> Cases arise in which a membrane stress produced by pressure or other mechanical loading and associated with a primary or discontinuity effect produces excessive distortion in the transfer of load to other portions of the structure. Conservatism requires that such a stress be classified as local primary membrane stress even though it has some characteristics of a secondary stress. A stress region may be considered local if the distance over which the membrane stress intensity exceeds 1.1 S_{mc} does not extend in the meridional direction more than $1.0\sqrt{(Rt)}$, where R is the minimum midsurface radius of curvature and t is the minimum thickness in the region considered. Regions of local primary membrane stress intensity involving axisymmetric membrane stress distributions which exceed 1.1 S_{mc} shall not be closer in the meridional direction than $2.5\sqrt{(Rt)}$, where R is defined as $(R_1+R_2)/2$ and t is defined as $(t_1+t_2)/2$, where t_1 and t_2 are the minimum thicknesses at each of the regions considered, and R_1 and R_2 are the minimum midsurface radii of curvature at these regions where the membrane stress intensity exceeds 1.1 S_{mc}. Discrete regions of local membrane stress intensity, such as those resulting from concentrated loads acting on brackets, where the membrane stress intensity exceeds 1.1 S_{mc} shall be spaced so that there is no overlapping of the areas in which the membrane stress intensity exceeds 1.1 S_{mc}.

The value of S_{mc} from NE of Section III is equivalent to 1.1 S from Section VIII.

There is no Code limit for the extent of the region in which the membrane stress exceeds 1.0 S_{mc} but is less than $1.1S_{mc}$. This 10% variation in the allowable stress was provided because of the "beam on elastic foundation" effects of such local regions, the stress decays as one moves away from the thin region, but overshoots general membrane stress value by a small amount as the effects dampen out with distance. Thus, this provision is not equivalent to a 10% increase in the allowable stress which can be taken advantage of in the original design. However, given a design which satisfies the general Code intent, as the Oyster Creek drywell does as originally constructed, it is not a violation of Subsection NE requirements for the membrane stress to be between $1.0S_{mc}$ and $1.1S_{mc}$ over significant distances.

Based on the preceding discussion, a limit of $1.1S_{mc}$ will be used in evaluating the general membrane stresses in areas of the drywell where reduced thicknesses are specified.

2.2.2 Allowable Stresses for Post-Accident Condition

In the post-accident condition, the drywell is flooded to elevation 74'-6". The allowable stress values for this condition are given in Table 3.8.2-1 of Reference 2-4. Table 2-3 shows the allowable stress values used for the post-accident condition.

2.3 Load Magnitudes and Combinations

The loads to be considered in the Oyster Creek drywell stress analysis, and the load combinations are specified in Reference 1-4. References 2-1 and 2-3 also contain similar descriptions of the loads and load combinations. Table 2-4 shows these load combinations. The Cases I and II pertain to test loads imposed on the drywell prior to plant startup. These loads are enveloped by the loads specified in Case V - Accident Condition. Therefore, separate calculations were not conducted for Cases I and II.

A comparison of the load combinations shown in Table 2-4 and those given in Reference 2-4 is covered in Reference 2-6. From that comparison it was concluded that the load combinations in Table 2-4 essentially envelope those described in Reference 2-4.

The dead load, live load and other equipment loads used in the stress calculations were obtained from an earlier study by CBI [Reference No. 2.4.3 of Reference 1-4], and are shown in Tables 2-5a though 2-5c. In the dead weight loading, the weight of the compressible material attached to the drywell was separately added. This weight was taken as 10 lbs. per sq. ft. of drywell surface [Reference No. 2.4.2 of Reference 1-4]. The additional weight on the cylindrical portion of the drywell during the refueling was obtained from Reference No. 2.4.3 in Reference 1-4 as 561 lbs/inch of drywell cylindrical region circumference.

The stresses from seismic loads were separately calculated as described in Section 4.

2.4 Temperature Gradients

The drywell shell is essentially at a uniform temperature during all of the operating conditions except the accident condition. During the accident condition it is assumed that the drywell shell except the region below the curb (i.e., the sand bed region) is at the same temperature as that of the environment inside the drywell. An analysis of the meridional temperature distribution in the sand bed region during the accident condition was reported in Reference 1-4.

The meridional temperature results in Reference 1-4 are given as a function of elapsed time from the start of the accident condition to 4500 seconds. These temperature distributions are used in Section 3 to calculate the stresses.

2.5 References

2-1 Technical Specification S-2299-4; Design, Furnishing, Erection and Testing of the Reactor Drywell. and Suppression Chamber Containment Vessels (1964).

2-2 "Forcasted Drywell Thicknesses to 14R," letter dated October 5, 1990 from S.C. Tumminelli of GPUN to H.S. Mehta of GE, dated.

2-3 "Primary Containment Design Report," prepared by The Ralph M. Parsons Company, FSAR Amendment 15.

2-4 Nuclear Regulatory Commission Standard Review Plan, Section 3.8.2, Steel Containment, Rev. 1, July 1981.

2-5 "Justification for use of Section III, Subsection NE, Guidance in Evaluating the Oyster Creek Drywell," Appendix A to letter dated December 21, 1990 from H.S. Mehta of GE to S.C. Tumminelli of GPUN.

2-6 "Comparison of FDSAR and SRP Load Combinations," Appendix D to letter dated December 21, 1990 from H.S. Mehta of GE to S.C. Tumminelli of GPUN.

TABLE 2-1

As-designed and Projected 95% Confidence thicknesses used in the Code Stress Evaluation

Drywell Region	As-designed Thicknesses (in)	Projected 95% 14R Thicknesses (in)
Cylindrical Region	0.640	0.619*
Knuckle	2.625	2.625
Upper Spherical Region	0.722	0.677
Middle Spherical Region	0.770	0.723
Lower Spherical Region Except Sand Bed Area	1.154	1.154
Sand Bed Region	1.154	0.736

* no on-going corrosion

TABLE 2-2

Allowable Stresses for Drywell Shell in Section VIII Analysis

(Except Post-Accident Condition)

Primary Stresses	
General membrane	19300 psi
General membrane plus bending	29000 psi
Primary plus Secondary Stresses	
Surface stresses including thermal effects	3x17500 or 52500 psi

NOTE: The general membrane stress allowable value of 19300 psi is equal to 1.1x17500, where 17500 psi is the allowable stress value for the drywell material in Table UCS-23 of Section VIII.

TABLE 2-3

Allowable Stresses for Post-Accident Condition

<u>Primary Stresses</u>	
General Membrane	38000 psi
General Membrane plus Bending	1.5x General membrane or 57000 psi
<u>Secondary Stresses</u>	
Primary plus Secondary	70000 psi

NOTE: The above allowable stresses are based Standard Review Plan, Section 3.8.2., Steel Containment

Table 2-4

Load Combinations specified in the Parsons Report (Reference 2-3)

CASE I - INITIAL TEST CONDITION
Deadweight + Design Pressure (62 psi) + Seismic (2 x DBE)

CASE II - FINAL TEST CONDITION
Deadweight + Design Pressure (35 psi) + Seismic (2 x DBE)

CASE III - NORMAL OPERATING CONDITION
Deadweight + Pressure (2 psi external) + Seismic (2 x DBE)

CASE IV - REFUELING CONDITION
Deadweight + Pressure (2 psi external) + Water load at water seal @ 118'-3" + Seismic (2 x DBE)

CASE V - ACCIDENT CONDITION
Deadweight + Pressure (62 psi & 175 F or 35 psi & 281 F) + Seismic (2 x DBE)

CASE VI - POST ACCIDENT CONDITION
Deadweight + Water Load @ 74' 6" + Seismic (2 x DBE)

Notes: (1) The loads shown above predominate. Reference 2-3 contains all of the loads.

(2) DBE is the design basis earthquake.

TABLE 2.5a

Dead Weight Loads

Item	Elevation (ft.)	Weight in lbs
Upper Header	60.00	36000
Lower Header	40.00	41000
Upper Weld Pads	65.00	40000
Middle Weld Pads	60.00	40000
Lower Weld Pads	56.00	48000
Top Flange	95.75	20100
Bottom Flange	93.75	20700
Stabilizers	82.17	21650
Upper Beam Seats	50.00	1102000
Lower Beam Seats	22.00	556000
12 Ft Diam. EQ DOOR	30.25	48000
Personnel Lock	30.00	64100
Vents	15.56	50000
13 Ft Diam EQ DOOR	30.25	57000
Upper Weld Pads	65.00	12000
Middle Weld Pads	60.00	19200
Lower Weld Pads	56.00	8400

TABLE 2-5b
Penetration Loads

Penetration ID	Elevation (ft.)	Weight in lbs
x - 54A	87.00	1000
x - 5 A Thru H	16.00	150000
x - 6	16.00	6000
x - 7A Thru D	30.00	45600
x - 8	26.00	2450
x - 9A, 9B	34.00	22600
x - 10, 11	26.00	8650
x - 12, 45	31.00	16500
x - 13A, 13B	33.00	15450
x - 14,15,39B	70.00	5750
x - 43, 44	54.00	7850
x - 16A,B	73.00	8850
x - 17	90.00	2750
x - 18, 19	20.00	900
x - 20,21,22	40.00	850
x - 23,24,34A,B	20.00	6000
x - 25	90.00	3750
x - 27	90.00	1000
x - 28A-G	34.00	5450
x - 30AB, 32A	16.00	3700
x - 31AB, 53	16.00	3750
x - 26	20.00	3900
x - 35A Thru G	16.00	900

TABLE 2-5b (Cont'd)
Penetration Loads

Penetration ID	Elevation (ft.)	Weight in lbs
x - 36	60.00	700
x - 37 A Thru D	40.00	8100
x - 38A Thru D	40.00	8100
x - 42	20.00	400
x - 39A	30.00	850
x - 40 AB, 46A	30.00	2400
x - 46B, 52	30.00	1650
x - 49, 50	35.00	1500
x - 51	32.00	750
x - 100AB, 104B	40.00	2500
x - 105A,D+107A	40.00	2500
x - 100C,D,G+104	40.00	4150
x - 105B,C+106B	40.00	2550
x - 100E, 103A,10	40.00	2500
x - 102B	40.00	850
x - 101A-F	40.00	5100
x - 104BD	40.00	1650
x - 54B	90.00	1000
x - 55 A+B	90.00	2000
x - 102A,104A,10	40.00	2650
x - 100F,103B	40.00	1850
x - 29A,B,47,48	90.00	4000
x - 32B,33A,33B	16.00	3750
x - 40CD	36.00	1550
x - 41	90.00	500

TABLE 2-5c

Live Loads

Item	Elevation (ft.)	Weight in lbs
Upper Header	60.00	4200
Lower Header	40.00	7150
Upper Weld Pads	65.00	20000
Middle Weld Pads	60.00	20000
Lower Weld Pads	56.00	24000
Equip Door	30.25	100000
Personnel Lock	30.00	15000

3. DRYWELL FINITE ELEMENT ANALYSIS

3.1 Description of Finite Element Models

The drywell was modelled for finite element analysis using the ANSYS computer program [3-1]. Two finite element models, an axisymmetric model and a 36° pie slice model, were used in the stress analysis. Both of these models are essentially the same as those used in the stress analyses [1-2] except that the elements representing sand stiffness were eliminated. The axisymmetric model was used in determining the stresses for the seismic and the thermal gradient load cases. The pie slice model was used for dead weight and pressure load cases and to evaluate the stresses for load combinations. The pie slice model includes the effect of vent pipes and the reinforcing ring on the stress state in the sandbed and adjacent region.

3.1.1 Axisymmetric Model

The axisymmetric model is shown in Figures 3-1 through 3-5, where Figure 3-1 is an overview, and Figures 3-2, 3-3, 3-4, and 3-5 show the sand bed, knuckle, cylindrical, and upper most cylindrical regions, respectively. The geometry as described in Subsection 2.1, along with References 3-2 and 3-3, was used in generating this model.

The model was developed using axisymmetric solid elements (STIF 25), with the lower most portion being fixed in all directions. This element has asymmetric load capability which was required for the seismic evaluation. Seismic evaluations are discussed in Section 4.

3.1.2 Pie Slice Finite Element Model

Taking advantage of symmetry of the drywell with 10 ventlines, a 36° section was modeled. Figure 3-6 shows the 36° pie slice finite element model of the drywell. This model includes the drywell shell from the base of the sandbed region to the top of the elliptical head and the vent and vent header. The torus is not included in this model because the bellows provide a very flexible connection which does not allow significant structural interaction between the drywell and torus. The various colors in Figure 3-6 represent the different shell thicknesses of the drywell and ventline. Figure 3-7 shows the view from the inside of the drywell with the gussets and the vent jet deflector.

The drywell and vent shell are modeled using the 3-dimensional plastic quadrilateral shell (STIF43) element. At a distance of 76 inches from the drywell shell, the ventline modeling was simplified by using beam elements. The transition from shell to beam elements is made by extending rigid beam elements from a node along the centerline of the vent radially outward to each of the shell nodes of the ventline. ANSYS STIF4 beam elements are then connected to this centerline node to model the axial and bending stiffness of the ventline and header. Spring (STIF14) elements are used to model the vertical header supports inside the torus. ANSYS STIF4 beam elements are also used to model the stiffeners in the cylindrical region of the drywell.

Symmetric boundary conditions are defined for both edges of the 36° drywell segment. This allows the nodes at this boundary to move radially outward from the drywell centerline and vertically, but not in the circumferential direction. Rotations are also fixed in two directions to prevent the boundary from rotating out of the plane of symmetry. Nodes at the bottom edge of the drywell are fixed in all directions to simulate the fixity of the shell within the concrete foundation.

3.2 Load Application on Pie Slice Model

The loads are applied to the drywell finite element model in the manner which most accurately represents the actual loads anticipated on the drywell. Details on the application of loads are discussed in the following paragraphs.

3.2.1 Gravity Loads

The gravity loads include dead weight loads of the drywell shell, weight of the compressible material and penetrations and live loads. The drywell shell loads are imposed on the model by defining the weight density of the shell material and applying a vertical acceleration of 1.0 g to simulate gravity. The ANSYS program automatically distributes the loads consistent with the mass and acceleration. The compressible material weight of 10 lb/ft^2 is added by adjusting the weight density of the shell to also include the compressible material. The adjusted weight densities for the various shell thicknesses are summarized in Table 3-2.

The additional dead weights, penetration weights and live loads are applied as additional nodal masses to the model. As shown on Table 3-3 for the refueling condition case, the total additional mass is summed for each 5 foot elevation of the drywell. The total is then divided by 10 for the 36° section assuming that the mass is evenly distributed around the perimeter of the drywell. The resulting mass is then applied uniformly to a set of nodes at the desired elevation as shown in Table 3-3. These applied masses automatically impose gravity loads on the drywell model with the defined acceleration of 1g. The same method is used to apply the additional masses to the model for the accident and the post-accident conditions as summarized in Table 3-4.

3.2.2 Pressure Load

The appropriate pressure load is applied to the internal/external faces of all of the drywell and vent shell elements. The axial stress at the transition from vent shell to beam elements is simulated by applying equivalent axial forces to the nodes of the shell elements.
In the post-accident condition, the drywell is assumed to be flooded to elevation 74'-6" (894 inches). Using a water density of 62.3 lb/ft^3 (0.0361 lb/in^3), the pressure gradient versus elevation is calculated as shown in Table 3-5. The hydrostatic pressure at the

bottom of the sandbed region is calculated to be 28.3 psi. According to the elevation of the element centerline, the appropriate pressures are applied to the inside surface of the shell elements.

3.2.3 Seismic Loads

Seismic inertia and displacement stresses were first calculated using the axisymmetric model. The seismic meridional stresses determined from the axisymmetric model were then imposed on the pie slice model by applying downward forces at four elevations of the model (A: 23'-7",B: 37'-3",C: 50'-11" and D: 88'-9") as shown on Figure 3-8. Using this method, the meridional stresses calculated from the axisymmetric model are duplicated at four sections of the pie slice model including 1) the mid-elevation of the sandbed region, 2) 17.25° below the equator, 3) 5.75° above the equator and 4) just above the knuckle region. These four sections were chosen to most accurately represent the loading in the lower drywell while also providing a reasonably accurate stress distribution in the upper drywell. Table 3-6 shows the meridional stress magnitudes at the four sections.

Unit loads are then applied to the pie slice model in separate load steps at each elevation shown in Figure 3-8. The resulting stresses at the four sections of interest are then averaged for each of the applied unit loads. By solving four equations with four unknowns, the correct loads are determined to match the stresses shown in Table 3-6 at the four sections. The calculation for the correct loads are shown in Tables 3-7 and 3-8 for the accident and post-accident conditions, respectively.

3.3 Stress Results for Various Load Cases and Combinations

Only the two orthogonal stress components - meridional and circumferential - are significant at the maximum stress locations in the drywell shell. A review of the component stresses indicated that the calculated shear stress magnitudes are insignificant compared to the values for the total meridional and circumferential stresses. Therefore, the orthogonal stress magnitudes and the principal stress magnitudes were essentially the same. Also, the maximum stress was equivalent to the stress intensity at the locations evaluated.

The stresses for the seismic inertia, seismic displacement and temperature load cases (see Table 3-1) were calculated using the axisymmetric model. The details of the temperature stress analysis is described in the next Subsection and the procedures used in the calculation of the seismic stresses are covered in Section 4. The calculated values of the membrane and membrane plus bending stresses for temperature case are tabulated in Appendix A.

The seismic stresses were incorporated in the pie slice model to determine the overall stress resultants for the accident and post-accident load combinations. The temperature stresses determined from the axisymmetric model were separately added to the accident condition stresses obtained from the pie slice model. The multipliers applied to the various unit load cases (Table 3-1) to obtain total stresses for a particular load combination are shown in Table 3-9. The resulting stresses for these load combinations are discussed and compared with the Code allowables in Section 5.

3.4 Temperature Stress Analysis

The thermal response in the sand bed region to a DBA LOCA has been analyzed by GPU in Reference 1-4. Figure 3-9 shows the meridional nodes below the drywell floor, for which the calculated temperatures as a function of elapsed time are reported in Reference 1-4. An example of the calculated temperatures is shown in Figure 3-10.

From a review of the temperature distributions, two intermediate time steps were identified as possibly yielding the most severe thermal stresses. At 60 seconds, the largest temperature gradient occurs over a two inch meridional length. At 210 seconds, the maximum temperature is achieved. In addition, a third time step, 690 seconds, was evaluated to verify that a more deeply penetrating temperature condition would not result in higher stresses than the first two cases.

The predominant stresses for each of these cases occurred near the top of the sand bed region (near the 0.736" to 1.154" transition) and were in the circumferential and meridional directions. It was found that the thermal stresses at 210 seconds yielded the more severe stress condition. Figures 3-11 and 3-12 show the meridional and circumferential stress distributions in the sand bed region.

3.5 References

3-1 Gabriel J. DeSalvo, Ph.D. and John A. Swanson, Ph.D, "ANSYS Engineering Analysis System User's Manual," Revision 4.1, Swanson Analysis System, Inc. Houston, PA, March 1, 1983.

3-2 CB&I Drwg. 9-0971 sheet number 4, Rev. 1, "Drywell - Field Weld Joint"

3-3 CB&I Drwg. 9-0971 sheet number 7, Rev. 5, "Drywell - Cylindrical Shell & Top Head"

TABLE 3-1

Load Cases Considered in the Finite Element Analysis

Case No.	Loading
1	Pressure
2	Gravity-1 (Accident Condition)
3	Gravity-2 (Refueling)
4*	Unflooded Seismic
5*	Flooded Seismic
6	Flooded Hydrostatic Pressure
7*	Seismic Relative Support Displacement
8*	Temperature Gradient During DBA

* Load Cases Analyzed by Axisymmetric Finite Element Model

TABLE 3-2

Adjusted Weight Densities of Shell to Account for Compressible Material Weight

Shell Thickness(in.)	Adjusted Weight Density (lb/in^3)
1.154	0.343
0.770	0.373
0.722	0.379
2.563	0.310
0.640	0.392
1.250	0.339

TABLE 3-3

Oyster Creek Drywell Additional Weights - Refueling Condition

ELEVATION (feet)	DEAD WEIGHT (lbf)	PENETR. WEIGHT (lbf)	& MISC. LOADS (lbf)	TOTAL LOAD (lbf)	5 FOOT RANGE LOAD	LOAD PER 36 DEG. (lbf)	# OF ELEMENTS	NODES OF APPLICATION	LOAD PER FULL NODE (lbf)	LOAD PER HALF NODE (lbf)
15.56	50000			50000						
16		168100		168100						
20		11200		11200						
** 15-20					229300	22930	6	116-119	3822	1911
22#	556000			556000						
** 21-25#					556000	55600	8	161-169	6950	3475
26		11100		11100						
30	64100	51500		115600						
30.25	105000		100000	205000						
** 26-30					331700	33170	8	179-187	4146	2073
31		16500		16500						
32		750		750						
33		15450		15450						
34		28050		28050						
35		1500		1500						
** 31-35					62250	6225	8	188-196	778	389
36		1550		1550						
40	41000	43350		84350						
** 36-40					85900	8590	8	197-205	1074	537
50#	1102000			1102000						
** 45-50#					1102000	110200	8	418-426	13775	6888
54		7850		7850						
** 51-55					7850	785	8	436-444	98	49
56	56400		24000	80400						
60	95200	700	20000	115900						
** 56-60					196300	19630	8	454-462	2454	1227
65	52000		20000	72000						
** 61-65					72000	7200	8	472-480	900	450
70		5750		5750						
** 66-70					5750	575	8	508-516	72	36
73		8850		8850						
** 71-75					8850	885	8	526-534	111	55
82.17	21650			21650						
** 81-85					21650	2165	8	553-561	271	135
87		1000		1000						
90		15000		15000						
** 86-90					16000	1600	8	571-579	200	100
93.75	20700			20700						
94.75#			698000	698000						
95.75	20100			20100						
** 91-96					738800	73880	8	589-597	9235	4618
TOTALS:	2184150	388200	862000	3434350	3434350	343435				

- LOAD TO BE APPLIED IN VERTICAL DIRECTION ONLY.
& - MISCELLANEOUS LOADS INCLUDE 698000 LB WATER WEIGHT AT 94.75 FT. ELEVATION 100000 LB EQUIPMENT DOOR WEIGHT AT 30.25 FT. ELEVATION AND WELD PAD LIVE LOADS OF 24000, 20000 AND 20000 AT 56, 60 AND 65 FT. ELEVATIONS

REFWGT.WK1

TABLE 3-4

Oyster Creek Drywell Additional Weights
Accident and Post-Accident Condition

ELEVATION (feet)	DEAD WEIGHT (lbf)	PENETR. WEIGHT (lbf)	& MISC. LOADS (lbf)	TOTAL LOAD (lbf)	5 FOOT RANGE LOAD	LOAD PER 36 DEG. (lbf)	# OF ELEMENTS	NODES OF APPLICATION	LOAD PER FULL NODE (lbf)	LOAD PER HALF NODE (lbf)
15.56	50000			50000						
16		168100		168100						
20		11200		11200						
** 15-20					229300	22930	6	116-119	3822	1911
22#	556000			556000						
** 21-25#					556000	55600	8	161-169	6950	3475
26		11100		11100						
30	64100	51500		115600						
30.25	105000			105000						
** 26-30					231700	23170	8	179-187	2896	1448
31		16500		16500						
32		750		750						
33		15450		15450						
34		28050		28050						
35		1500		1500						
** 31-35					62250	6225	8	188-196	778	389
36		1550		1550						
40	41000	43350		84350						
** 36-40					85900	8590	8	197-205	1074	537
50#	1102000			1102000						
** 45-50#					1102000	110200	8	418-426	13775	6888
54		7850		7850						
** 51-55					7850	785	8	436-444	98	49
56	56400			56400						
60	95200	700		95900						
** 56-60					152300	15230	8	454-462	1904	952
65	52000			52000						
** 61-65					52000	5200	8	472-480	650	325
70		5750		5750						
** 66-70					5750	575	8	508-516	72	36
73		8850		8850						
** 71-75					8850	885	8	526-534	111	55
82.17	21650			21650						
** 81-85					21650	2165	8	553-561	271	135
87		1000		1000						
90		15000		15000						
** 86-90					16000	1600	8	571-579	200	100
93.75	20700			20700						
95.75	20100			20100						
** 91-96					40800	4080	8	589-597	510	255
TOTALS:	2184150	388200	0	2572350	2572350	257235				

- LOAD TO BE APPLIED IN VERTICAL DIRECTION ONLY.
& - NO MISCELLANEOUS LOADS FOR THIS CONDITION.

FLOODWGT.WK1

TABLE 3-5

Hydrostatic Pressures for Post-Accident Condition

WATER DENSITY: 62.32 lb/ft3
0.03606 lb/in3

FLOODED ELEV: 74.5 ft
894 inches

ELEMENTS ABOVE NODES	ANGLE ABOVE EQUATOR (degrees)	ELEVATION (inch)	DEPTH (inch)	PRESSURE (psi)	ELEMENTS
27	-53.32	110.2	783.8	28.3	1-12
40	-51.97	116.2	777.8	28.1	13-24
53	-50.62	122.4	771.6	27.8	25-36
66	-49.27	128.8	765.2	27.6	37-48
79	-47.50	137.3	756.7	27.3	49-51, 61-66 ,55-57
92	-46.20	143.9	750.1	27.1	52-54, 138-141 ,58-60
102	-44.35	153.4	740.6	26.7	142-147, 240-242, 257-259
108	-41.89	166.6	727.4	26.2	148-151, 243, 256
112	-39.43	180.2	713.8	25.7	152-155, 244, 255
116	-36.93	194.6	699.4	25.2	156-159, 245, 254
120	-34.40	209.7	684.3	24.7	160-165, 246, 253
124	-31.87	225.2	668.8	24.1	166-173, 247, 252
130	-29.33	241.3	652.7	23.5	174-183, 248-251
138	-26.80	257.6	636.4	23.0	184-195
148	-24.27	274.4	619.6	22.3	196-207
161	-20.13	302.5	591.5	21.3	208-215
170	-14.38	342.7	551.3	19.9	216-223
179	-8.63	384.0	510.0	18.4	224-231
188	-2.88	425.9	468.1	16.9	232-239
197	2.88	468.1	425.9	15.4	430-437
400	8.63	510.0	384.0	13.8	438-445
409	14.38	551.3	342.7	12.4	446-453
418	20.13	591.5	302.5	10.9	454-461
427	25.50	627.8	266.2	9.6	462-469
436	30.50	660.2	233.8	8.4	470-477
445	35.50	690.9	203.1	7.3	478-485
454	40.50	719.8	174.2	6.3	486-493
463	45.50	746.6	147.4	5.3	494-501
472	50.50	771.1	122.9	4.4	502-509
481	54.86	790.5	103.5	3.7	510-517
490	-	805.6	88.4	3.2	518-525
499	-	820.7	73.3	2.6	526-533
508	-	835.7	58.3	2.1	534-541
517	-	850.8	43.2	1.6	542-549
526	-	885.3	8.7	0.3	550-557
-	-	187.3	706.7	25.5	340-399 (Ventline)

FLOODP.WK1

TABLE 3-6

Meridional Seismic Stresses at Four Sections

Section	Elevation (inches)	2-D Shell Model Node	Meridional Stresses Accident (psi)	Post-Accident (psi)
A) Middle of Sandbed	119	32	1258	1288
B) 17.25° Below Equator	323	302	295	585
C) 5.75° Above Equator	489	461	214	616
D) Above Knuckle	1037	1037	216	808

TABLE 3-7

Application of Loads to Match Seismic Stresses - Accident Condition

COMPRESSIVE STRESSES FROM 2-D ANALYSIS		2-D SEISMIC STRESSES AT SECTION (psi)			
	SECTION:	1	2	3	4
	2-D NODE:	32	302	461	1037
	ELEV:	119.3"	322.5"	489.1"	912.3"
0.058" SEISMIC DEFLECTION:		788.67	155.54	103.46	85.31
HORIZ. PLUS VERTICAL SEISMIC INERTIA:		469.55	139.44	110.13	130.21
TOTAL SEISMIC COMPRESSIVE STRESSES:		1258.22	294.98	213.59	215.52

3-D INPUT LOAD SECTION	INPUT 3-D UNIT LOAD DESCRIPTION		3-D STRESSES AT SECTION (psi)			
		SECTION:	1	2	3	4
		3-D NODES:	53-65	170-178	400-408	526-534
		ELEV:	119.3"	322.5"	489.1"	912.3"
A	1000 lbs at nodes 563 through 569		85.43	37.94	34.94	55.23
B	500 lbs at 427&435, 1000 lbs at 428-434		89.88	39.92	36.76	0.00
C	500 lbs at 197&205, 1000 lbs at 198-204		97.64	43.37	0.00	0.00
D	500 lbs at 161&169, 1000 lbs at 162-168		89.85	0.00	0.00	0.00
	DESIRED COMPRESSIVE STRESSES (psi):		1258.22	294.98	213.59	215.52

3-D INPUT LOAD SECTION	LOAD TO BE APPLIED TO MATCH 2-D STRESSES		RESULTING STRESSES AT SECTION (psi)			
A	3902.2		333.37	148.05	136.34	215.52
B	2101.4		188.87	83.89	77.25	0.00
C	1453.6		141.93	63.04	0.00	0.00
D	6611.6		594.05	0.00	0.00	0.00
		SUM:	1258.22	294.98	213.59	215.52

SEISUNFL.WK1

TABLE 3-8

Application of Loads to Match Seismic Stresses
Post-Accident Condition

COMPRESSIVE STRESSES FROM 2-D ANALYSIS		2-D SEISMIC STRESSES AT SECTION (psi)			
	SECTION:	1	2	3	4
	2-D NODE:	32	302	461	1037
	ELEV:	119.3"	322.5"	489.1"	912.3"
0.058" SEISMIC DEFLECTION:		788.67	155.54	103.46	85.31
HORIZ. PLUS VERTICAL SEISMIC INERTIA:		499.79	429.39	512.76	723.14
TOTAL SEISMIC COMPRESSIVE STRESSES:		1288.46	584.93	616.22	808.45

3-D INPUT LOAD SECTION	INPUT 3-D UNIT LOAD DESCRIPTION		3-D STRESSES AT SECTION (psi)			
		SECTION:	1	2	3	4
		3-D NODES:	53-65	170-178	400-408	526-534
		ELEV:	119.3"	322.5"	489.1"	912.3"
A	1000 lbs at nodes 563 through 569		85.43	37.94	34.94	55.23
B	500 lbs at 427&435, 1000 lbs at 428-434		89.88	39.92	36.76	0.00
C	500 lbs at 197&205, 1000 lbs at 198-204		97.64	43.37	0.00	0.00
D	500 lbs at 161&169, 1000 lbs at 162-168		89.85	0.00	0.00	0.00
	DESIRED COMPRESSIVE STRESSES (psi):		1288.46	584.93	616.22	808.45

3-D INPUT LOAD SECTION	LOAD TO BE APPLIED TO MATCH 2-D STRESSES		RESULTING STRESSES AT SECTION (psi)			
A	14637.9		1250.51	555.36	511.45	808.45
B	2850.2		256.17	113.78	104.77	0.00
C	-1941.7		-189.58	-84.21	0.00	0.00
D	-318.8		-28.64	0.00	0.00	0.00
		SUM:	1288.46	584.93	616.22	808.45

SEISFL.WK1

TABLE 3-9

Description of Load Combinations in Terms of Unit Load Case Sum

Load Combination	Load Comb. Case(4)	Constituent Load Cases
Normal Operating Condition(3)	III	- (Case 1)x0.03226 + Case 2 ± Case 4 ± Case 7
Refueling Condition	IV	- (Case 1)x0.03226 + Case 3 ± Case 4 ± Case 7
Accident Condition - 1	V-1	+ Case 1 + Case 2 ± Case 4 ± Case 7 + Case 8
Accident Condition - 2	V-2	+ (Case 1)x0.565 + Case 2 ± Case 4 ± Case 7 + Case 8
Post-Accident Condition	VI	+ Case 2 ± Case 5 + Case 6 ± Case 7

Notes: (1) For load combination definition see Reference 2-3.

(2) For unit load case description see Table 3-1.

(3) Normal Operation also includes live load due to personnel lock.

(4) Load Combination Case Numbers are based on Table 2-44

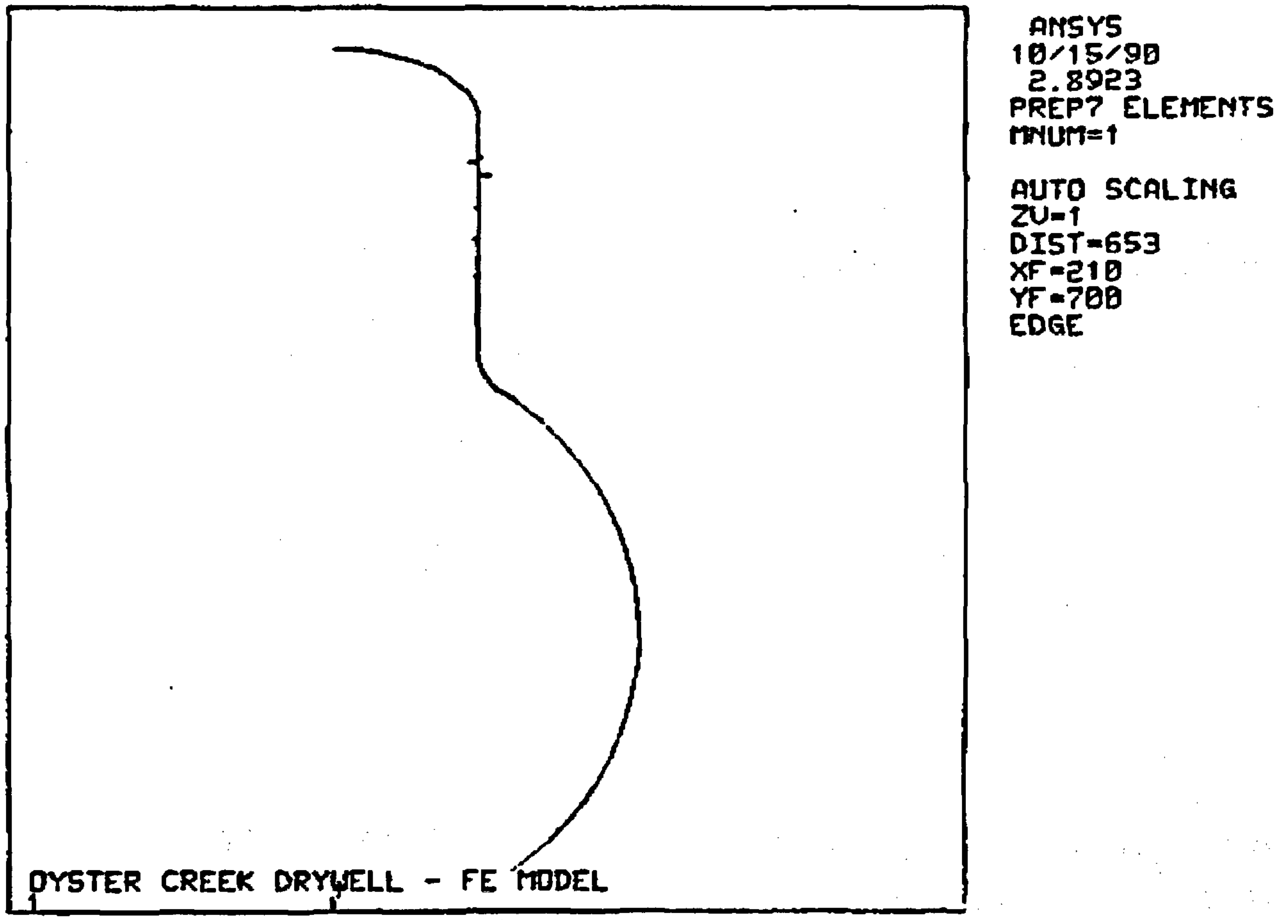

Figure 3-1 Complete Finite Element Model of Drywell

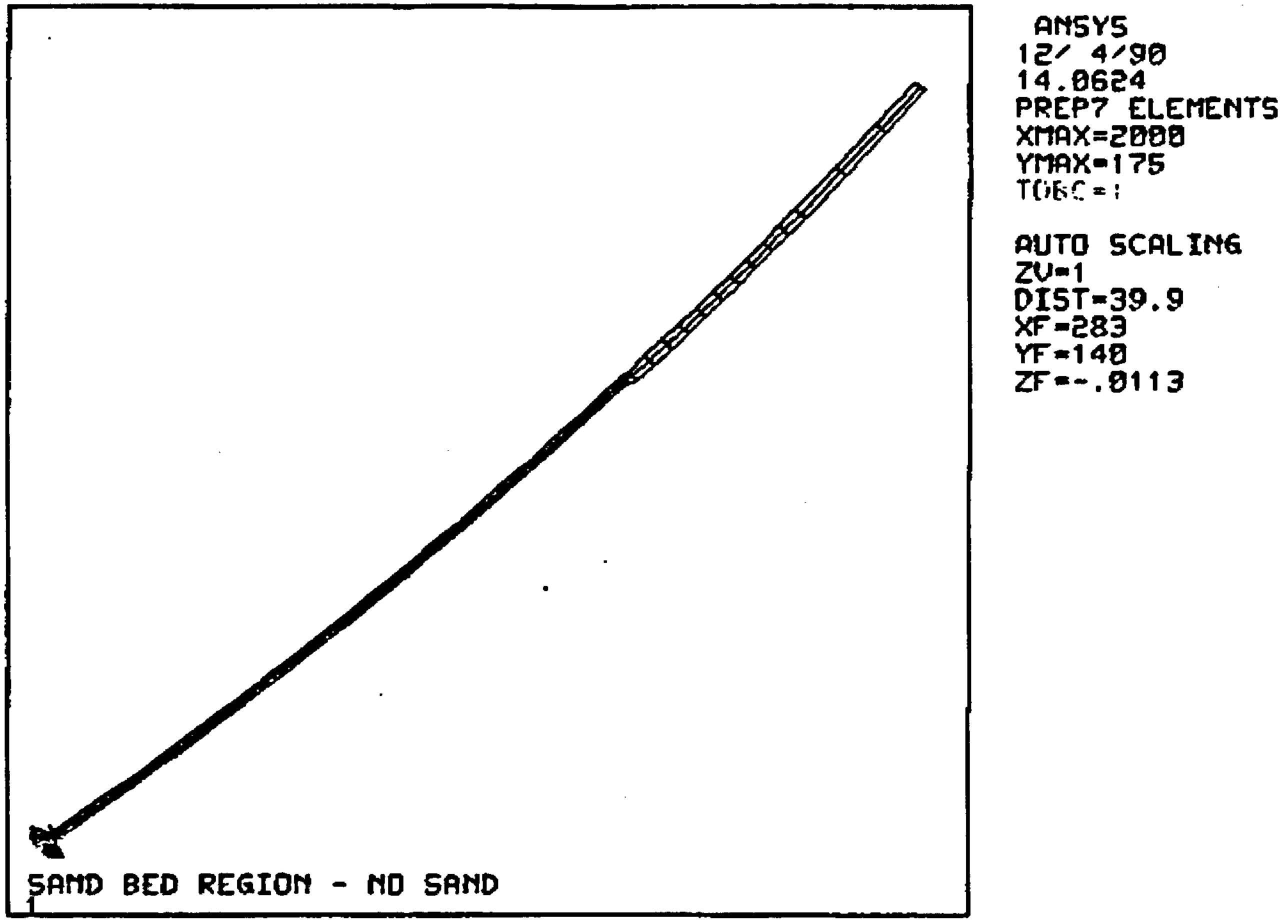

Figure 3-2 Sand Bed Region of Drywell Finite Element Model

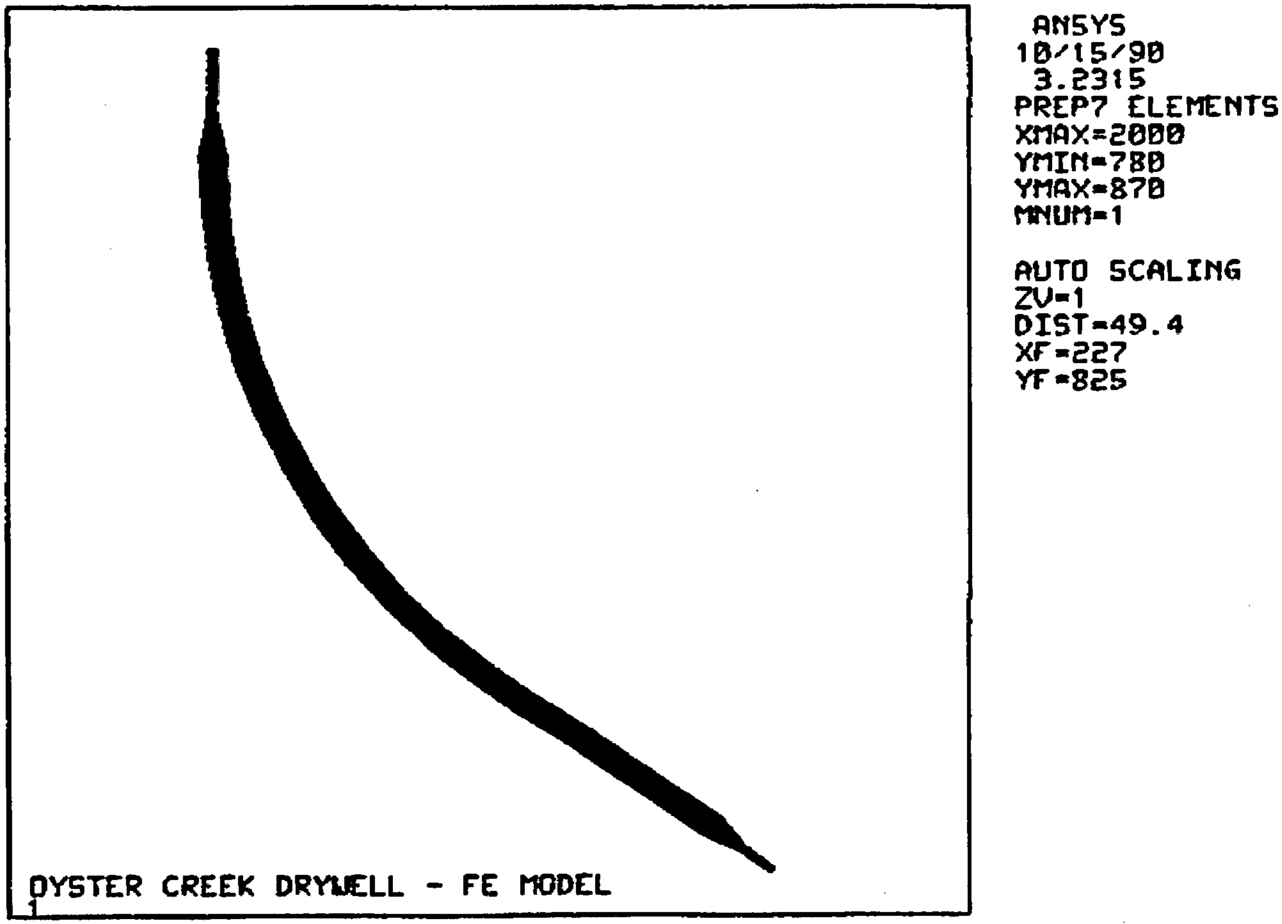

Figure 3-3 Knuckle Region of Drywell Finite Element Model

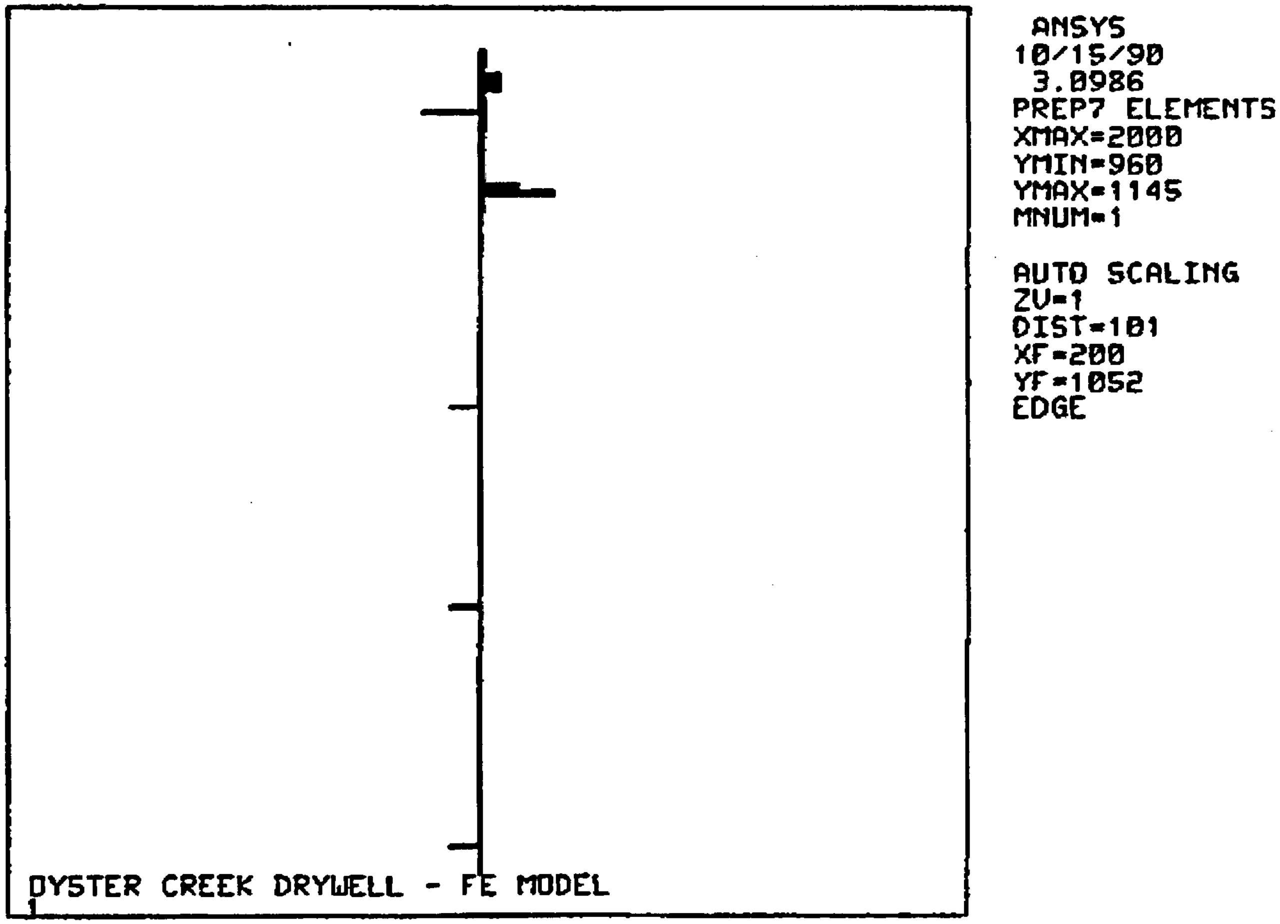

Figure 3-4 Cylindrical Region of Drywell Finite Element Model

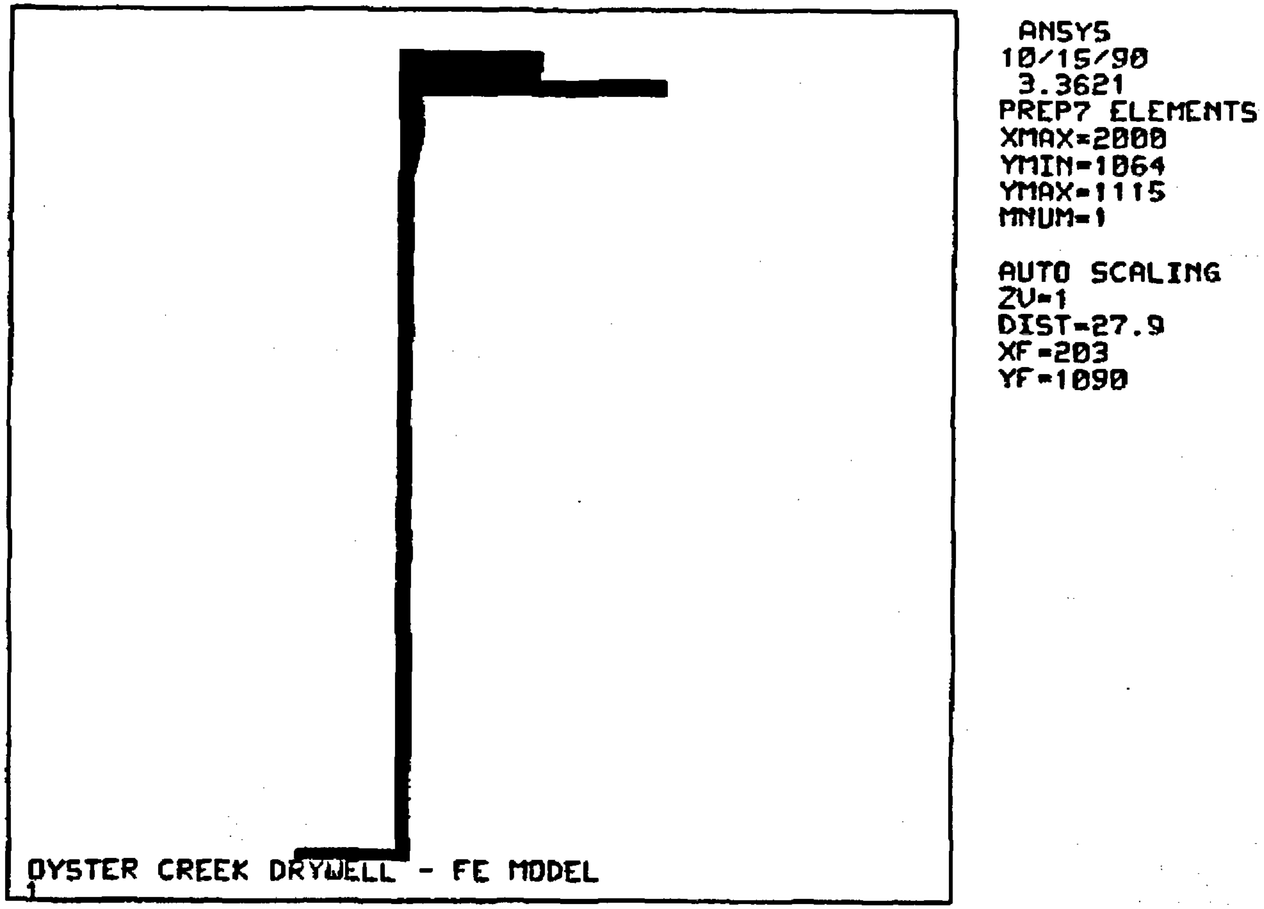

Figure 3-5 Upper Cylindrical Region of Drywell Finite Element Model

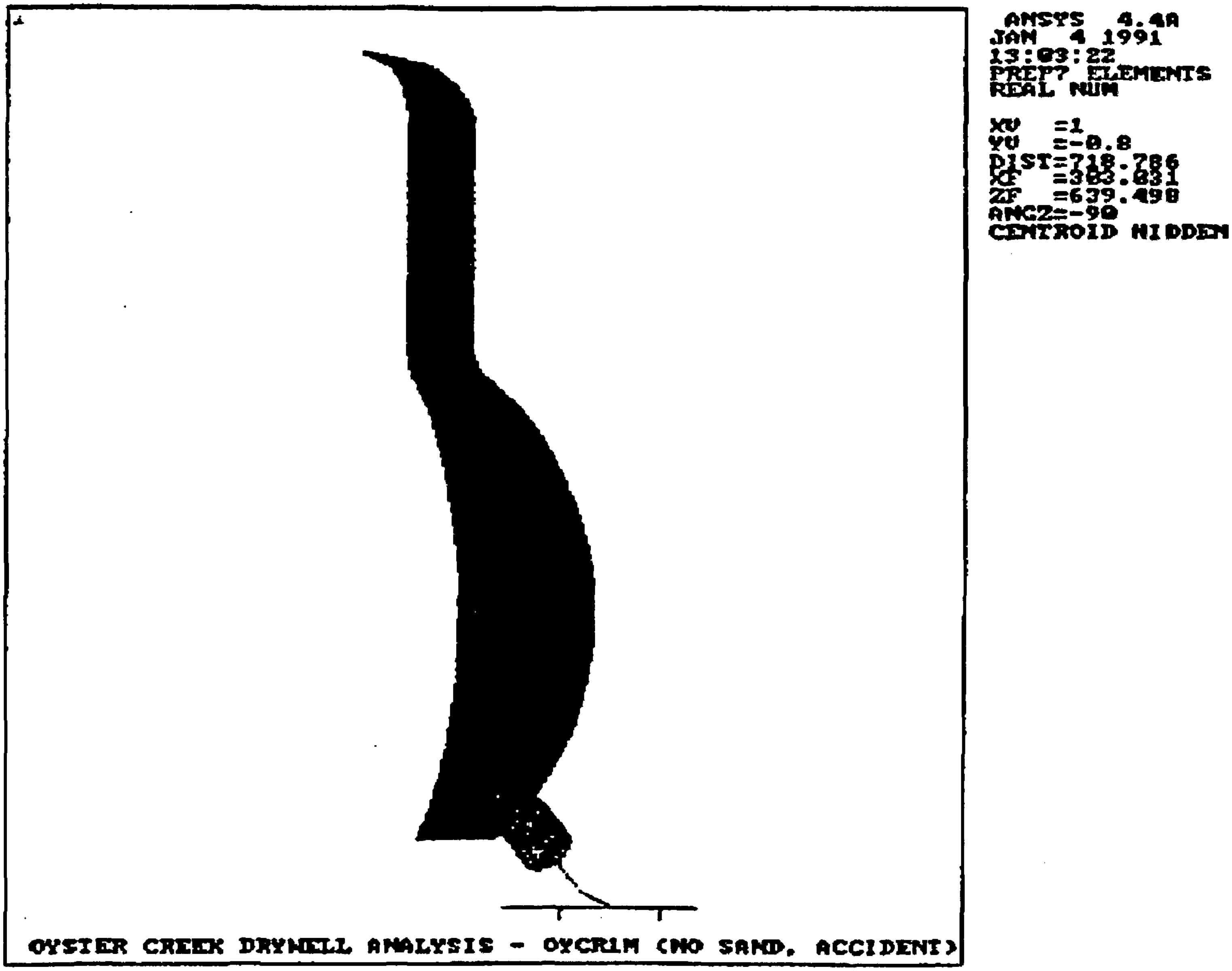

Figure 3-6 Oyster Creek Drywell Pie Slice Finite Element Model

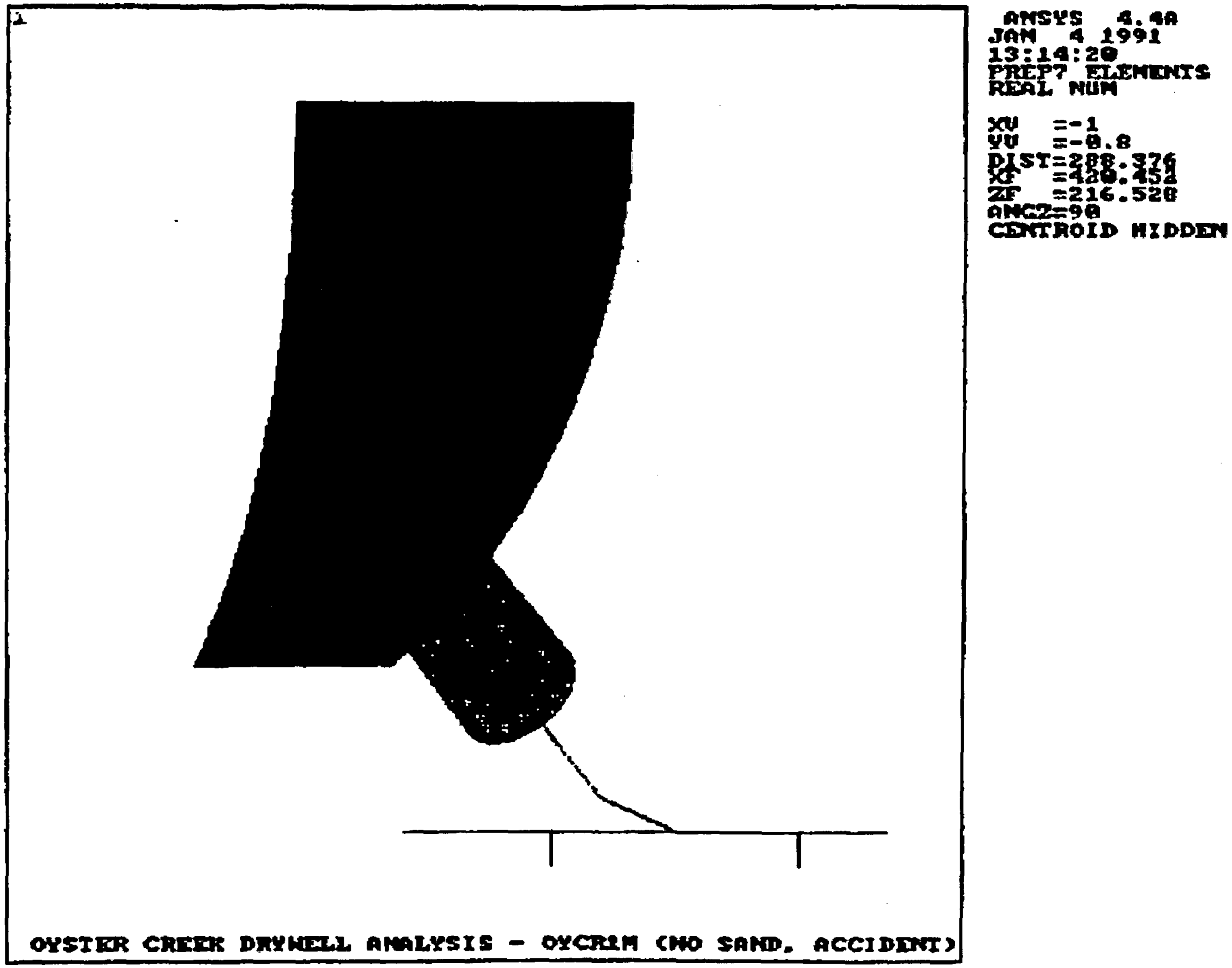

Figure 3-7 Inside Closeup View of Lower Drywell Section

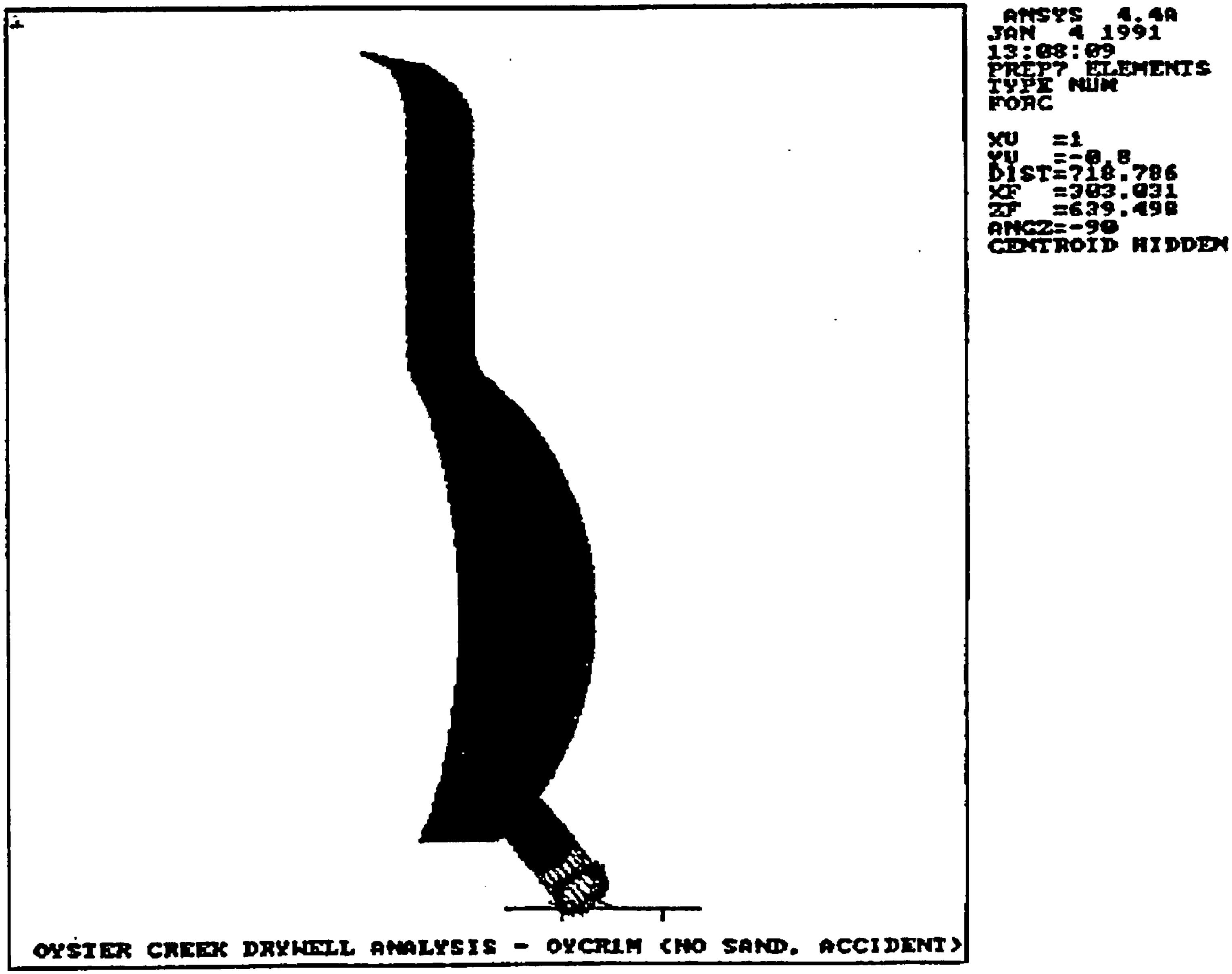

Figure 3-8 Application of Loading to Simulate Seismic Stresses

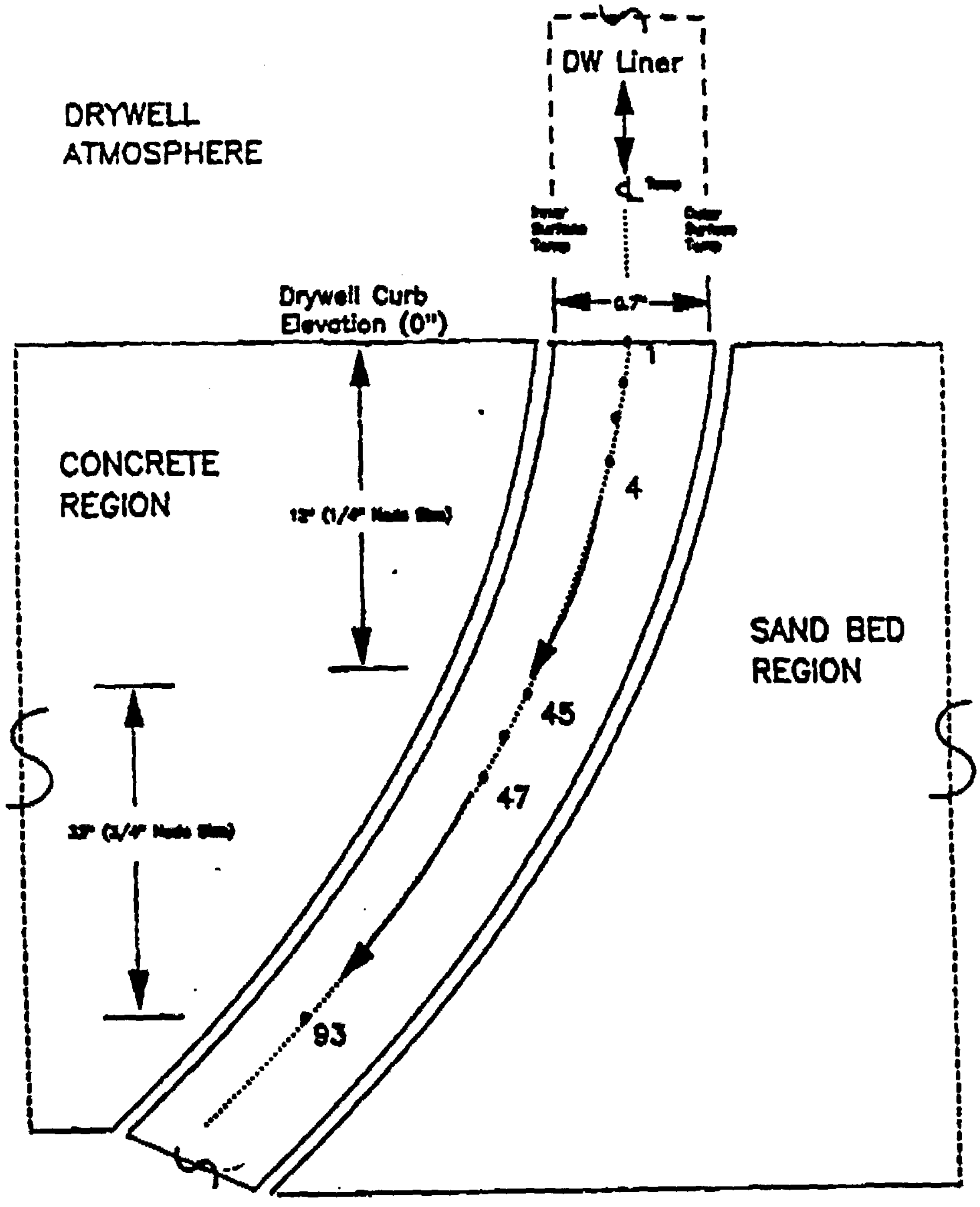

Figure 3-9 Below Curb Drywell Model Nodalization for Temperature Analysis During Accident Condition

TIME (SECONDS)

DIST IN INCH	110	120	150	180	210	240	270	300
	TEMPERATURE IN DEGREES F							
0	247.3	248.6	250.5	251.3	251.8	251.7	251.7	251.7
0.25	228.6	230.7	234.9	237.3	239.1	240.1	240.9	241.5
0.5	210.6	213.6	219.6	223.6	226.4	228.5	230.1	231.3
0.75	193.7	197.1	205	210.3	214.3	217.2	219.4	221.3
1	178	181.9	191	197.5	202.4	204.1	209	211.4
1.25	163.7	167.9	178	185.4	191	195.4	198.9	201.8
1.5	150.9	155.3	165.9	173.9	180.2	185.1	189.2	192.5
1.75	139.7	144	154.9	163.3	170	175.6	179.8	183.6
2	130.1	134.2	144.9	153.5	160.4	166.2	171	175
2.25	121.8	125.7	136	144.5	151.6	157.4	142.6	166.9
2.5	115	118.5	128.2	136.5	143.5	149.6	154.7	159.2
2.75	109.3	112.5	121.4	129.3	136.2	142.2	147.4	152
3	104.7	107.5	115.5	122.9	129.6	135.5	140.7	145.3
3.25	101.1	103.6	110.4	117.4	123.7	129.4	134.5	139
3.5	98.23	100.2	106.4	112.6	118.5	123.9	128.8	133.3
3.75	96.03	97.64	103	108.5	113.9	119	123.7	128
4	94.35	95.66	100.1	105	109.9	114.6	119.1	123.3
4.25	93.1	94.13	97.83	102.1	106.4	110.8	115	118.9
4.5	92.18	92.98	96	99.6	103.5	107.4	111.3	115
4.75	91.51	92.12	94.54	97.59	101	104.5	108.1	111.6
5	91.03	91.49	93.41	95.95	98.89	102	105.3	108.5
5.25	90.69	91.04	92.53	94.63	97.16	99.92	102.8	105.8
5.5	90.46	90.71	91.86	93.56	95.69	98.11	100.7	103.4
5.75	90.3	90.48	91.35	92.72	94.51	96.59	98.88	101.3
6	90.2	90.32	90.98	92.06	93.54	95.32	97.33	99.48
6.25	90.12	90.21	90.7	91.55	92.76	94.27	96.01	97.92
6.5	90.08	90.14	90.49	91.15	92.16	93.41	94.91	96.58
6.75	90.05	90.09	90.34	90.85	91.64	92.7	93.98	95.44
7	90.03	90.06	90.24	90.62	91.25	92.12	93.21	94.48
7.25	90.02	90.04	90.16	90.45	90.95	91.66	92.57	93.66
7.5	90.01	90.02	90.11	90.33	90.71	91.29	92.05	92.98
7.75	90.01	90.01	90.07	90.23	90.53	91	91.63	92.41
8	90	90.01	90.05	90.16	90.39	90.76	91.28	91.95
8.25	90	90	90.03	90.11	90.29	90.58	91	91.56
8.5	90	90	90.02	90.08	90.21	90.44	90.78	91.24
8.75	90	90	90.01	90.06	90.15	90.33	90.61	90.99
9	90	90	90.01	90.04	90.11	90.25	90.47	90.78
9.25	90	90	90.01	90.03	90.08	90.18	90.36	90.61
9.5	90	90	90	90.02	90.06	90.14	90.27	90.48
9.75	90	90	90	90.01	90.04	90.1	90.21	90.37
10	90	90	90	90.01	90.03	90.07	90.15	90.29
10.25	90	90	90	90	90.02	90.05	90.12	90.22
10.5	90	90	90	90	90.01	90.04	90.09	90.17
10.75	90	90	90	90	90.01	90.03	90.06	90.13
11	90	90	90	90	90.01	90.02	90.05	90.1
11.25	90	90	90	90	90	90.01	90.03	90.07
11.5	90	90	90	90	90	90.01	90.02	90.05
11.75	90	90	90	90	90	90.01	90.02	90.04
12	90	90	90	90	90	90	90.01	90.03
12.75	90	90	90	90	90	90	90	90.01
13.5	90	90	90	90	90	90	90	90
14.25	90	90	90	90	90	90	90	90
15	90	90	90	90	90	90	90	90
15.75	90	90	90	90	90	90	90	90
16.5	90	90	90	90	90	90	90	90
17.25	90	90	90	90	90	90	90	90
18	90	90	90	90	90	90	90	90
18.75	90	90	90	90	90	90	90	90
19.5	90	90	90	90	90	90	90	90
20.25	90	90	90	90	90	90	90	90
21	90	90	90	90	90	90	90	90
21.75	90	90	90	90	90	90	90	90
22.5	90	90	90	90	90	90	90	90
23.25	90	90	90	90	90	90	90	90
24	90	90	90	90	90	90	90	90
24.75	90	90	90	90	90	90	90	90
25.5	90	90	90	90	90	90	90	90
26.25	90	90	90	90	90	90	90	90
27	90	90	90	90	90	90	90	90
27.75	90	90	90	90	90	90	90	90
28.5	90	90	90	90	90	90	90	90
29.25	90	90	90	90	90	90	90	90
30	90	90	90	90	90	90	90	90
30.75	90	90	90	90	90	90	90	90

Figure 3-10 Example of Calculated Temperature Distribution at Various Elapsed Times

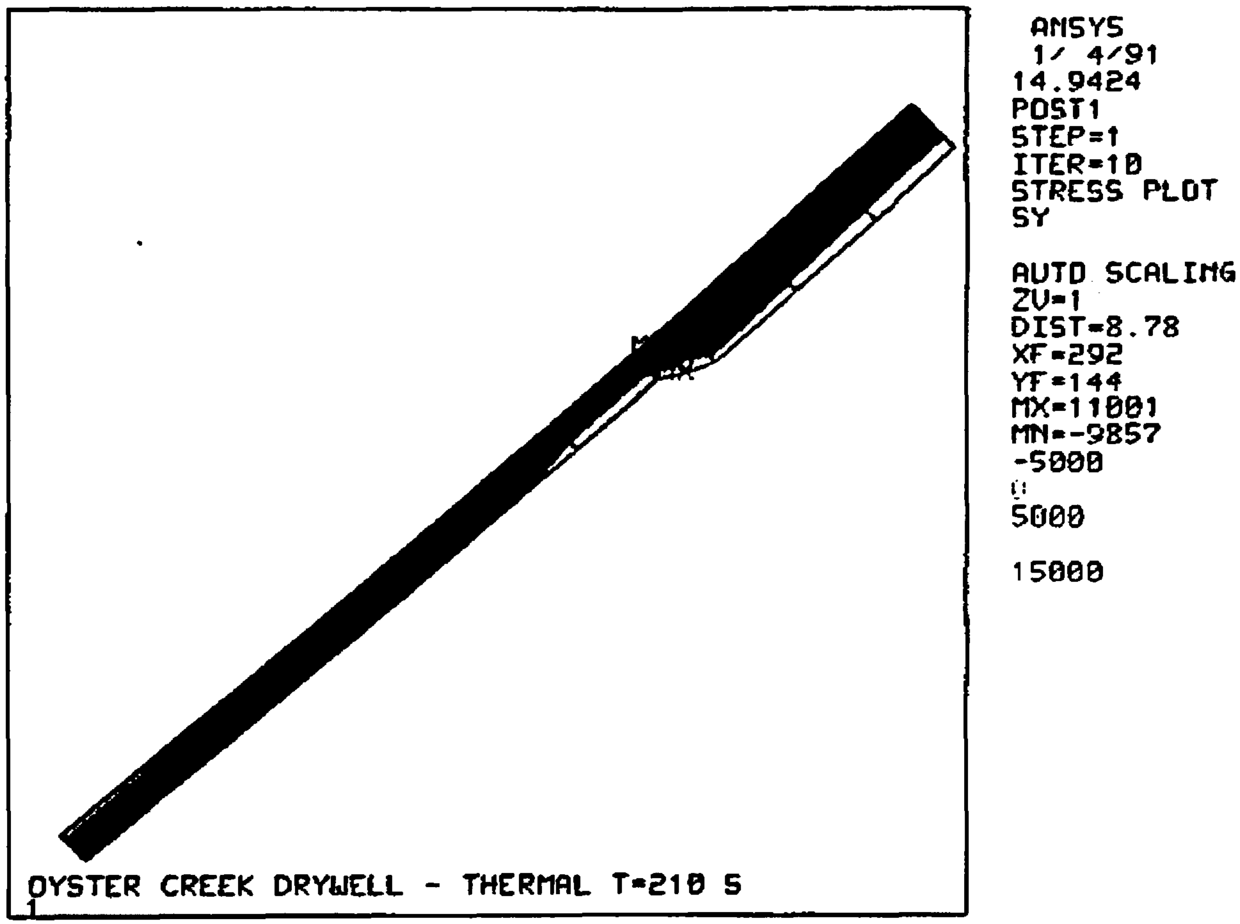

Figure 3-11 Meridional Stress Distribution in the Sand Bed Region From Temperature Distribution at t=210 Seconds

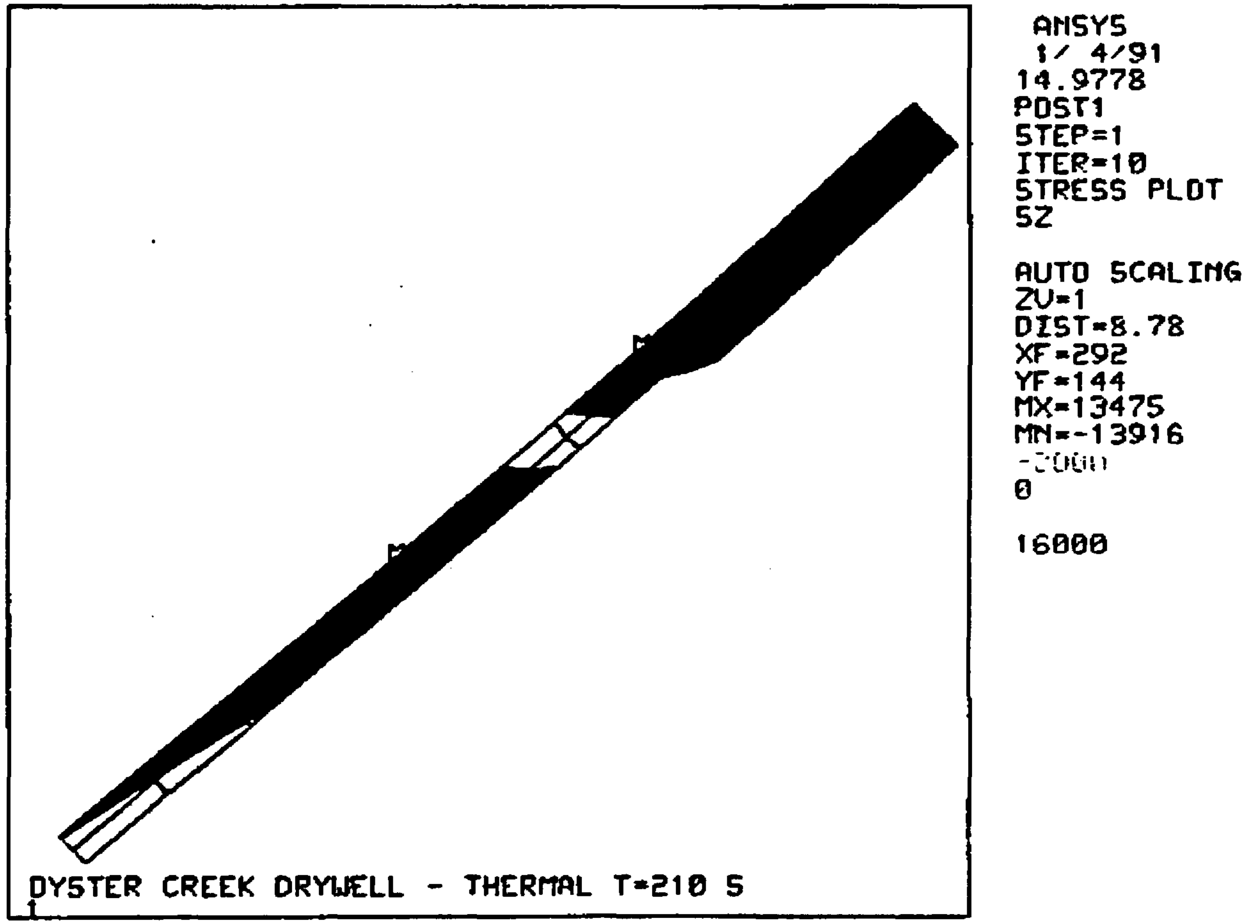

Figure 3-12 Circumferential Stress Distribution in the Sand Bed Region From Temperature Distribution at t=210 Seconds

4. SEISMIC LOAD DEFINITION

This section briefly describes the general methodology followed in the seismic evaluation of the drywell. A detailed report on the seismic analysis methodology and the results is included in Reference 4-1.

4.1 Finite Element Model

The axisymmetric finite element model was used in the seismic analysis. All of the concentrated loads listed in Tables 2-5a and 2-5b were included in both the flooded and unflooded seismic analyses. Since the lower and upper beams connect to the drywell through pads, the beam weights do not act during the horizontal earthquake excitation. Therefore, the beam weights are active only in the vertical direction. In addition, the live loads listed in Table 2-5c were included in the unflooded seismic analysis.

The drywell is constrained at the "reactor building/drywell/star truss" interface at elevation 82'-6" and at its base. The upper constraint was implemented in the finite element analysis by restraining the middle node in the horizontal direction at this elevation. The base constraint is as before, i.e., all nodes fixed.

4.2 Dynamic Analysis Methodology and Response Spectra

The seismic input motion spectra were provided by GPUN in Reference 1-4. The seismic motion spectra were for two locations: at the mat foundation and at the upper constraint. Since the ANSYS program can only accept one input spectrum, the input spectra at the two elevations were enveloped.

The response spectrum dynamic analyses were first conducted for frequencies up to the ZPA frequencies of the input motion spectra. The response contributions due to the truncated higher frequency modes were calculated by static analyses in which the total model mass is subjected to support accelerations. These were taken as ZPA accelerations for each of the orthogonal spatial directions. All colinear modal response contributions were combined by the Double Sum Method and the spatial contributions by the SRSS method. The response contributions due to the truncated higher frequency modes were combined with the response totals due to the lower frequency modes included in the analysis by the SRSS method. The resulting total colinear inertia responses were combined with the corresponding responses due to relative support motion by the absolute sum method. These stresses were then combined with the stresses from other loads (e.g., pressure, thermal, etc.) for the Code evaluation.

4.3 Post-Accident Seismic Analysis

In the post-accident condition, the drywell is flooded to elevation 74'-6". The weight of the water was lumped at several elevations along the meridian of the drywell. Based on previous experience, the fluid-structure interaction effects were assumed as negligible and the hydrodynamic mass of water was assumed as 80% of the total mass of water which would fill an empty drywell. This exclusion of 20% mass reasonably accounts for the volume of RPV, shield wall and pedestal.

4.4 Analysis for Relative Support Displacement Effects

The drywell is fixed at its base and is laterally constrained by the reactor building at elevation 82'-6". During seismic excitation, the reactor building would experience relative displacement between the drywell constraint elevation and the basemat. Since the reactor building is much stiffer and much more massive than the drywell, it will take the drywell for a 'ride' during relative support displacement. Therefore, the stresses in the drywell due to relative support displacement were determined and added to those from the seismic inertia loads.

The horizontal relative displacement of the drywell upper support with respect to the drywell at the basemat was specified as 0.058 inch for 2xDBE condition [1-4]. The stresses from this relative displacement were obtained by applying a horizontal displacement of 0.058 inch at the upper support elevation.

4.5 References

4-1 "Seismic Analysis Details," Appendix B of letter dated December 21, 1990 from H.S. Mehta of GE to S.C. Tumminelli of GPUN.

5. CODE STRESS EVALUATION

Sections 3 and 4 describe the analyses for shell stresses for the various unit load cases and the limiting load combinations V and VI. The stress analysis for the 'with sand case' in Reference 1-2a has shown that the accident condition, load combination V-1, and the post-accident condition, load combination VI, represent the limiting load combinations for the Code stress evaluation. This was also determined to be the case for the 'without sand' configuration considered in this report. The removal of sand from the sandbed region affects the stresses only in the sandbed and the adjacent lower spherical region. Therefore, the Code stress evaluation of these regions is described separately from the other regions of the drywell.

5.1 Code Stress Evaluation of Regions Above the Lower Sphere

Figure 5-1 shows a plot of the accident condition membrane circumferential stresses for the 'with' and 'without' sand cases as a function of meridional distance. Stresses in both the sandbed and the other drywell regions are included in Figure 5-1. It is seen that in the other regions the stress magnitudes for the two cases are essentially identical.

From the preceding it is clear that the stresses in the other regions (i.e., other than the sandbed and the adjacent lower spherical region) are unaffected by removing the sand. Nevertheless, for completeness, the calculated stress magnitudes for these regions from Reference 1-2a are repeated in Tables 5-1a and 5-1b.

The stress magnitudes shown in Tables 5-1a and 5-1b are computed using elastic small displacement analysis. As discussed in Subsection 5.2, the stresses in the sandbed and lower sphere regions were also evaluated using elastic large displacement analysis. A comparison of the component stresses from the small and large displacement solutions for the drywell regions above the lower sphere showed insignificant differences.

In order to evaluate the impact on the penetration analyses, a comparison of the radial and meridional displacements at the equator plane of the sphere (elevation 37'-3") for the with and without sand cases was performed. The comparison showed that the radial displacements in the two cases were essentially identical but the meridional or vertical displacements differed by ≈ 0.042 inch for load combination V-1. This difference was judged to be small compared to the calculated vertical thermal displacement of ≈ 0.5 inch for the accident condition load combination V-2.

5.2 Elastic Stress Analysis of Sandbed and Lower Sphere

5.2.1 Small Displacement Solution Results

The maximum stresses are along the meridional boundary of the model (i.e., the plane of symmetry between the vents), so the stresses along this boundary will be considered first. Figure 5-2 shows the plot of meridional membrane stress magnitudes for the accident condition V-1 as a function of meridional distance from the bottom of the sandbed. A comparison of the membrane stress magnitudes in Figures 5-1 'without sand' case and Figure 5-2 shows that the circumferential stress is higher than the meridional stress in both the sandbed region and the lower spherical region. This is expected since the absence of sand springs allows more radial displacement of the drywell shell under dead weight and internal pressure. Figure 5-3 shows a plot of the membrane circumferential stress distribution. The maximum value of the circumferential membrane stress is ≈ 23.0 ksi. Further, this stress exceeds 1.1 S_{mc} (21.2 ksi) for a meridional distance of ≈ 26 inches (see Figure 5-1).

The Code (NE-3213.10) states that cases arise in which a membrane stress produced by pressure or other mechanical loading and associated with a primary or discontinuity effect produces excessive distortion in the transfer of load to other portions of the structure. Such a membrane stress is conservatively classified by the Code as local primary membrane stress. The Code limits the magnitude of this stress to 1.5 S_{mc} (29.0 ksi). A stressed region may be considered local if the distance over which the membrane stress intensity exceeds 1.1 S_{mc} does not extend in the meridional direction more than $1.0\sqrt{(Rt)}$. With R=420 in. and t=0.736 inch in the sandbed region, $1.0\sqrt{(Rt)}$ is equal to 17.6 inches. Thus, the maximum value of the circumferential membrane stress (23.0 ksi) meets the Code stress limit (29.0 ksi) but its meridional extent over 1.1 S_{mc} is greater than $1.0\sqrt{(Rt)}$.

The meridional extent of 26 in. occurs only at the plane of symmetry between the vent lines. The extent is less at other meridional planes. Figure 5-4 shows the meridional extent of circumferential membrane stress above 1.1 S_{mc} at four meridional planes. Using a weighted average over the circumference of the model, the meridional extent was calculated as 14 inches. This average value is less than $1.0\sqrt{(Rt)}$ and, thus, meets the meridional extent criterion given in NE-3213.10.

The objective of the Code in limiting the meridional extent and magnitude of the local primary membrane stress is to preclude excessive distortion in the transfer of load to other portions of the structure, since such distortion could invalidate the elastic analysis. The small displacement results showed that the maximum radial displacement in the sandbed region was 0.28 inch for the accident condition V-1. This is less than half the modeled thickness of the drywell in that region and, therefore, is judged not to be excessive.

The small displacement analysis conducted previously is conservative because the stiffening effect of the tensile in-plane stresses is not considered. This effect would tend to reduce the local radial deflection (thus, also the local circumferential stress) of the drywell shell in the sandbed region. For example, consider the case of a beam subjected to both transverse and tensile axial loads as shown in Figure 5-5. A small displacement analysis of this configuration considers the bending moments based on the transverse load only. The bending stresses and deflections of the beam are overpredicted based on these bending moments. In a real structure, tensile axial loads in combination with the deflections of the beam produced by transverse loads creates an opposing bending moment. As a result the overall bending moment is reduced, leading to smaller bending deflections and stresses. This stiffening effect can be included only by conducting a large displacement analysis.

5.2.2 Large Displacement Solution Results

Based on the preceding discussion, a large displacement analysis was conducted using the same pie slice model and the accident condition V-1 loads. A large displacement analysis can be conducted using the ANSYS code by activating the KAY(6) key. When this option is chosen, the ANSYS program first calculates displacements of the structure based on a small displacement analysis. The geometry of the structure is then updated based on the calculated displacements. The loads are again applied to the structure and the displacements are recalculated. The geometry of the structure is continually updated and the displacements are recalculated until the maximum displacement change between successive iterations is reduced below the selected convergence criteria. A convergence criteria of 0.01 inch was chosen for this analysis. In this manner, the ANSYS code accurately accounts for the stiffening of the structure due to in-plane tensile stresses.

Figure 5-6 shows the distribution of membrane circumferential stress. Figure 5-7 shows a plot of membrane circumferential stress as a function of meridional distance when the large displacement option in ANSYS was used. For comparison, the stress results from the small displacement solution (Figure 5-1) are also shown in Figure 5-7. It is seen that the maximum value from the large displacement solution is ≈ 21.5 ksi (compared to ≈ 23 ksi in the small displacement analysis), and it exceeds 1.1 S_{mc} (21.2 ksi) over a maximum distance of only 11 inches at the meridional plane between the vent lines. This is clearly less than the 1.0 $\sqrt{(Rt)}$ distance of 17.6 in.

Figure 5-8 shows the circumferential membrane stress magnitudes at four different meridional planes based on large displacement solution. Using a weighted average over the circumference of the model, the meridional extent was calculated as ≈ 2 in.

5.3 Code Evaluation of the Sandbed and Lower Sphere

5.3.1 Primary Stress Evaluation

Tables 5-2a and 5-2b show the maximum values of primary stresses for the accident condition load combination V-1, and the Code allowable values for the small and large displacement solutions, respectively. In the primary membrane stress category, the calculated stress intensities for the sandbed region are based on the average values. The peak value of the circumferential membrane stress in the sandbed region was compared with the local primary membrane stress limits.

As expected, a comparison of Tables 5-2a and 5-2b shows that the calculated stress magnitudes using the large displacement option are in general slightly lower than those obtained using the small displacement option. The differences in the stresses are larger in the sandbed region where the radial displacements are larger. The calculated primary stress magnitudes in the sandbed region and lower sphere meet the Code stress limits.

5.3.2 Extent of Local Primary Membrane Stress

Paragraph NE-3213.10 of the Code states that a stresses region may be considered local if the distance over which the membrane stress intensity exceeds 1.1 S_{mc} does not extend in the meridional direction more than $1.0\surd(Rt)$, which is ≈ 17.6 inches. When the small displacement solution is used (5.2.1), the membrane circumferential stress magnitude in the sandbed region exceeds 1.1 S_{mc} over a meridional distance of ≈ 26 inches at the plane of symmetry between the vent lines. However, this distance was found to be 14 inches using a weighted average considering other meridionals.

Furthermore, this distance of 26 inches at the plane of symmetry between the vent lines was reduced to ≈ 11 inches when the large displacement solution was used in which the stiffness matrix is updated based on the deformed shape. Therefore, it is concluded that the circumferential stress in the sandbed region meets the meridional extent criterion of the Code Paragraph NE-3213.10.

5.3.3 Primary Plus Secondary Stress Evaluation

Only two load cases result in significant secondary stresses in the shell. The first is the temperature gradient (accident condition V-1) which produces secondary stresses in the sandbed and lower sphere. The second is the post-accident condition which produces discontinuity bending moments in the shell at the bottom of the sandbed. The post-accident load combination case VI controls. Tables 5-3a and 5-3b show the calculated values of primary plus secondary stresses and a comparison with the allowable values for small and large displacement solutions, respectively. All of the calculated primary plus secondary stress values are within the Code allowable values.

TABLE 5-1a

Comparison of Calculated Stresses to Code Allowable Values
(Nominal Drywell Wall Thicknesses Above Lower Sphere)
Limiting Load Combination - V-1

Drywell Region	Stress Categ.	Calc. Stress Magnitude, Max. (psi)	Allowable Stress (psi)
Cylinder (t=0.640 in.)	Prim. Memb.	19200	19300
	Prim. Memb. + Bending	20280	29000
Knuckle (t=2.625 in.)	Prim. Memb.	18430	19300
	Prim. Memb. + Bending	20620	29000
Upper Sphere (t=0.722 in.)	Prim. Memb.	19090	19300
	Prim. Memb. + Bending	26350	29000
Middle Sphere (t=0.770 in.)	Prim. Memb.	18460	19300
	Prim. Memb. + Bending	23110	29000

TABLE 5-1b

Comparison of Calculated Stresses to Code Allowable Values
(95% Projected Drywell Wall Thicknesses Above Lower Sphere)
Limiting Load Combination - V-1

Drywell Region	Stress Categ.	Calc. Stress Magnitude, Max. (psi)	Allowable Stress (psi)
Cylinder (t=0.619 in.)	Prim. Memb.	19850	21200
	Prim. Memb. + Bending	20970	29000
Upper Sphere (t=0.677 in.)	Prim. Memb.	20360	21200
	Prim. Memb. + Bending	28100	29000
Middle Sphere (t=0.723 in.)	Prim. Memb.	19660	21200
	Prim. Memb. + Bending	24610	29000

TABLE 5-2a

Comparison of Calculated Primary Stresses to Code Allowable Values
(Small Displacement; Lower Sphere and Sandbed)
Limiting Load Combination - V-1

Drywell Region	Stress Categ.	Calc. Stress Magnitude, Max. (psi)	Allowable Stress (psi)
Lower Sphere (t=1.154 in.)	Prim. Memb.	13800	21200
	Local Prim. Memb.	17690	29000
	Prim. Memb. + Bending	17800	29000
Sandbed (t=0.736 in.)	Prim. Memb.	17430	21200
	Local Prim. Memb.	22970	29000
	Prim. Memb. + Bending	24950	29000

TABLE 5-2b

Comparison of Calculated Primary Stresses to Code Allowable Values
(Large Displacement; Lower Sphere and Sandbed)
Limiting Load Combination - V-1

Drywell Region	Stress Categ.	Calc. Stress Magnitude, Max. (psi)	Allowable Stress (psi)
Lower Sphere (t=1.154 in.)	Prim. Memb.	13940	21200
	Local Prim. Memb.	17530	29000
	Prim. Memb. + Bending	17640	29000
Sandbed (t=0.736 in.)	Prim. Memb.	16540	21200
	Local Prim. Memb.	21540	29000
	Prim. Memb. + Bending	23130	29000

TABLE 5-3a

Comparison of Calculated Primary Plus Secondary Stresses
to Code Allowable Values
(Small Displacement -Lower Sphere and Sandbed)

Drywell Region	Stress Categ.	Calc. Stress Magnitude, Max. (psi)	Allowable Stress (psi)
Lower Sphere (t=1.154 in.)	Prim. + Sec. (Acc. Load Cond. V-1)	29020	52500
	Prim. + Sec. (Post-Acc. Load Cond. VI)	30280	70000
Sandbed Region (t=0.736 in.)	Prim. + Sec. (Acc. Load Cond. V-1)	38420	52500
	Prim. + Sec. (Post-Acc. Load Cond. VI)	67020	70000

TABLE 5-3b

Comparison of Calculated Primary Plus Secondary Stresses
to Code Allowable Values
(Large Displacement -Lower Sphere and Sandbed)

Drywell Region	Stress Categ.	Calc. Stress Magnitude, Max. (psi)	Allowable Stress (psi)
Lower Sphere (t=1.154 in.)	Prim. + Sec. (Acc. Load Cond. V-1)	28860	52500
	Prim. + Sec. (Post-Acc. Load Cond. VI)	30280	70000
Sandbed Region (t=0.736 in.)	Prim. + Sec. (Acc. Load Cond. V-1)	36600	52500
	Prim. + Sec. (Post-Acc. Load Cond. VI)	67020	70000

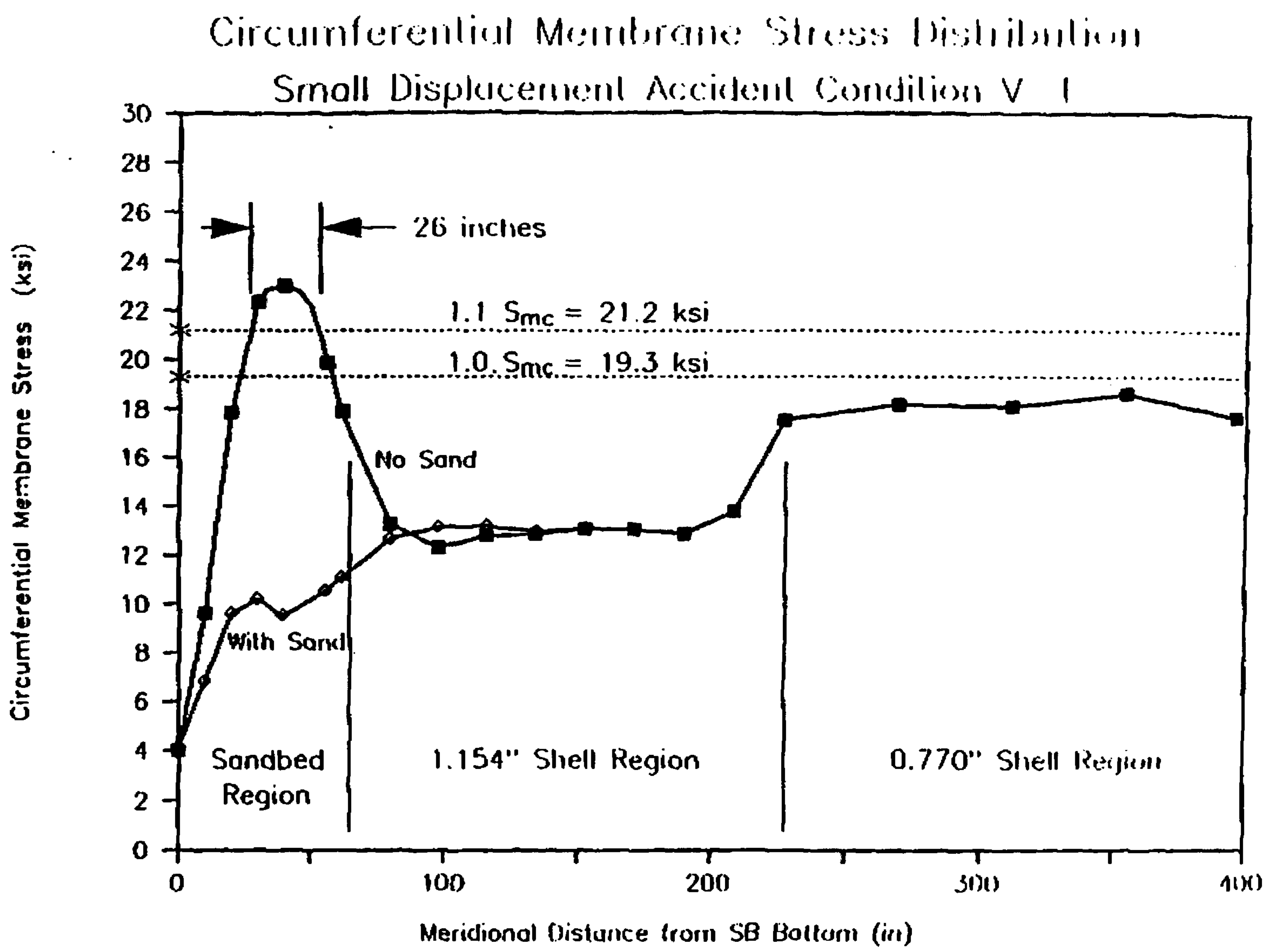

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Figure 5-1 Circumferential Stresses for Accident Condition V-1 in 'With Sand' and 'Without Sand' Cases - Small Displacement

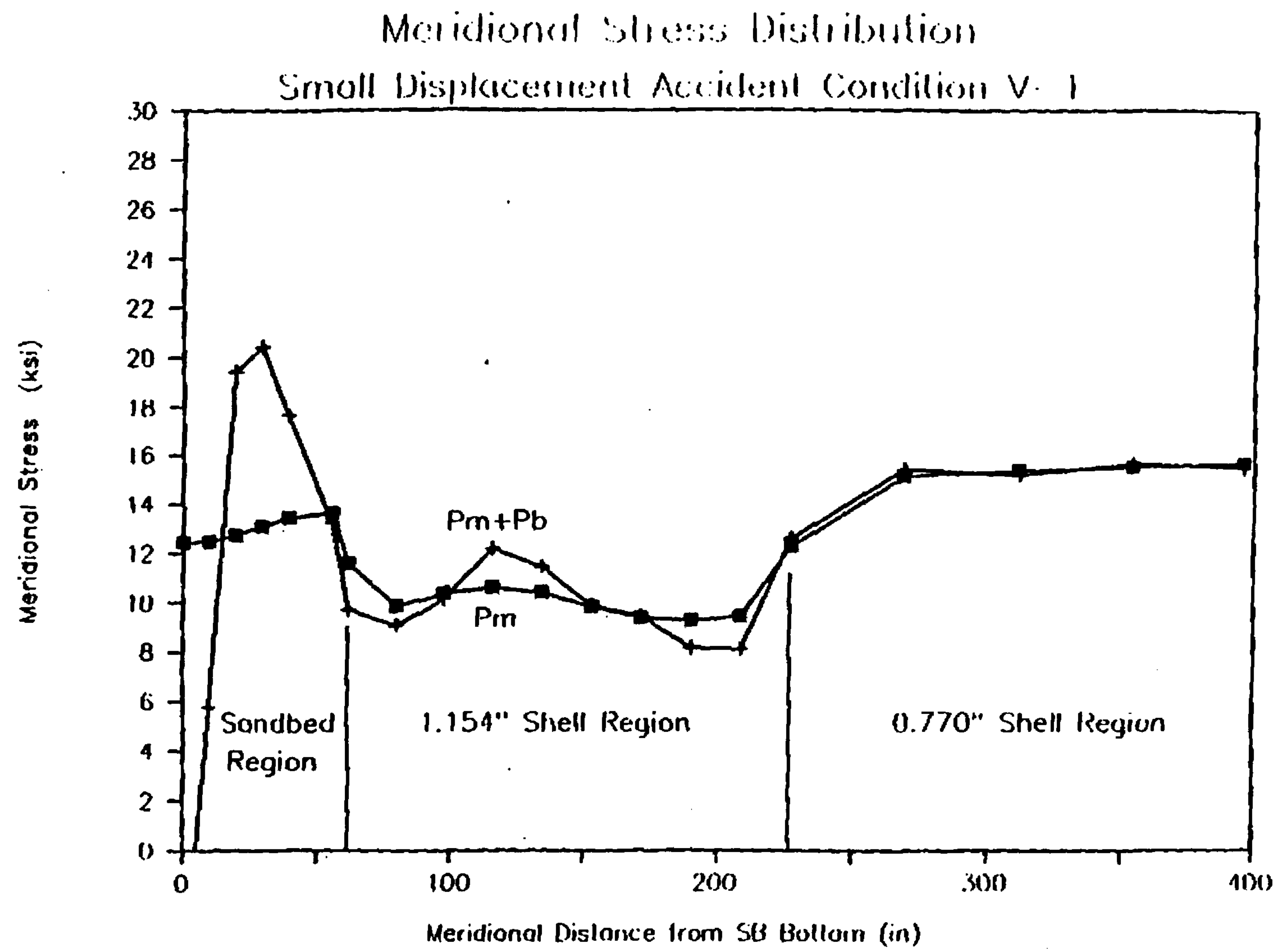

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Figure 5-1 Plot of Accident Condition V-1 Meridional Stresses for 'Without Sand' Case - Small Displacement

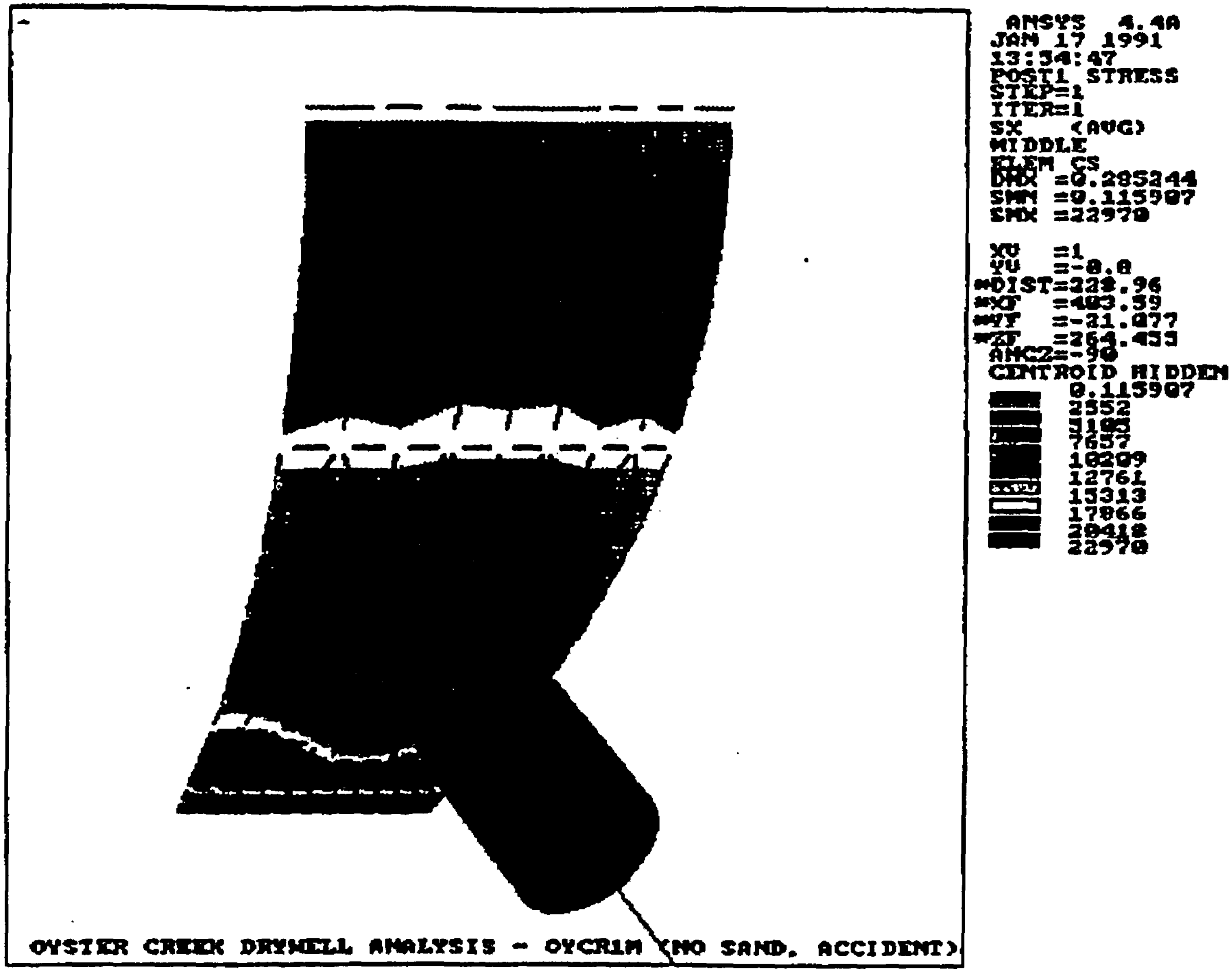

Figure 5-3 Circumferential Membrane Stress Distribution Using Small Displacement Option.

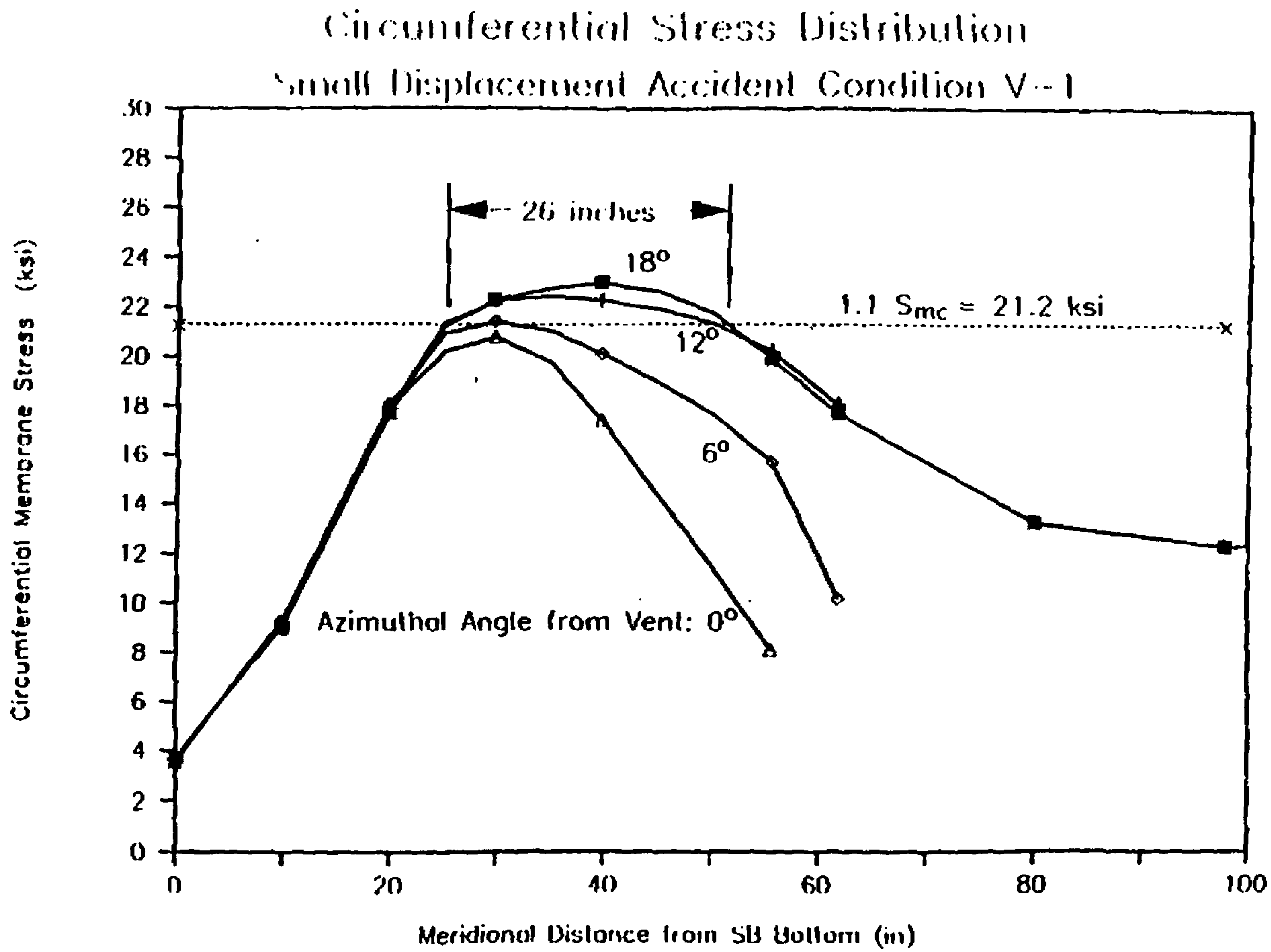

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Figure 5-4 Circumferential Membrane Stress Magnitudes at Four Meridional Planes in Sandbed Region - Small Displacement

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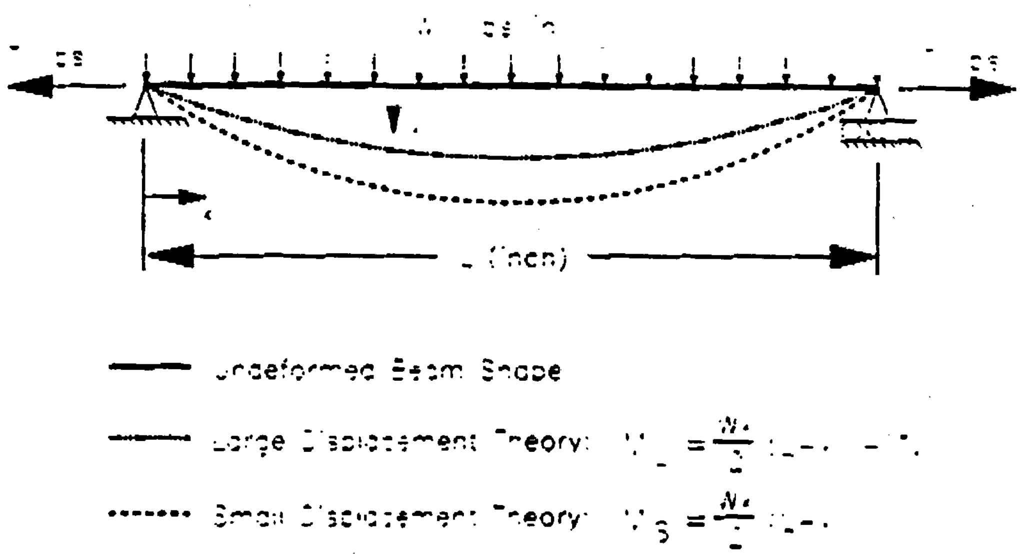

Figure 5-5 Beam With Transverse Plus Axial Loading

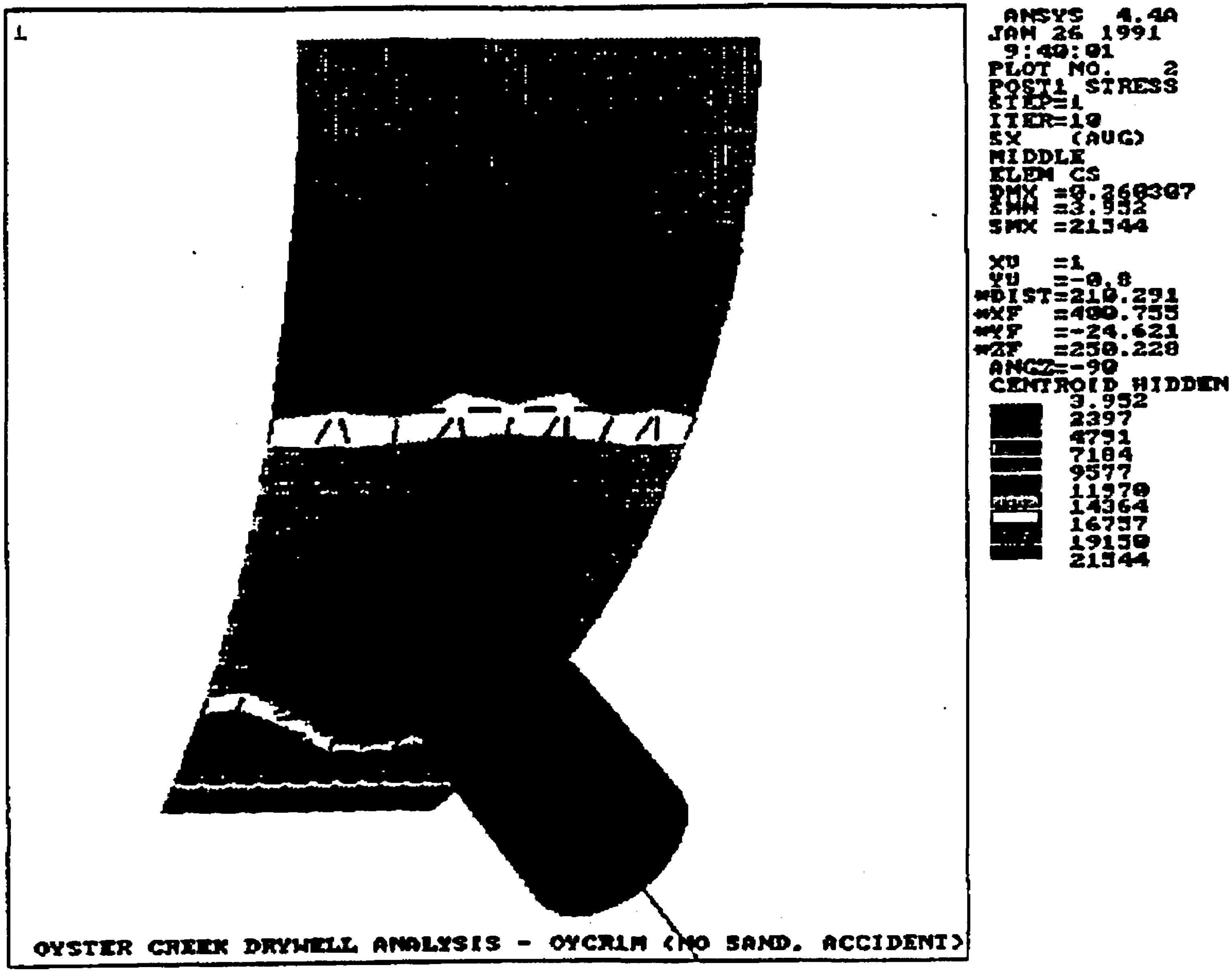

Figure 5-6 Circumferential Membrane Stress Distribution Using Large Displacement Option.

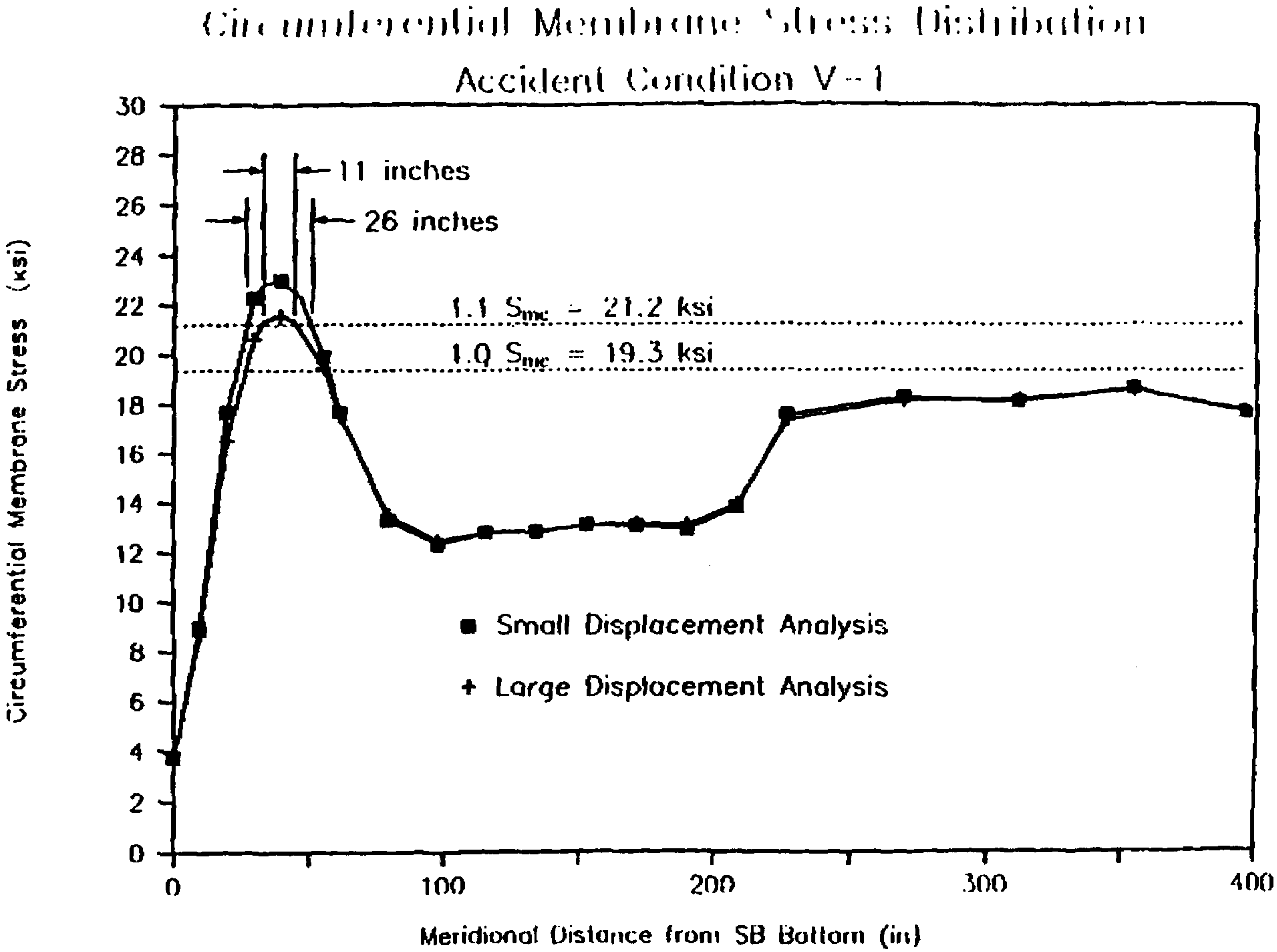

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Figure 5-7 Comparison of Circumferential Membrane Stress Magnitudes With Large and Small Displacement Options

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INDEX NO. 9-3, REV. 0

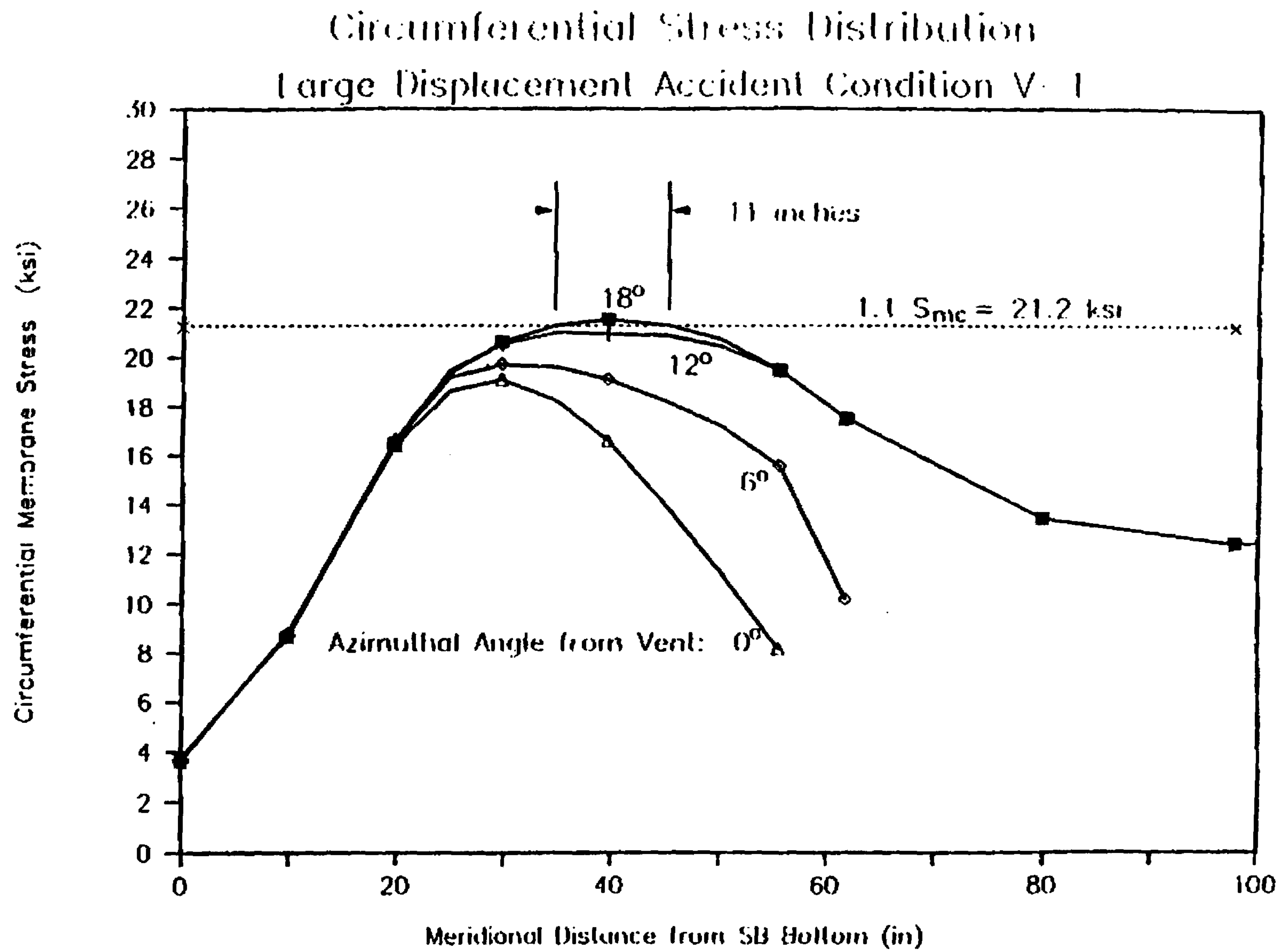

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Figure 5-8 Circumferential Membrane Stress Magnitudes at Four Meridional Planes in Sandbed Region - Large Displacement

DRF # 00664
INDEX NO. 9-3, REV. 0

6. SUMMARY AND CONCLUSIONS

This report is a supplementary report to the Code stress report (Reference 1-2) of record and addresses aspects of Code compliance as they relate to the local wall thinning observed and the removal of sand from the sandbed region in the Oyster Creek drywell. The loads and load combinations used in the analysis were based on the previous drywell stress analyses and the GPUN technical specification (Reference 1-4). In developing the allowable stress limits guidance was taken from Subsection NE of Section III, ASME Code where the Code of record, Section VIII and Code Case 1272N-5, is not explicit.

The stress analysis first considered a model in which everywhere as-designed thicknesses were used except in the sandbed region where the thickness was assumed as 0.736 inch. This served as a basis for evaluating the stresses for the 95% confidence projected thicknesses to 14R.

The highest stresses were determined to be from the Case V-1 and VI load combinations in all the different regions of the drywell. It was shown that the primary and secondary stresses are within the allowable limits for both conditions (as-designed thicknesses and 95% projected 14R thicknesses). At the plane of symmetry between the vent lines, the meridional extent of the circumferential membrane stress above $1.1S_{mc}$, was in excess of $1.0\sqrt{(Rt)}$. However, using a weighted average considering other meridional planes, this distance was less than $1.0\sqrt{(Rt)}$. Furthermore, a large displacement solution indicated the extent at the symmetry plane to be also less than $1.0\sqrt{(Rt)}$. This clearly satisfied the Code criterion for the extent of local primary membrane stress.

It is concluded that the Oyster Creek drywell shell will continue to meet the Code of record requirements at least up to 14R with the sand removed from the sandbed region. The analysis for buckling capability of the drywell shell without sand is contained in a companion GE report (Reference 1-5).

APPENDIX A

DETAILED RESULTS FOR AXISYMMETRIC MODEL TEMPERATURE STRESS ANALYSIS

This appendix presents a summary of the finite element analysis results for the temperature stress case (Load Case No. 8 in Table 3-1). The stresses reported in these tables are the nodal stresses. Since there are three nodes across the thickness of the drywell shell (e.g., see Figure 3-3), the stress at the center node is essentially a membrane stress. The difference between the stress at an inner or the outer node and the middle node is indicative of the bending stress at that section.

In each of the stress tables, the second and third columns from the left show the radial and vertical coordinates of the center nodes. Four stress components (three normal stresses and one shear stress) are listed for each of the inner, middle and the outer nodes.

Table 2-1 shows the wall thicknesses in the various regions of the drywell. To help assess the maximum stress levels, the range of node numbers associated with each wall thickness are given below:

Drywell Region	Node Number Range
Sandbed Region	1 through 96
Lower Spherical Region except Sandbed Area	100 through 237
Middle Spherical Region	241 through 603
Upper Spherical Region	604 through 876
Knuckle	880 through 942
Cylindrical Region	946 through 1449

ter Creek Raw Data for Thermal Stress at 210 seconds - No Send

					Outside Nodes					Middle Nodes					Inside Nodes			
					Radial	Meridional	Hoop			Radial	Meridional	Hoop			Radial	Meridional	Hoop	
ode	X	Y	Theta	Node	SX	SY	SZ	SXY	Node	SX	SY	SZ	SXY	Node	SX	SY	SZ	SXY
	(inch)	(inch)	(degrees)		(psi)	(psi)	(psi)	(psi)		(psi)	(psi)	(psi)	(psi)		(psi)	(psi)	(psi)	(psi)
2	247.08	106.93	36.00	1	226.09	1034.01	380.85	-9.14	2	-6.29	-8.65	-3.20	-6.90	3	-238.43	-1053.61	-387.87	-4.21
5	248.68	108.10	36.27	4	-82.03	985.03	271.56	-8.96	5	3.34	-8.66	-12.63	-6.88	6	60.72	-1004.52	-297.76	-4.42
8	250.28	109.28	36.54	7	18.78	872.26	231.35	-8.94	8	0.65	-8.80	-49.55	-7.00	9	-17.18	-891.83	-331.27	-4.76
11	251.87	110.48	36.81	10	-4.22	743.82	133.30	-9.02	11	1.10	-9.26	-106.80	-7.38	12	6.59	-764.10	-347.85	-5.42
14	253.45	111.66	37.08	13	1.89	609.76	23.76	-9.43	14	0.81	-10.17	-182.09	-8.02	15	0.10	-631.47	-388.54	-6.38
17	255.03	112.86	37.35	16	-0.58	459.91	-108.18	-10.20	17	0.64	-11.55	-271.83	-9.07	18	2.00	-484.13	-435.98	-7.76
20	256.61	114.06	37.62	19	-0.61	288.40	-257.49	-11.37	20	0.46	-13.55	-372.39	-10.57	21	1.63	-316.12	-487.59	-9.65
23	258.18	115.28	37.89	22	-1.40	88.88	-423.52	-12.97	23	0.18	-16.11	-479.58	-12.56	24	1.81	-119.42	-535.80	-12.09
26	259.74	116.50	38.16	25	-1.98	-152.78	-603.70	-14.98	26	-0.04	-19.39	-588.56	-15.06	27	1.87	114.41	-573.30	-15.16
29	261.30	117.73	38.43	28	-2.78	-439.18	-795.23	-17.41	29	-0.48	-23.16	-693.60	-18.06	30	1.78	393.65	-591.68	-18.81
32	262.85	118.97	38.70	31	-3.42	-780.08	-993.77	-20.13	32	-0.75	-27.66	-787.92	-21.52	33	1.73	726.71	-581.34	-23.13
35	264.39	120.21	38.98	34	-4.38	-1182.93	-1193.91	-23.18	35	-1.39	-32.38	-863.45	-25.39	36	1.30	1120.45	-532.04	-27.94
38	265.93	121.46	39.25	37	-4.91	-1652.58	-1387.74	-26.24	38	-1.74	-37.77	-910.68	-29.54	39	1.03	1581.18	-431.99	-33.34
41	267.47	122.72	39.52	40	-5.97	-2192.89	-1565.98	-29.41	41	-2.69	-42.79	-918.57	-33.82	42	0.03	2111.54	-269.35	-38.90
44	269.00	123.99	39.79	43	-6.20	-2802.51	-1715.52	-32.09	44	-3.61	-48.36	-874.40	-38.02	45	-0.52	2713.00	-30.40	-44.81
47	270.52	125.26	40.06	46	-7.38	-3478.59	-1822.08	-34.55	47	-4.46	-52.48	-763.87	-41.85	48	-2.42	3380.10	297.18	-50.23
50	272.03	126.54	40.33	49	-6.85	-4208.92	-1865.70	-35.67	50	-4.49	-57.08	-571.08	-44.97	51	-3.22	4106.08	728.07	-55.56
53	273.54	127.83	40.60	52	-8.24	-4980.28	-1828.71	-36.18	53	-6.69	-58.39	-278.98	-46.96	54	-6.44	4872.00	1272.68	-59.25
56	275.05	129.13	40.87	55	-6.16	-5763.37	-1678.89	-34.03	56	-5.97	-60.51	130.80	-47.29	57	-7.28	5659.14	1944.74	-62.32
59	276.54	130.43	41.14	58	-8.10	-6531.01	-1392.12	-30.95	59	-9.34	-58.11	675.68	-45.39	60	-12.29	6428.10	2748.54	-61.83
62	278.04	131.74	41.41	61	-3.20	-7230.80	-935.86	-23.08	62	-7.04	-53.90	1374.72	-40.55	63	-12.78	7146.60	3694.30	-60.29
65	279.54	133.07	41.68	64	-6.63	-7818.72	-271.20	-14.20	65	-13.01	-39.78	2254.64	-31.96	66	-21.46	7748.21	4784.93	-52.12
68	281.03	134.41	41.96	67	3.87	-8200.93	843.46	2.54	68	-6.63	-31.34	3322.91	-18.87	69	-19.12	8171.78	6014.92	-42.49
71	282.52	135.75	42.23	70	-2.54	-8313.58	1828.22	19.01	71	-16.73	-1.40	4587.72	0.07	72	-33.16	8308.43	7349.11	-21.43
74	284.01	137.11	42.50	73	18.71	-8015.78	3341.44	48.55	74	-2.78	13.73	6052.16	25.40	75	-24.45	8091.46	8779.96	-0.36
77	285.48	138.47	42.78	76	3.35	-7240.83	5179.99	73.93	77	-21.43	67.73	7707.77	57.98	78	-48.22	7350.12	10230.17	39.81
80	286.96	139.83	43.05	79	38.07	-5780.88	7407.65	120.94	80	7.18	87.33	9530.91	99.05	81	-25.38	6026.09	11677.57	75.06
83	288.42	141.21	43.33	82	12.42	-3599.93	9913.37	153.88	83	-27.11	182.58	11429.45	148.67	84	-67.78	3865.39	12917.21	142.37
86	289.88	142.59	43.60	85	56.15	-427.51	12302.47	221.80	86	23.22	215.99	12886.75	206.92	87	-10.11	889.81	13474.73	191.84
89	291.33	143.98	43.87	88	52.43	3582.20	12454.55	245.39	89	-16.56	394.74	11868.16	268.24	90	-84.78	-3247.12	11144.07	287.76
92	292.77	145.37	44.15	91	-131.59	8527.28	6323.45	308.60	92	-20.80	355.34	4258.37	305.94	93	91.71	-7947.40	2150.06	307.38
95	294.21	146.77	44.42	94	703.92	11000.93	-8125.28	1694.61	95	86.02	-12.80	-11318.26	-267.26	96	289.00	-9856.70	-13916.42	-182.15
98	294.65	147.04	44.49	97	1072.89	8080.70	-8625.81	2643.90	98	-131.17	561.36	-10877.87	-727.93	99	200.89	-8526.92	-13138.37	-584.42
101	295.08	147.31	44.56	100	31.35	5771.47	-9376.01	1086.78	101	-391.95	974.74	-10499.76	-116.71	102	-253.59	-7181.17	-12462.12	-291.51
104	296.51	148.72	44.83	103	28.09	6870.25	-7417.07	103.83	104	27.27	165.66	-9013.26	105.53	105	28.74	-6780.11	-10683.19	109.97
107	297.92	150.14	45.10	106	-5.45	7802.93	-5629.43	32.02	107	17.57	37.99	-7569.98	66.37	108	43.12	-7620.35	-9480.61	103.21

rter Creek Raw Data for Thermal Stress at 210 seconds - No Sand

					Outside Nodes					Middle Nodes					Inside Nodes			
					Radial	Meridional	Hoop			Radial	Meridional	Hoop			Radial	Meridional	Hoop	
Node	X (inch)	Y (inch)	Theta (degrees)	Node	SX (psi)	SY (psi)	SZ (psi)	SXY (psi)	Node	SX (psi)	SY (psi)	SZ (psi)	SXY (psi)	Node	SX (psi)	SY (psi)	SZ (psi)	SXY (psi)
110	299.33	151.56	45.37	109	-26.01	8227.45	-4115.90	17.47	110	-13.52	58.61	-8216.64	33.43	111	1.02	-8219.11	-8352.30	52.51
113	300.74	152.99	45.65	112	2.54	8436.21	-2787.41	-18.71	113	13.59	1.86	-5003.42	6.92	114	27.62	-8414.57	-7218.38	35.53
116	302.13	154.42	45.92	115	-11.79	8342.41	-1695.31	-33.27	116	-3.55	-2.16	-3923.80	-14.30	117	7.71	-8401.38	-6171.25	7.78
119	303.52	155.87	46.19	118	0.89	8089.45	-779.80	-51.47	119	6.37	-26.78	-2976.28	-30.59	120	14.83	-8161.44	-5180.91	-6.74
122	304.91	157.31	46.47	121	-4.82	7679.44	-47.92	-60.21	122	0.31	-34.03	-2157.55	-42.72	123	8.31	-7781.78	-4280.01	-22.39
125	306.28	158.77	46.74	124	8.32	7172.89	536.22	-68.38	125	6.23	-43.87	-1458.13	-51.20	126	6.89	-7285.78	-3482.47	-31.40
128	307.65	160.23	47.01	127	-28.28	6591.58	987,44	-71.28	128	-9.85	-47.72	-877.11	-56.72	129	8.98	-6714.93	-2732.34	-39.72
131	309.01	161.70	47.28	130	40.14	5741.73	1255.64	-82.07	131	32.25	-49.25	-371.53	-59.80	132	26.44	-5858.08	-2005.51	-35.38
134	312.35	165.36	47.96	133	23.07	4430.63	1737.09	-83.20	134	32.77	-44.56	462.83	-58.87	135	44.14	-4536.62	-818.54	-32.85
137	315.65	169.06	48.64	136	30.11	3020.78	1748.72	-86.92	137	15.95	-39.01	855.05	-50.73	138	3.07	-3109.98	-43.12	-33.40
140	318.91	172.81	49.31	139	21.10	1851.50	1528.91	-49.24	140	11.03	-30.65	966.51	-39.78	141	1.79	-1920.23	401.13	-29.58
143	322.12	176.58	49.99	142	18.22	968.99	1213.11	-33.25	143	5.40	-22.34	905.30	-28.61	144	-4.95	-1015.15	596.02	-23.80
146	325.28	180.40	50.66	145	10.49	351.91	882.73	-20.07	146	1.83	-14.76	756.51	-18.78	147	-6.62	-383.08	629.61	-17.34
149	328.40	184.25	51.34	148	6.35	-34.83	588.87	-10.24	149	-0.35	-8.94	577.73	-10.92	150	-7.01	17.20	568.64	-11.60
152	331.48	188.14	52.01	151	3.11	-245.84	347.57	-3.43	152	-1.57	-4.54	405.00	-5.17	153	-6.31	237.50	462.71	-6.98
155	334.51	192.07	52.68	154	0.74	-332.09	170.21	0.76	155	-2.17	-1.71	257.42	-1.31	156	-5.18	330.00	345.14	-3.49
158	337.49	196.03	53.38	157	-0.28	-339.77	49.71	2.88	158	-1.82	0.14	142.97	1.00	159	-3.47	341.28	238.72	-0.99
161	340.00	199.45	53.94	160	-0.54	-307.07	-14.99	3.56	161	-1.08	0.99	71.33	2.04	162	-1.69	310.29	158.12	0.43
164	342.48	202.89	54.52	163	-0.97	-257.44	-52.87	3.74	164	-1.13	1.39	20.71	2.49	165	-1.40	261.13	94.65	1.15
167	344.93	206.36	55.10	166	-0.94	-202.45	-70.61	3.47	167	-0.81	1.44	-11.90	2.51	168	-0.78	208.13	47.13	1.49
170	347.34	209.85	55.68	169	-0.91	-149.60	-74.54	2.99	170	-0.83	1.35	-30.52	2.29	171	-0.41	152.83	13.72	1.54
173	349.71	213.38	56.25	172	-0.76	-103.09	-69.67	2.40	173	-0.42	1.13	-38.85	1.93	174	-0.11	105.77	-7.88	1.43
176	352.05	216.90	56.83	175	-0.63	-64.95	-59.99	1.81	176	-0.27	0.91	-40.15	1.53	177	0.06	67.00	-20.21	1.22
179	354.35	220.46	57.41	178	-0.46	-35.54	-48.29	1.28	179	-0.14	0.67	-37.05	1.13	180	0.17	37.04	-25.75	0.98
182	356.62	224.05	57.99	181	-0.33	-14.29	-36.54	0.83	182	-0.06	0.48	-31.60	0.79	183	0.21	15.29	-28.84	0.73
185	358.85	227.88	58.57	184	-0.21	-0.01	-25.87	0.48	185	0.00	0.31	-25.24	0.50	186	0.22	0.63	-24.81	0.52
188	361.04	231.29	59.14	187	-0.13	8.65	-16.90	0.22	188	0.04	0.18	-18.95	0.28	189	0.20	-8.32	-21.01	0.33
191	363.20	234.94	59.72	190	-0.08	13.07	-9.82	0.04	191	0.08	0.09	-13.30	0.12	192	0.17	-12.94	-16.79	0.19
194	365.32	238.61	60.30	193	-0.01	14.49	-4.58	-0.07	194	0.08	0.03	-8.59	0.01	195	0.14	-14.49	-12.62	0.09
197	367.41	242.31	60.88	196	0.02	13.95	-0.98	-0.13	197	0.08	-0.01	-4.90	-0.06	198	0.10	-14.02	-8.86	0.01
200	369.45	246.03	61.45	199	0.03	12.28	1.34	-0.16	200	0.05	-0.03	-2.18	-0.09	201	0.07	-12.39	-5.72	-0.03
203	371.46	249.76	62.03	202	0.04	10.08	2.60	-0.16	203	0.04	-0.04	-0.32	-0.11	204	0.05	-10.20	-3.26	-0.06
206	373.43	253.52	62.61	205	0.04	7.78	3.13	-0.14	206	0.03	-0.04	0.85	-0.10	207	0.03	-7.89	-1.45	-0.06
209	375.38	257.30	63.19	208	0.04	5.64	3.15	-0.12	209	0.02	-0.04	1.48	-0.09	210	0.01	-5.74	-0.20	-0.06
212	377.26	261.09	63.77	211	0.03	3.81	2.87	-0.09	212	0.02	-0.03	1.73	-0.07	213	0.00	-3.89	0.58	-0.06
215	379.11	264.91	64.34	214	0.02	2.35	2.44	-0.07	215	0.01	-0.02	1.72	-0.06	216	0.00	-2.41	0.99	-0.05

ter Creek Raw Data for Thermal Stress at 210 seconds - No Sand

					Outside Nodes					Middle Nodes					Inside Nodes			
					Radial	Meridional	Hoop			Radial	Meridional	Hoop			Radial	Meridional	Hoop	
ode	X (inch)	Y (inch)	Theta (degrees)	Node	SX (psi)	SY (psi)	SZ (psi)	SXY (psi)	Node	SX (psi)	SY (psi)	SZ (psi)	SXY (psi)	Node	SX (psi)	SY (psi)	SZ (psi)	SXY (psi)
218	380.93	268.74	64.92	217	0.02	1.27	1.95	-0.05	218	0.00	-0.02	1.55	-0.04	219	-0.01	-1.31	1.15	-0.04
221	382.71	272.59	65.50	220	0.01	0.59	1.49	-0.03	221	0.00	-0.01	1.30	-0.03	222	0.00	-0.61	1.10	-0.02
224	383.49	274.32	65.76	223	0.01	0.25	1.27	-0.02	224	0.00	-0.01	1.17	-0.02	225	-0.01	-0.27	1.07	-0.02
227	384.26	276.04	66.02	226	0.00	0.07	1.08	-0.02	227	0.00	-0.01	1.04	-0.02	228	0.00	-0.08	1.00	-0.02
230	385.03	277.78	66.27	229	0.00	-0.07	0.91	-0.01	230	0.00	0.00	0.91	-0.01	231	0.00	0.05	0.91	-0.01
233	385.79	279.51	66.53	232	0.00	-0.18	0.75	-0.01	233	0.00	0.00	0.78	-0.01	234	0.00	0.15	0.82	-0.01
236	386.54	281.25	66.79	235	0.00	-0.22	0.61	0.02	236	0.01	-0.02	0.66	-0.01	237	0.01	0.25	0.72	-0.02
239	386.75	282.00	66.90	238	-0.01	-0.35	0.51	0.06	239	0.01	-0.01	0.61	-0.03	240	0.00	0.37	0.71	-0.03
242	386.97	282.74	67.00	241	-0.02	-0.52	0.41	0.03	242	-0.01	0.00	0.56	-0.02	243	-0.01	0.50	0.70	-0.02
245	387.40	283.76	67.15	244	0.00	-0.60	0.32	0.00	245	0.00	0.00	0.49	0.00	246	0.00	0.59	0.66	0.00
248	387.82	284.77	67.30	247	0.00	-0.61	0.25	0.00	248	0.00	0.00	0.43	0.00	249	0.00	0.61	0.60	0.00
251	388.24	285.79	67.45	250	0.00	-0.62	0.19	0.00	251	0.00	0.00	0.37	0.00	252	0.00	0.62	0.55	0.00
254	388.67	286.80	67.60	253	0.00	-0.62	0.14	0.00	254	0.00	0.00	0.31	0.00	255	0.00	0.62	0.49	0.00
257	389.08	287.82	67.75	256	0.00	-0.61	0.09	0.00	257	0.00	0.00	0.27	0.00	258	0.00	0.61	0.44	0.00
260	389.50	288.84	67.90	259	0.00	-0.60	0.05	0.00	260	0.00	0.00	0.22	0.00	261	0.00	0.60	0.39	0.00
263	389.91	289.86	68.05	262	0.00	-0.58	0.01	0.00	263	0.00	0.00	0.18	0.00	264	0.00	0.58	0.35	0.00
266	390.32	290.88	68.20	265	0.00	-0.56	-0.02	0.00	266	0.00	0.00	0.14	0.00	267	0.00	0.56	0.30	0.00
269	390.73	291.90	68.35	268	0.00	-0.53	-0.05	0.00	269	0.00	0.00	0.11	0.00	270	0.00	0.53	0.26	0.00
272	391.13	292.93	68.50	271	0.00	-0.49	-0.07	0.00	272	0.00	0.00	0.08	0.00	273	0.00	0.49	0.22	0.00
275	392.28	295.87	68.93	274	0.00	-0.42	-0.11	0.01	275	0.00	0.00	0.01	0.00	276	0.00	0.42	0.13	0.00
278	393.40	298.82	69.36	277	0.00	-0.33	-0.13	0.00	278	0.00	0.00	-0.03	0.00	279	0.00	0.33	0.06	0.00
281	394.50	301.77	69.79	280	0.00	-0.24	-0.13	0.00	281	0.00	0.00	-0.06	0.00	282	0.00	0.25	0.01	0.00
284	395.58	304.74	70.22	283	0.00	-0.17	-0.12	0.00	284	0.00	0.00	-0.07	0.00	285	0.00	0.17	-0.02	0.00
287	396.64	307.71	70.65	286	0.00	-0.11	-0.10	0.00	287	0.00	0.00	-0.07	0.00	288	0.00	0.11	-0.04	0.00
290	397.67	310.69	71.08	289	0.00	-0.06	-0.09	0.00	290	0.00	0.00	-0.07	0.00	291	0.00	0.07	-0.05	0.00
293	398.68	313.68	71.51	292	0.00	-0.03	-0.07	0.00	293	0.00	0.00	-0.06	0.00	294	0.00	0.03	-0.05	0.00
296	399.67	316.68	71.94	295	0.00	0.00	-0.05	0.00	296	0.00	0.00	-0.05	0.00	297	0.00	0.00	-0.05	0.00
299	400.64	319.68	72.37	298	0.00	0.01	-0.03	0.00	299	0.00	0.00	-0.04	0.00	300	0.00	-0.01	-0.04	0.00
302	401.58	322.69	72.80	301	0.00	0.02	-0.02	0.00	302	0.00	0.00	-0.03	0.00	303	0.00	-0.02	-0.03	0.00
305	402.51	325.71	73.23	304	0.00	0.03	-0.01	0.00	305	0.00	0.00	-0.02	0.00	306	0.00	-0.03	-0.03	0.00
308	403.41	328.73	73.66	307	0.00	0.03	0.00	0.00	308	0.00	0.00	-0.01	0.00	309	0.00	-0.03	-0.02	0.00
311	404.28	331.76	74.09	310	0.00	0.02	0.00	0.00	311	0.00	0.00	-0.01	0.00	312	0.00	-0.02	-0.01	0.00
314	405.13	334.80	74.52	313	0.00	0.02	0.00	0.00	314	0.00	0.00	0.00	0.00	315	0.00	-0.02	-0.01	0.00
317	405.97	337.84	74.95	316	0.00	0.02	0.01	0.00	317	0.00	0.00	0.00	0.00	318	0.00	-0.02	-0.01	0.00
320	406.77	340.89	75.38	319	0.00	0.01	0.01	0.00	320	0.00	0.00	0.00	0.00	321	0.00	-0.01	0.00	0.00
323	407.58	343.95	75.81	322	0.00	0.01	0.01	0.00	323	0.00	0.00	0.00	0.00	324	0.00	-0.01	0.00	0.00

ter Creek Raw Data for Thermal Stress at 210 seconds - No Sand

Node	X (inch)	Y (inch)	Theta (degrees)	Outside Nodes: Node	Outside Radial SX (psi)	Outside Meridional SY (psi)	Outside Hoop SZ (psi)	Outside SXY (psi)	Middle Nodes: Node	Middle Radial SX (psi)	Middle Meridional SY (psi)	Middle Hoop SZ (psi)	Middle SXY (psi)	Inside Nodes: Node	Inside Radial SX (psi)	Inside Meridional SY (psi)	Inside Hoop SZ (psi)	Inside SXY (psi)
326	408.32	347.01	76.24	325	0.00	0.01	0.01	0.00	326	0.00	0.00	0.00	0.00	327	0.00	-0.01	0.00	0.00
329	409.06	350.08	76.67	328	0.00	0.00	0.00	0.00	329	0.00	0.00	0.00	0.00	330	0.00	0.00	0.00	0.00
332	409.77	353.15	77.10	331	0.00	0.00	0.00	0.00	332	0.00	0.00	0.00	0.00	333	0.00	0.00	0.00	0.00
335	410.47	356.23	77.53	334	0.00	0.00	0.00	0.00	335	0.00	0.00	0.00	0.00	336	0.00	0.00	0.00	0.00
338	411.14	359.31	77.96	337	0.00	0.00	0.00	0.00	338	0.00	0.00	0.00	0.00	339	0.00	0.00	0.00	0.00
341	411.78	362.40	78.39	340	0.00	0.00	0.00	0.00	341	0.00	0.00	0.00	0.00	342	0.00	0.00	0.00	0.00
344	412.41	365.49	78.82	343	0.00	0.00	0.00	0.00	344	0.00	0.00	0.00	0.00	345	0.00	0.00	0.00	0.00
347	413.01	368.59	79.25	346	0.00	0.00	0.00	0.00	347	0.00	0.00	0.00	0.00	348	0.00	0.00	0.00	0.00
350	413.58	371.69	79.68	349	0.00	0.00	0.00	0.00	350	0.00	0.00	0.00	0.00	351	0.00	0.00	0.00	0.00
353	414.14	374.80	80.11	352	0.00	0.00	0.00	0.00	353	0.00	0.00	0.00	0.00	354	0.00	0.00	0.00	0.00
356	414.67	377.91	80.54	355	0.00	0.00	0.00	0.00	356	0.00	0.00	0.00	0.00	357	0.00	0.00	0.00	0.00
359	415.17	381.02	80.97	358	0.00	0.00	0.00	0.00	359	0.00	0.00	0.00	0.00	360	0.00	0.00	0.00	0.00
362	415.66	384.14	81.40	361	0.00	0.00	0.00	0.00	362	0.00	0.00	0.00	0.00	363	0.00	0.00	0.00	0.00
365	416.12	387.26	81.83	364	0.00	0.00	0.00	0.00	365	0.00	0.00	0.00	0.00	366	0.00	0.00	0.00	0.00
368	416.56	390.38	82.26	367	0.00	0.00	0.00	0.00	368	0.00	0.00	0.00	0.00	369	0.00	0.00	0.00	0.00
371	416.97	393.51	82.69	370	0.00	0.00	0.00	0.00	371	0.00	0.00	0.00	0.00	372	0.00	0.00	0.00	0.00
374	417.36	396.64	83.12	373	0.00	0.00	0.00	0.00	374	0.00	0.00	0.00	0.00	375	0.00	0.00	0.00	0.00
377	417.72	399.78	83.55	376	0.00	0.00	0.00	0.00	377	0.00	0.00	0.00	0.00	378	0.00	0.00	0.00	0.00
380	418.07	402.91	83.98	379	0.00	0.00	0.00	0.00	380	0.00	0.00	0.00	0.00	381	0.00	0.00	0.00	0.00
383	418.39	406.05	84.41	382	0.00	0.00	0.00	0.00	383	0.00	0.00	0.00	0.00	384	0.00	0.00	0.00	0.00
386	418.68	409.19	84.84	385	0.00	0.00	0.00	0.00	386	0.00	0.00	0.00	0.00	387	0.00	0.00	0.00	0.00
389	418.95	412.33	85.27	388	0.00	0.00	0.00	0.00	389	0.00	0.00	0.00	0.00	390	0.00	0.00	0.00	0.00
392	419.20	415.48	85.70	391	0.00	0.00	0.00	0.00	392	0.00	0.00	0.00	0.00	393	0.00	0.00	0.00	0.00
395	419.43	418.63	86.13	394	0.00	0.00	0.00	0.00	395	0.00	0.00	0.00	0.00	396	0.00	0.00	0.00	0.00
398	419.63	421.78	86.56	397	0.00	0.00	0.00	0.00	398	0.00	0.00	0.00	0.00	399	0.00	0.00	0.00	0.00
401	419.81	424.93	86.99	400	0.00	0.00	0.00	0.00	401	0.00	0.00	0.00	0.00	402	0.00	0.00	0.00	0.00
404	419.96	428.08	87.42	403	0.00	0.00	0.00	0.00	404	0.00	0.00	0.00	0.00	405	0.00	0.00	0.00	0.00
407	420.09	431.23	87.85	406	0.00	0.00	0.00	0.00	407	0.00	0.00	0.00	0.00	408	0.00	0.00	0.00	0.00
410	420.20	434.38	88.28	409	0.00	0.00	0.00	0.00	410	0.00	0.00	0.00	0.00	411	0.00	0.00	0.00	0.00
413	420.28	437.54	88.71	412	0.00	0.00	0.00	0.00	413	0.00	0.00	0.00	0.00	414	0.00	0.00	0.00	0.00
416	420.34	440.69	89.14	415	0.00	0.00	0.00	0.00	416	0.00	0.00	0.00	0.00	417	0.00	0.00	0.00	0.00
419	420.37	443.85	89.57	418	0.00	0.00	0.00	0.00	419	0.00	0.00	0.00	0.00	420	0.00	0.00	0.00	0.00
422	420.39	447.00	90.00	421	0.00	0.00	0.00	0.00	422	0.00	0.00	0.00	0.00	423	0.00	0.00	0.00	0.00
425	420.37	450.15	90.43	424	0.00	0.00	0.00	0.00	425	0.00	0.00	0.00	0.00	426	0.00	0.00	0.00	0.00
428	420.34	453.31	90.86	427	0.00	0.00	0.00	0.00	428	0.00	0.00	0.00	0.00	429	0.00	0.00	0.00	0.00
431	420.28	456.46	91.29	430	0.00	0.00	0.00	0.00	431	0.00	0.00	0.00	0.00	432	0.00	0.00	0.00	0.00

Oyster Creek Raw Data for Thermal Stress at 210 seconds - No Sand

					Outside Nodes					Middle Nodes					Inside Nodes			
Node	X (inch)	Y (inch)	Theta (degrees)	Node	Radial SX (psi)	Meridional SY (psi)	Hoop SZ (psi)	SXY (psi)	Node	Radial SX (psi)	Meridional SY (psi)	Hoop SZ (psi)	SXY (psi)	Node	Radial SX (psi)	Meridional SY (psi)	Hoop SZ (psi)	SXY (psi)
434	420.20	459.62	91.72	433	0.00	0.00	0.00	0.00	434	0.00	0.00	0.00	0.00	435	0.00	0.00	0.00	0.00
437	420.09	462.77	92.15	436	0.00	0.00	0.00	0.00	437	0.00	0.00	0.00	0.00	438	0.00	0.00	0.00	0.00
440	419.96	465.92	92.58	439	0.00	0.00	0.00	0.00	440	0.00	0.00	0.00	0.00	441	0.00	0.00	0.00	0.00
443	419.81	469.07	93.01	442	0.00	0.00	0.00	0.00	443	0.00	0.00	0.00	0.00	444	0.00	0.00	0.00	0.00
446	419.63	472.22	93.44	445	0.00	0.00	0.00	0.00	446	0.00	0.00	0.00	0.00	447	0.00	0.00	0.00	0.00
449	419.43	475.37	93.87	448	0.00	0.00	0.00	0.00	449	0.00	0.00	0.00	0.00	450	0.00	0.00	0.00	0.00
452	419.20	478.52	94.30	451	0.00	0.00	0.00	0.00	452	0.00	0.00	0.00	0.00	453	0.00	0.00	0.00	0.00
455	418.95	481.67	94.73	454	0.00	0.00	0.00	0.00	455	0.00	0.00	0.00	0.00	456	0.00	0.00	0.00	0.00
458	418.68	484.81	95.16	457	0.00	0.00	0.00	0.00	458	0.00	0.00	0.00	0.00	459	0.00	0.00	0.00	0.00
461	418.39	487.95	95.59	460	0.00	0.00	0.00	0.00	461	0.00	0.00	0.00	0.00	462	0.00	0.00	0.00	0.00
464	418.07	491.09	96.02	463	0.00	0.00	0.00	0.00	464	0.00	0.00	0.00	0.00	465	0.00	0.00	0.00	0.00
467	417.72	494.22	96.45	466	0.00	0.00	0.00	0.00	467	0.00	0.00	0.00	0.00	468	0.00	0.00	0.00	0.00
470	417.36	497.36	96.88	469	0.00	0.00	0.00	0.00	470	0.00	0.00	0.00	0.00	471	0.00	0.00	0.00	0.00
473	416.97	500.49	97.31	472	0.00	0.00	0.00	0.00	473	0.00	0.00	0.00	0.00	474	0.00	0.00	0.00	0.00
476	416.56	503.62	97.74	475	0.00	0.00	0.00	0.00	476	0.00	0.00	0.00	0.00	477	0.00	0.00	0.00	0.00
479	416.12	506.74	98.17	478	0.00	0.00	0.00	0.00	479	0.00	0.00	0.00	0.00	480	0.00	0.00	0.00	0.00
482	415.66	509.86	98.60	481	0.00	0.00	0.00	0.00	482	0.00	0.00	0.00	0.00	483	0.00	0.00	0.00	0.00
485	415.17	512.98	99.03	484	0.00	0.00	0.00	0.00	485	0.00	0.00	0.00	0.00	486	0.00	0.00	0.00	0.00
488	414.67	516.09	99.46	487	0.00	0.00	0.00	0.00	488	0.00	0.00	0.00	0.00	489	0.00	0.00	0.00	0.00
491	414.14	519.20	99.89	490	0.00	0.00	0.00	0.00	491	0.00	0.00	0.00	0.00	492	0.00	0.00	0.00	0.00
494	413.58	522.31	100.32	493	0.00	0.00	0.00	0.00	494	0.00	0.00	0.00	0.00	495	0.00	0.00	0.00	0.00
497	413.01	525.41	100.75	496	0.00	0.00	0.00	0.00	497	0.00	0.00	0.00	0.00	498	0.00	0.00	0.00	0.00
500	412.41	528.51	101.18	499	0.00	0.00	0.00	0.00	500	0.00	0.00	0.00	0.00	501	0.00	0.00	0.00	0.00
503	411.78	531.60	101.61	502	0.00	0.00	0.00	0.00	503	0.00	0.00	0.00	0.00	504	0.00	0.00	0.00	0.00
506	411.14	534.69	102.04	505	0.00	0.00	0.00	0.00	506	0.00	0.00	0.00	0.00	507	0.00	0.00	0.00	0.00
509	410.47	537.77	102.47	508	0.00	0.00	0.00	0.00	509	0.00	0.00	0.00	0.00	510	0.00	0.00	0.00	0.00
512	409.77	540.85	102.90	511	0.00	0.00	0.00	0.00	512	0.00	0.00	0.00	0.00	513	0.00	0.00	0.00	0.00
515	409.06	543.92	103.33	514	0.00	0.00	0.00	0.00	515	0.00	0.00	0.00	0.00	516	0.00	0.00	0.00	0.00
518	408.32	546.99	103.76	517	0.00	0.00	0.00	0.00	518	0.00	0.00	0.00	0.00	519	0.00	0.00	0.00	0.00
521	407.56	550.05	104.19	520	0.00	0.00	0.00	0.00	521	0.00	0.00	0.00	0.00	522	0.00	0.00	0.00	0.00
524	406.77	553.11	104.62	523	0.00	0.00	0.00	0.00	524	0.00	0.00	0.00	0.00	525	0.00	0.00	0.00	0.00
527	405.97	556.16	105.05	526	0.00	0.00	0.00	0.00	527	0.00	0.00	0.00	0.00	528	0.00	0.00	0.00	0.00
530	405.13	559.20	105.48	529	0.00	0.00	0.00	0.00	530	0.00	0.00	0.00	0.00	531	0.00	0.00	0.00	0.00
533	404.28	562.24	105.91	532	0.00	0.00	0.00	0.00	533	0.00	0.00	0.00	0.00	534	0.00	0.00	0.00	0.00
536	403.41	565.27	106.34	535	0.00	0.00	0.00	0.00	536	0.00	0.00	0.00	0.00	537	0.00	0.00	0.00	0.00
539	402.51	568.29	106.77	538	0.00	0.00	0.00	0.00	539	0.00	0.00	0.00	0.00	540	0.00	0.00	0.00	0.00

Oyster Creek Raw Data for Thermal Stress at 210 seconds - No Sand

Node	X (inch)	Y (inch)	Theta (degrees)	Outside Nodes: Node	Outside Nodes: Radial SX (psi)	Outside Nodes: Meridional SY (psi)	Outside Nodes: Hoop SZ (psi)	Outside Nodes: SXY (psi)	Middle Nodes: Node	Middle Nodes: Radial SX (psi)	Middle Nodes: Meridional SY (psi)	Middle Nodes: Hoop SZ (psi)	Middle Nodes: SXY (psi)	Inside Nodes: Node	Inside Nodes: Radial SX (psi)	Inside Nodes: Meridional SY (psi)	Inside Nodes: Hoop SZ (psi)	Inside Nodes: SXY (psi)
542	401.58	571.31	107.20	541	0.00	0.00	0.00	0.00	542	0.00	0.00	0.00	0.00	543	0.00	0.00	0.00	0.00
545	400.64	574.32	107.63	544	0.00	0.00	0.00	0.00	545	0.00	0.00	0.00	0.00	546	0.00	0.00	0.00	0.00
548	399.67	577.32	108.06	547	0.00	0.00	0.00	0.00	548	0.00	0.00	0.00	0.00	549	0.00	0.00	0.00	0.00
551	398.68	580.32	108.49	550	0.00	0.00	0.00	0.00	551	0.00	0.00	0.00	0.00	552	0.00	0.00	0.00	0.00
554	397.67	583.31	108.92	553	0.00	0.00	0.00	0.00	554	0.00	0.00	0.00	0.00	555	0.00	0.00	0.00	0.00
557	396.64	586.29	109.35	556	0.00	0.00	0.00	0.00	557	0.00	0.00	0.00	0.00	558	0.00	0.00	0.00	0.00
560	395.58	589.26	109.78	559	0.00	0.00	0.00	0.00	560	0.00	0.00	0.00	0.00	561	0.00	0.00	0.00	0.00
563	394.50	592.23	110.21	562	0.00	0.00	0.00	0.00	563	0.00	0.00	0.00	0.00	564	0.00	0.00	0.00	0.00
566	393.40	595.18	110.64	565	0.00	0.00	0.00	0.00	566	0.00	0.00	0.00	0.00	567	0.00	0.00	0.00	0.00
569	392.28	598.13	111.07	568	0.00	0.00	0.00	0.00	569	0.00	0.00	0.00	0.00	570	0.00	0.00	0.00	0.00
572	391.13	601.07	111.50	571	0.00	0.00	0.00	0.00	572	0.00	0.00	0.00	0.00	573	0.00	0.00	0.00	0.00
575	390.73	602.10	111.65	574	0.00	0.00	0.00	0.00	575	0.00	0.00	0.00	0.00	576	0.00	0.00	0.00	0.00
578	390.32	603.12	111.80	577	0.00	0.00	0.00	0.00	578	0.00	0.00	0.00	0.00	579	0.00	0.00	0.00	0.00
581	389.91	604.14	111.95	580	0.00	0.00	0.00	0.00	581	0.00	0.00	0.00	0.00	582	0.00	0.00	0.00	0.00
584	389.50	605.16	112.10	583	0.00	0.00	0.00	0.00	584	0.00	0.00	0.00	0.00	585	0.00	0.00	0.00	0.00
587	389.08	606.18	112.25	586	0.00	0.00	0.00	0.00	587	0.00	0.00	0.00	0.00	588	0.00	0.00	0.00	0.00
590	388.67	607.20	112.40	589	0.00	0.00	0.00	0.00	590	0.00	0.00	0.00	0.00	591	0.00	0.00	0.00	0.00
593	388.24	608.21	112.55	592	0.00	0.00	0.00	0.00	593	0.00	0.00	0.00	0.00	594	0.00	0.00	0.00	0.00
596	387.82	609.23	112.70	595	0.00	0.00	0.00	0.00	596	0.00	0.00	0.00	0.00	597	0.00	0.00	0.00	0.00
599	387.40	610.24	112.85	598	0.00	0.00	0.00	0.00	599	0.00	0.00	0.00	0.00	600	0.00	0.00	0.00	0.00
602	386.97	611.26	113.00	601	0.00	0.00	0.00	0.00	602	0.00	0.00	0.00	0.00	603	0.00	0.00	0.00	0.00
605	386.88	611.39	113.02	604	0.00	0.00	0.00	0.00	605	0.00	0.00	0.00	0.00	606	0.00	0.00	0.00	0.00
608	386.11	613.20	113.29	607	0.00	0.00	0.00	0.00	608	0.00	0.00	0.00	0.00	609	0.00	0.00	0.00	0.00
611	385.33	615.01	113.56	610	0.00	0.00	0.00	0.00	611	0.00	0.00	0.00	0.00	612	0.00	0.00	0.00	0.00
614	384.54	616.81	113.83	613	0.00	0.00	0.00	0.00	614	0.00	0.00	0.00	0.00	615	0.00	0.00	0.00	0.00
617	383.74	618.61	114.09	616	0.00	0.00	0.00	0.00	617	0.00	0.00	0.00	0.00	618	0.00	0.00	0.00	0.00
620	382.93	620.41	114.36	619	0.00	0.00	0.00	0.00	620	0.00	0.00	0.00	0.00	621	0.00	0.00	0.00	0.00
623	382.11	622.20	114.63	622	0.00	0.00	0.00	0.00	623	0.00	0.00	0.00	0.00	624	0.00	0.00	0.00	0.00
626	381.29	623.98	114.90	625	0.00	0.00	0.00	0.00	626	0.00	0.00	0.00	0.00	627	0.00	0.00	0.00	0.00
629	380.45	625.77	115.17	628	0.00	0.00	0.00	0.00	629	0.00	0.00	0.00	0.00	630	0.00	0.00	0.00	0.00
632	379.61	627.55	115.44	631	0.00	0.00	0.00	0.00	632	0.00	0.00	0.00	0.00	633	0.00	0.00	0.00	0.00
635	378.76	629.32	115.70	634	0.00	0.00	0.00	0.00	635	0.00	0.00	0.00	0.00	636	0.00	0.00	0.00	0.00
638	377.91	631.09	115.97	637	0.00	0.00	0.00	0.00	638	0.00	0.00	0.00	0.00	639	0.00	0.00	0.00	0.00
641	377.04	632.86	116.24	640	0.00	0.00	0.00	0.00	641	0.00	0.00	0.00	0.00	642	0.00	0.00	0.00	0.00
644	376.16	634.63	116.51	643	0.00	0.00	0.00	0.00	644	0.00	0.00	0.00	0.00	645	0.00	0.00	0.00	0.00
647	375.28	636.39	116.78	646	0.00	0.00	0.00	0.00	647	0.00	0.00	0.00	0.00	648	0.00	0.00	0.00	0.00

Oyster Creek Raw Data for Thermal Stress at 210 seconds - No Sand

				Outside Nodes					Middle Nodes					Inside Nodes				
Node	X (inch)	Y (inch)	Theta (degrees)	Node	Radial SX (psi)	Meridional SY (psi)	Hoop SZ (psi)	SXY (psi)	Node	Radial SX (psi)	Meridional SY (psi)	Hoop SZ (psi)	SXY (psi)	Node	Radial SX (psi)	Meridional SY (psi)	Hoop SZ (psi)	SXY (psi)
650	374.39	638.14	117.05	649	0.00	0.00	0.00	0.00	650	0.00	0.00	0.00	0.00	651	0.00	0.00	0.00	0.00
653	373.49	639.89	117.31	652	0.00	0.00	0.00	0.00	653	0.00	0.00	0.00	0.00	654	0.00	0.00	0.00	0.00
656	372.58	641.64	117.58	655	0.00	0.00	0.00	0.00	656	0.00	0.00	0.00	0.00	657	0.00	0.00	0.00	0.00
659	371.67	643.38	117.85	658	0.00	0.00	0.00	0.00	659	0.00	0.00	0.00	0.00	660	0.00	0.00	0.00	0.00
662	370.74	645.12	118.12	661	0.00	0.00	0.00	0.00	662	0.00	0.00	0.00	0.00	663	0.00	0.00	0.00	0.00
665	369.81	646.85	118.39	664	0.00	0.00	0.00	0.00	665	0.00	0.00	0.00	0.00	666	0.00	0.00	0.00	0.00
668	368.87	648.58	118.66	667	0.00	0.00	0.00	0.00	668	0.00	0.00	0.00	0.00	669	0.00	0.00	0.00	0.00
671	368.80	648.72	118.68	670	0.00	0.00	0.00	0.00	671	0.00	0.00	0.00	0.00	672	0.00	0.00	0.00	0.00
674	367.64	650.82	119.00	673	0.00	0.00	0.00	0.00	674	0.00	0.00	0.00	0.00	675	0.00	0.00	0.00	0.00
677	366.48	652.91	119.33	676	0.00	0.00	0.00	0.00	677	0.00	0.00	0.00	0.00	678	0.00	0.00	0.00	0.00
680	365.30	654.99	119.66	679	0.00	0.00	0.00	0.00	680	0.00	0.00	0.00	0.00	681	0.00	0.00	0.00	0.00
683	364.11	657.06	119.98	682	0.00	0.00	0.00	0.00	683	0.00	0.00	0.00	0.00	684	0.00	0.00	0.00	0.00
686	362.91	659.13	120.31	685	0.00	0.00	0.00	0.00	686	0.00	0.00	0.00	0.00	687	0.00	0.00	0.00	0.00
689	361.70	661.19	120.63	688	0.00	0.00	0.00	0.00	689	0.00	0.00	0.00	0.00	690	0.00	0.00	0.00	0.00
692	360.47	663.25	120.96	691	0.00	0.00	0.00	0.00	692	0.00	0.00	0.00	0.00	693	0.00	0.00	0.00	0.00
695	359.24	665.30	121.29	694	0.00	0.00	0.00	0.00	695	0.00	0.00	0.00	0.00	696	0.00	0.00	0.00	0.00
698	357.99	667.34	121.61	697	0.00	0.00	0.00	0.00	698	0.00	0.00	0.00	0.00	699	0.00	0.00	0.00	0.00
701	356.73	669.37	121.94	700	0.00	0.00	0.00	0.00	701	0.00	0.00	0.00	0.00	702	0.00	0.00	0.00	0.00
704	355.46	671.40	122.26	703	0.00	0.00	0.00	0.00	704	0.00	0.00	0.00	0.00	705	0.00	0.00	0.00	0.00
707	354.17	673.42	122.59	706	0.00	0.00	0.00	0.00	707	0.00	0.00	0.00	0.00	708	0.00	0.00	0.00	0.00
710	352.88	675.43	122.92	709	0.00	0.00	0.00	0.00	710	0.00	0.00	0.00	0.00	711	0.00	0.00	0.00	0.00
713	351.57	677.43	123.24	712	0.00	0.00	0.00	0.00	713	0.00	0.00	0.00	0.00	714	0.00	0.00	0.00	0.00
716	350.26	679.43	123.57	715	0.00	0.00	0.00	0.00	716	0.00	0.00	0.00	0.00	717	0.00	0.00	0.00	0.00
719	348.93	681.42	123.89	718	0.00	0.00	0.00	0.00	719	0.00	0.00	0.00	0.00	720	0.00	0.00	0.00	0.00
722	347.59	683.40	124.22	721	0.00	0.00	0.00	0.00	722	0.00	0.00	0.00	0.00	723	0.00	0.00	0.00	0.00
725	346.24	685.37	124.55	724	0.00	0.00	0.00	0.00	725	0.00	0.00	0.00	0.00	726	0.00	0.00	0.00	0.00
728	344.88	687.34	124.87	727	0.00	0.00	0.00	0.00	728	0.00	0.00	0.00	0.00	729	0.00	0.00	0.00	0.00
731	343.50	689.30	125.20	730	0.00	0.00	0.00	0.00	731	0.00	0.00	0.00	0.00	732	0.00	0.00	0.00	0.00
734	342.12	691.25	125.52	733	0.00	0.00	0.00	0.00	734	0.00	0.00	0.00	0.00	735	0.00	0.00	0.00	0.00
737	340.72	693.19	125.85	736	0.00	0.00	0.00	0.00	737	0.00	0.00	0.00	0.00	738	0.00	0.00	0.00	0.00
740	339.32	695.13	126.18	739	0.00	0.00	0.00	0.00	740	0.00	0.00	0.00	0.00	741	0.00	0.00	0.00	0.00
743	337.90	697.05	126.50	742	0.00	0.00	0.00	0.00	743	0.00	0.00	0.00	0.00	744	0.00	0.00	0.00	0.00
746	336.47	698.97	126.83	745	0.00	0.00	0.00	0.00	746	0.00	0.00	0.00	0.00	747	0.00	0.00	0.00	0.00
749	335.03	700.88	127.15	748	0.00	0.00	0.00	0.00	749	0.00	0.00	0.00	0.00	750	0.00	0.00	0.00	0.00
752	333.58	702.79	127.48	751	0.00	0.00	0.00	0.00	752	0.00	0.00	0.00	0.00	753	0.00	0.00	0.00	0.00
755	332.12	704.68	127.81	754	0.00	0.00	0.00	0.00	755	0.00	0.00	0.00	0.00	756	0.00	0.00	0.00	0.00

rster Creek Raw Data for Thermal Stress at 210 seconds - No Sand

Node	X (inch)	Y (inch)	Theta (degrees)	Node	Outside Nodes Radial SX (psi)	Outside Nodes Meridional SY (psi)	Outside Nodes Hoop SZ (psi)	SXY (psi)	Node	Middle Nodes Radial SX (psi)	Middle Nodes Meridional SY (psi)	Middle Nodes Hoop SZ (psi)	SXY (psi)	Node	Inside Nodes Radial SX (psi)	Inside Nodes Meridional SY (psi)	Inside Nodes Hoop SZ (psi)	SXY (psi)
758	330.85	706.57	128.13	757	0.00	0.00	0.00	0.00	758	0.00	0.00	0.00	0.00	759	0.00	0.00	0.00	0.00
761	329.17	708.44	128.46	760	0.00	0.00	0.00	0.00	761	0.00	0.00	0.00	0.00	762	0.00	0.00	0.00	0.00
764	327.87	710.31	128.78	763	0.00	0.00	0.00	0.00	764	0.00	0.00	0.00	0.00	765	0.00	0.00	0.00	0.00
767	326.17	712.17	129.11	766	0.00	0.00	0.00	0.00	767	0.00	0.00	0.00	0.00	768	0.00	0.00	0.00	0.00
770	324.66	714.02	129.44	769	0.00	0.00	0.00	0.00	770	0.00	0.00	0.00	0.00	771	0.00	0.00	0.00	0.00
773	323.13	715.87	129.78	772	0.00	0.00	0.00	0.00	773	0.00	0.00	0.00	0.00	774	0.00	0.00	0.00	0.00
776	321.60	717.70	130.09	775	0.00	0.00	0.00	0.00	776	0.00	0.00	0.00	0.00	777	0.00	0.00	0.00	0.00
779	320.05	719.53	130.41	778	0.00	0.00	0.00	0.00	779	0.00	0.00	0.00	0.00	780	0.00	0.00	0.00	0.00
782	318.50	721.34	130.74	781	0.00	0.00	0.00	0.00	782	0.00	0.00	0.00	0.00	783	0.00	0.00	0.00	0.00
785	316.93	723.15	131.07	784	0.00	0.00	0.00	0.00	785	0.00	0.00	0.00	0.00	786	0.00	0.00	0.00	0.00
788	315.35	724.95	131.39	787	0.00	0.00	0.00	0.00	788	0.00	0.00	0.00	0.00	789	0.00	0.00	0.00	0.00
791	313.77	726.74	131.72	790	0.00	0.00	0.00	0.00	791	0.00	0.00	0.00	0.00	792	0.00	0.00	0.00	0.00
794	312.17	728.52	132.04	793	0.00	0.00	0.00	0.00	794	0.00	0.00	0.00	0.00	795	0.00	0.00	0.00	0.00
797	310.56	730.29	132.37	796	0.00	0.00	0.00	0.00	797	0.00	0.00	0.00	0.00	798	0.00	0.00	0.00	0.00
800	308.94	732.06	132.70	799	0.00	0.00	0.00	0.00	800	0.00	0.00	0.00	0.00	801	0.00	0.00	0.00	0.00
803	307.32	733.81	133.02	802	0.00	0.00	0.00	0.00	803	0.00	0.00	0.00	0.00	804	0.00	0.00	0.00	0.00
806	305.68	735.55	133.35	805	0.00	0.00	0.00	0.00	806	0.00	0.00	0.00	0.00	807	0.00	0.00	0.00	0.00
809	304.03	737.29	133.68	808	0.00	0.00	0.00	0.00	809	0.00	0.00	0.00	0.00	810	0.00	0.00	0.00	0.00
812	302.38	739.01	134.00	811	0.00	0.00	0.00	0.00	812	0.00	0.00	0.00	0.00	813	0.00	0.00	0.00	0.00
815	300.71	740.73	134.33	814	0.00	0.00	0.00	0.00	815	0.00	0.00	0.00	0.00	816	0.00	0.00	0.00	0.00
818	299.03	742.44	134.65	817	0.00	0.00	0.00	0.00	818	0.00	0.00	0.00	0.00	819	0.00	0.00	0.00	0.00
821	297.35	744.13	134.98	820	0.00	0.00	0.00	0.00	821	0.00	0.00	0.00	0.00	822	0.00	0.00	0.00	0.00
824	295.65	745.82	135.31	823	0.00	0.00	0.00	0.00	824	0.00	0.00	0.00	0.00	825	0.00	0.00	0.00	0.00
827	293.95	747.50	135.63	826	0.00	0.00	0.00	0.00	827	0.00	0.00	0.00	0.00	828	0.00	0.00	0.00	0.00
830	292.23	749.16	135.96	829	0.00	0.00	0.00	0.00	830	0.00	0.00	0.00	0.00	831	0.00	0.00	0.00	0.00
833	290.51	750.82	136.29	832	0.00	0.00	0.00	0.00	833	0.00	0.00	0.00	0.00	834	0.00	0.00	0.00	0.00
836	288.77	752.47	136.61	835	0.00	0.00	0.00	0.00	836	0.00	0.00	0.00	0.00	837	0.00	0.00	0.00	0.00
839	287.03	754.11	136.94	838	0.00	0.00	0.00	0.00	839	0.00	0.00	0.00	0.00	840	0.00	0.00	0.00	0.00
842	285.28	755.74	137.26	841	0.00	0.00	0.00	0.00	842	0.00	0.00	0.00	0.00	843	0.00	0.00	0.00	0.00
845	283.52	757.36	137.59	844	0.00	0.00	0.00	0.00	845	0.00	0.00	0.00	0.00	846	0.00	0.00	0.00	0.00
848	280.57	760.02	138.13	847	0.00	0.00	0.00	0.00	848	0.00	0.00	0.00	0.00	849	0.00	0.00	0.00	0.00
851	277.60	762.66	138.67	850	0.00	0.00	0.00	0.00	851	0.00	0.00	0.00	0.00	852	0.00	0.00	0.00	0.00
854	274.61	765.27	139.21	853	0.00	0.00	0.00	0.00	854	0.00	0.00	0.00	0.00	855	0.00	0.00	0.00	0.00
857	271.59	767.85	139.75	856	0.00	0.00	0.00	0.00	857	0.00	0.00	0.00	0.00	858	0.00	0.00	0.00	0.00
860	268.55	770.40	140.29	859	0.00	0.00	0.00	0.00	860	0.00	0.00	0.00	0.00	861	0.00	0.00	0.00	0.00
863	265.40	772.92	140.84	862	0.00	0.00	0.00	0.00	863	0.00	0.00	0.00	0.00	864	0.00	0.00	0.00	0.00

Oyster Creek Raw Data for Thermal Stress at 210 seconds - No Sand

Node	X (inch)	Y (inch)	Theta (degrees)	Outside Nodes: Node	Outside Nodes: Radial SX (psi)	Outside Nodes: Meridional SY (psi)	Outside Nodes: Hoop SZ (psi)	Outside Nodes: SXY (psi)	Middle Nodes: Node	Middle Nodes: Radial SX (psi)	Middle Nodes: Meridional SY (psi)	Middle Nodes: Hoop SZ (psi)	Middle Nodes: SXY (psi)	Inside Nodes: Node	Inside Nodes: Radial SX (psi)	Inside Nodes: Meridional SY (psi)	Inside Nodes: Hoop SZ (psi)	Inside Nodes: SXY (psi)
866	262.39	775.41	141.38	865	0.00	0.00	0.00	0.00	866	0.00	0.00	0.00	0.00	867	0.00	0.00	0.00	0.00
869	259.28	777.88	141.92	868	0.00	0.00	0.00	0.00	869	0.00	0.00	0.00	0.00	870	0.00	0.00	0.00	0.00
872	256.14	780.31	142.46	871	0.00	0.00	0.00	0.00	872	0.00	0.00	0.00	0.00	873	0.00	0.00	0.00	0.00
875	252.98	782.72	143.00	874	0.00	0.00	0.00	0.00	875	0.00	0.00	0.00	0.00	876	0.00	0.00	0.00	0.00
878	251.40	783.85	143.26	877	0.00	0.00	0.00	0.00	878	0.00	0.00	0.00	0.00	879	0.00	0.00	0.00	0.00
881	249.98	784.97	143.51	880	0.00	0.00	0.00	0.00	881	0.00	0.00	0.00	0.00	882	0.00	0.00	0.00	0.00
884	247.27	786.96	143.97	883	0.00	0.00	0.00	0.00	884	0.00	0.00	0.00	0.00	885	0.00	0.00	0.00	0.00
887	244.55	788.92	144.43	886	0.00	0.00	0.00	0.00	887	0.00	0.00	0.00	0.00	888	0.00	0.00	0.00	0.00
890	241.81	790.87	144.89	889	0.00	0.00	0.00	0.00	890	0.00	0.00	0.00	0.00	891	0.00	0.00	0.00	0.00
893	239.05	792.79	145.34	892	0.00	0.00	0.00	0.00	893	0.00	0.00	0.00	0.00	894	0.00	0.00	0.00	0.00
896	236.28	794.69	145.80	895	0.00	0.00	0.00	0.00	896	0.00	0.00	0.00	0.00	897	0.00	0.00	0.00	0.00
899	233.49	796.57	146.26	898	0.00	0.00	0.00	0.00	899	0.00	0.00	0.00	0.00	900	0.00	0.00	0.00	0.00
902	230.69	798.42	146.72	901	0.00	0.00	0.00	0.00	902	0.00	0.00	0.00	0.00	903	0.00	0.00	0.00	0.00
905	225.89	801.06	147.52	904	0.00	0.00	0.00	0.00	905	0.00	0.00	0.00	0.00	906	0.00	0.00	0.00	0.00
908	221.39	805.68	148.32	907	0.00	0.00	0.00	0.00	908	0.00	0.00	0.00	0.00	909	0.00	0.00	0.00	0.00
911	217.22	809.87	149.09	910	0.00	0.00	0.00	0.00	911	0.00	0.00	0.00	0.00	912	0.00	0.00	0.00	0.00
914	213.41	814.38	149.85	913	0.00	0.00	0.00	0.00	914	0.00	0.00	0.00	0.00	915	0.00	0.00	0.00	0.00
917	209.99	819.19	150.57	916	0.00	0.00	0.00	0.00	917	0.00	0.00	0.00	0.00	918	0.00	0.00	0.00	0.00
920	206.97	824.26	151.25	919	0.00	0.00	0.00	0.00	920	0.00	0.00	0.00	0.00	921	0.00	0.00	0.00	0.00
923	204.30	829.57	151.89	922	0.00	0.00	0.00	0.00	923	0.00	0.00	0.00	0.00	924	0.00	0.00	0.00	0.00
926	202.23	835.08	152.47	925	0.00	0.00	0.00	0.00	926	0.00	0.00	0.00	0.00	927	0.00	0.00	0.00	0.00
929	200.55	840.74	153.01	928	0.00	0.00	0.00	0.00	929	0.00	0.00	0.00	0.00	930	0.00	0.00	0.00	0.00
932	199.34	846.52	153.48	931	0.00	0.00	0.00	0.00	932	0.00	0.00	0.00	0.00	933	0.00	0.00	0.00	0.00
935	198.61	852.38	153.90	934	0.00	0.00	0.00	0.00	935	0.00	0.00	0.00	0.00	936	0.00	0.00	0.00	0.00
938	198.37	858.28	154.25	937	0.00	0.00	0.00	0.00	938	0.00	0.00	0.00	0.00	939	0.00	0.00	0.00	0.00
941	198.31	858.78	154.28	940	0.00	0.00	0.00	0.00	941	0.00	0.00	0.00	0.00	942	0.00	0.00	0.00	0.00
944	198.32	860.78	154.39	943	0.00	0.00	0.00	0.00	944	0.00	0.00	0.00	0.00	945	0.00	0.00	0.00	0.00
947	198.32	862.78	154.50	946	0.00	0.00	0.00	0.00	947	0.00	0.00	0.00	0.00	948	0.00	0.00	0.00	0.00
950	198.32	863.78	154.55	949	0.00	0.00	0.00	0.00	950	0.00	0.00	0.00	0.00	951	0.00	0.00	0.00	0.00
953	198.32	864.78	154.61	952	0.00	0.00	0.00	0.00	953	0.00	0.00	0.00	0.00	954	0.00	0.00	0.00	0.00
956	198.32	865.78	154.66	955	0.00	0.00	0.00	0.00	956	0.00	0.00	0.00	0.00	957	0.00	0.00	0.00	0.00
959	198.32	866.78	154.71	958	0.00	0.00	0.00	0.00	959	0.00	0.00	0.00	0.00	960	0.00	0.00	0.00	0.00
962	198.32	867.78	154.76	961	0.00	0.00	0.00	0.00	962	0.00	0.00	0.00	0.00	963	0.00	0.00	0.00	0.00
965	198.32	868.83	154.82	964	0.00	0.00	0.00	0.00	965	0.00	0.00	0.00	0.00	966	0.00	0.00	0.00	0.00
968	198.32	869.88	154.87	967	0.00	0.00	0.00	0.00	968	0.00	0.00	0.00	0.00	969	0.00	0.00	0.00	0.00
971	198.32	870.93	154.93	970	0.00	0.00	0.00	0.00	971	0.00	0.00	0.00	0.00	972	0.00	0.00	0.00	0.00

Oyster Creek Raw Data for Thermal Stress at 210 seconds - No Sand

Node	X (inch)	Y (inch)	Theta (degrees)	Outside Nodes: Node	Outside Nodes: Radial SX (psi)	Outside Nodes: Meridional SY (psi)	Outside Nodes: Hoop SZ (psi)	Outside Nodes: SXY (psi)	Middle Nodes: Node	Middle Nodes: Radial SX (psi)	Middle Nodes: Meridional SY (psi)	Middle Nodes: Hoop SZ (psi)	Middle Nodes: SXY (psi)	Inside Nodes: Node	Inside Nodes: Radial SX (psi)	Inside Nodes: Meridional SY (psi)	Inside Nodes: Hoop SZ (psi)	Inside Nodes: SXY (psi)
974	198.32	871.98	154.98	973	0.00	0.00	0.00	0.00	974	0.00	0.00	0.00	0.00	975	0.00	0.00	0.00	0.00
977	198.32	873.03	155.04	976	0.00	0.00	0.00	0.00	977	0.00	0.00	0.00	0.00	978	0.00	0.00	0.00	0.00
980	198.32	874.08	155.09	979	0.00	0.00	0.00	0.00	980	0.00	0.00	0.00	0.00	981	0.00	0.00	0.00	0.00
983	198.32	875.13	155.15	982	0.00	0.00	0.00	0.00	983	0.00	0.00	0.00	0.00	984	0.00	0.00	0.00	0.00
986	198.32	876.18	155.20	985	0.00	0.00	0.00	0.00	986	0.00	0.00	0.00	0.00	987	0.00	0.00	0.00	0.00
989	198.32	877.23	155.25	988	0.00	0.00	0.00	0.00	989	0.00	0.00	0.00	0.00	990	0.00	0.00	0.00	0.00
992	198.32	878.28	155.31	991	0.00	0.00	0.00	0.00	992	0.00	0.00	0.00	0.00	993	0.00	0.00	0.00	0.00
995	198.32	880.55	155.42	994	0.00	0.00	0.00	0.00	995	0.00	0.00	0.00	0.00	996	0.00	0.00	0.00	0.00
998	198.32	882.81	155.53	997	0.00	0.00	0.00	0.00	998	0.00	0.00	0.00	0.00	999	0.00	0.00	0.00	0.00
1001	198.32	885.08	155.64	1000	0.00	0.00	0.00	0.00	1001	0.00	0.00	0.00	0.00	1002	0.00	0.00	0.00	0.00
1004	198.32	887.34	155.75	1003	0.00	0.00	0.00	0.00	1004	0.00	0.00	0.00	0.00	1005	0.00	0.00	0.00	0.00
1007	198.32	889.61	155.86	1006	0.00	0.00	0.00	0.00	1007	0.00	0.00	0.00	0.00	1008	0.00	0.00	0.00	0.00
1010	198.32	891.88	155.97	1009	0.00	0.00	0.00	0.00	1010	0.00	0.00	0.00	0.00	1011	0.00	0.00	0.00	0.00
1013	198.32	894.14	156.08	1012	0.00	0.00	0.00	0.00	1013	0.00	0.00	0.00	0.00	1014	0.00	0.00	0.00	0.00
1016	198.32	896.41	156.19	1015	0.00	0.00	0.00	0.00	1016	0.00	0.00	0.00	0.00	1017	0.00	0.00	0.00	0.00
1019	198.32	898.67	156.29	1018	0.00	0.00	0.00	0.00	1019	0.00	0.00	0.00	0.00	1020	0.00	0.00	0.00	0.00
1022	198.32	900.94	156.40	1021	0.00	0.00	0.00	0.00	1022	0.00	0.00	0.00	0.00	1023	0.00	0.00	0.00	0.00
1025	198.32	903.20	156.50	1024	0.00	0.00	0.00	0.00	1025	0.00	0.00	0.00	0.00	1026	0.00	0.00	0.00	0.00
1028	198.32	905.47	156.61	1027	0.00	0.00	0.00	0.00	1028	0.00	0.00	0.00	0.00	1029	0.00	0.00	0.00	0.00
1031	198.32	907.73	156.71	1030	0.00	0.00	0.00	0.00	1031	0.00	0.00	0.00	0.00	1032	0.00	0.00	0.00	0.00
1034	198.32	910.00	156.81	1033	0.00	0.00	0.00	0.00	1034	0.00	0.00	0.00	0.00	1035	0.00	0.00	0.00	0.00
1037	198.32	912.27	156.91	1036	0.00	0.00	0.00	0.00	1037	0.00	0.00	0.00	0.00	1038	0.00	0.00	0.00	0.00
1040	198.32	914.53	157.01	1039	0.00	0.00	0.00	0.00	1040	0.00	0.00	0.00	0.00	1041	0.00	0.00	0.00	0.00
1043	198.32	916.80	157.11	1042	0.00	0.00	0.00	0.00	1043	0.00	0.00	0.00	0.00	1044	0.00	0.00	0.00	0.00
1046	198.32	919.06	157.21	1045	0.00	0.00	0.00	0.00	1046	0.00	0.00	0.00	0.00	1047	0.00	0.00	0.00	0.00
1049	198.32	921.33	157.31	1048	0.00	0.00	0.00	0.00	1049	0.00	0.00	0.00	0.00	1050	0.00	0.00	0.00	0.00
1052	198.32	923.59	157.41	1051	0.00	0.00	0.00	0.00	1052	0.00	0.00	0.00	0.00	1053	0.00	0.00	0.00	0.00
1055	198.32	925.86	157.50	1054	0.00	0.00	0.00	0.00	1055	0.00	0.00	0.00	0.00	1056	0.00	0.00	0.00	0.00
1058	198.32	928.13	157.60	1057	0.00	0.00	0.00	0.00	1058	0.00	0.00	0.00	0.00	1059	0.00	0.00	0.00	0.00
1061	198.32	930.39	157.69	1060	0.00	0.00	0.00	0.00	1061	0.00	0.00	0.00	0.00	1062	0.00	0.00	0.00	0.00
1064	198.32	932.66	157.79	1063	0.00	0.00	0.00	0.00	1064	0.00	0.00	0.00	0.00	1065	0.00	0.00	0.00	0.00
1067	198.32	934.92	157.88	1066	0.00	0.00	0.00	0.00	1067	0.00	0.00	0.00	0.00	1068	0.00	0.00	0.00	0.00
1070	198.32	937.19	157.97	1069	0.00	0.00	0.00	0.00	1070	0.00	0.00	0.00	0.00	1071	0.00	0.00	0.00	0.00
1073	198.32	939.45	158.06	1072	0.00	0.00	0.00	0.00	1073	0.00	0.00	0.00	0.00	1074	0.00	0.00	0.00	0.00
1076	198.32	941.72	158.16	1075	0.00	0.00	0.00	0.00	1076	0.00	0.00	0.00	0.00	1077	0.00	0.00	0.00	0.00
1079	198.32	943.98	158.25	1078	0.00	0.00	0.00	0.00	1079	0.00	0.00	0.00	0.00	1080	0.00	0.00	0.00	0.00

Oyster Creek Raw Data for Thermal Stress at 210 seconds - No Sand

Node	X (inch)	Y (inch)	Theta (degrees)	Outside Nodes: Node	Outside Nodes: Radial SX (psi)	Outside Nodes: Meridional SY (psi)	Outside Nodes: Hoop SZ (psi)	Outside Nodes: SXY (psi)	Middle Nodes: Node	Middle Nodes: Radial SX (psi)	Middle Nodes: Meridional SY (psi)	Middle Nodes: Hoop SZ (psi)	Middle Nodes: SXY (psi)	Inside Nodes: Node	Inside Nodes: Radial SX (psi)	Inside Nodes: Meridional SY (psi)	Inside Nodes: Hoop SZ (psi)	Inside Nodes: SXY (psi)
1082	198.32	946.25	158.34	1081	0.00	0.00	0.00	0.00	1082	0.00	0.00	0.00	0.00	1083	0.00	0.00	0.00	0.00
1085	198.32	948.25	158.41	1084	0.00	0.00	0.00	0.00	1085	0.00	0.00	0.00	0.00	1086	0.00	0.00	0.00	0.00
1088	198.32	950.25	158.49	1087	0.00	0.00	0.00	0.00	1088	0.00	0.00	0.00	0.00	1089	0.00	0.00	0.00	0.00
1091	198.32	952.25	158.57	1090	0.00	0.00	0.00	0.00	1091	0.00	0.00	0.00	0.00	1092	0.00	0.00	0.00	0.00
1094	198.32	954.25	158.65	1093	0.00	0.00	0.00	0.00	1094	0.00	0.00	0.00	0.00	1095	0.00	0.00	0.00	0.00
1097	198.32	956.25	158.72	1096	0.00	0.00	0.00	0.00	1097	0.00	0.00	0.00	0.00	1098	0.00	0.00	0.00	0.00
1100	198.32	957.20	158.76	1099	0.00	0.00	0.00	0.00	1100	0.00	0.00	0.00	0.00	1101	0.00	0.00	0.00	0.00
1103	198.32	958.16	158.79	1102	0.00	0.00	0.00	0.00	1103	0.00	0.00	0.00	0.00	1104	0.00	0.00	0.00	0.00
1106	198.32	959.11	158.83	1105	0.00	0.00	0.00	0.00	1106	0.00	0.00	0.00	0.00	1107	0.00	0.00	0.00	0.00
1109	198.32	960.06	158.87	1108	0.00	0.00	0.00	0.00	1109	0.00	0.00	0.00	0.00	1110	0.00	0.00	0.00	0.00
1112	198.32	961.01	158.90	1111	0.00	0.00	0.00	0.00	1112	0.00	0.00	0.00	0.00	1113	0.00	0.00	0.00	0.00
1115	198.32	961.97	158.94	1114	0.00	0.00	0.00	0.00	1115	0.00	0.00	0.00	0.00	1116	0.00	0.00	0.00	0.00
1118	198.32	962.92	158.97	1117	0.00	0.00	0.00	0.00	1118	0.00	0.00	0.00	0.00	1119	0.00	0.00	0.00	0.00
1121	198.32	963.87	159.01	1120	0.00	0.00	0.00	0.00	1121	0.00	0.00	0.00	0.00	1122	0.00	0.00	0.00	0.00
1124	198.32	964.82	159.04	1123	0.00	0.00	0.00	0.00	1124	0.00	0.00	0.00	0.00	1125	0.00	0.00	0.00	0.00
1127	198.32	965.78	159.06	1126	0.00	0.00	0.00	0.00	1127	0.00	0.00	0.00	0.00	1128	0.00	0.00	0.00	0.00
1130	198.32	965.88	159.08	1129	0.00	0.00	0.00	0.00	1130	0.00	0.00	0.00	0.00	1131	0.00	0.00	0.00	0.00
1133	198.32	966.25	159.10	1132	0.00	0.00	0.00	0.00	1133	0.00	0.00	0.00	0.00	1134	0.00	0.00	0.00	0.00
1136	198.32	966.63	159.11	1135	0.00	0.00	0.00	0.00	1136	0.00	0.00	0.00	0.00	1137	0.00	0.00	0.00	0.00
1139	198.32	966.73	159.11	1138	0.00	0.00	0.00	0.00	1139	0.00	0.00	0.00	0.00	1140	0.00	0.00	0.00	0.00
1142	198.32	967.73	159.15	1141	0.00	0.00	0.00	0.00	1142	0.00	0.00	0.00	0.00	1143	0.00	0.00	0.00	0.00
1145	198.32	968.73	159.19	1144	0.00	0.00	0.00	0.00	1145	0.00	0.00	0.00	0.00	1146	0.00	0.00	0.00	0.00
1148	198.32	969.73	159.22	1147	0.00	0.00	0.00	0.00	1148	0.00	0.00	0.00	0.00	1149	0.00	0.00	0.00	0.00
1151	198.32	970.73	159.26	1150	0.00	0.00	0.00	0.00	1151	0.00	0.00	0.00	0.00	1152	0.00	0.00	0.00	0.00
1154	198.32	971.73	159.30	1153	0.00	0.00	0.00	0.00	1154	0.00	0.00	0.00	0.00	1155	0.00	0.00	0.00	0.00
1157	198.32	972.73	159.33	1156	0.00	0.00	0.00	0.00	1157	0.00	0.00	0.00	0.00	1158	0.00	0.00	0.00	0.00
1160	198.32	973.73	159.37	1159	0.00	0.00	0.00	0.00	1160	0.00	0.00	0.00	0.00	1161	0.00	0.00	0.00	0.00
1163	198.32	974.73	159.40	1162	0.00	0.00	0.00	0.00	1163	0.00	0.00	0.00	0.00	1164	0.00	0.00	0.00	0.00
1166	198.32	975.73	159.44	1165	0.00	0.00	0.00	0.00	1166	0.00	0.00	0.00	0.00	1167	0.00	0.00	0.00	0.00
1169	198.32	976.73	159.47	1168	0.00	0.00	0.00	0.00	1169	0.00	0.00	0.00	0.00	1170	0.00	0.00	0.00	0.00
1172	198.32	978.93	159.55	1171	0.00	0.00	0.00	0.00	1172	0.00	0.00	0.00	0.00	1173	0.00	0.00	0.00	0.00
1175	198.32	981.13	159.63	1174	0.00	0.00	0.00	0.00	1175	0.00	0.00	0.00	0.00	1176	0.00	0.00	0.00	0.00
1178	198.32	983.33	159.71	1177	0.00	0.00	0.00	0.00	1178	0.00	0.00	0.00	0.00	1179	0.00	0.00	0.00	0.00
1181	198.32	985.53	159.78	1180	0.00	0.00	0.00	0.00	1181	0.00	0.00	0.00	0.00	1182	0.00	0.00	0.00	0.00
1184	198.32	987.73	159.86	1183	0.00	0.00	0.00	0.00	1184	0.00	0.00	0.00	0.00	1185	0.00	0.00	0.00	0.00
1187	198.32	989.94	159.93	1186	0.00	0.00	0.00	0.00	1187	0.00	0.00	0.00	0.00	1188	0.00	0.00	0.00	0.00

lyster Creek Raw Data for Thermal Stress at 210 seconds - No Sand

Node	X (inch)	Y (inch)	Theta (degrees)	Node	Outside Nodes Radial SX (psi)	Outside Nodes Meridional SY (psi)	Outside Nodes Hoop SZ (psi)	SXY (psi)	Node	Middle Nodes Radial SX (psi)	Middle Nodes Meridional SY (psi)	Middle Nodes Hoop SZ (psi)	SXY (psi)	Node	Inside Nodes Radial SX (psi)	Inside Nodes Meridional SY (psi)	Inside Nodes Hoop SZ (psi)	SXY (psi)
1190	198.32	992.14	160.01	1189	0.00	0.00	0.00	0.00	1190	0.00	0.00	0.00	0.00	1191	0.00	0.00	0.00	0.00
1193	198.32	994.34	160.08	1192	0.00	0.00	0.00	0.00	1193	0.00	0.00	0.00	0.00	1194	0.00	0.00	0.00	0.00
1196	198.32	996.54	160.16	1195	0.00	0.00	0.00	0.00	1196	0.00	0.00	0.00	0.00	1197	0.00	0.00	0.00	0.00
1199	198.32	998.74	160.23	1198	0.00	0.00	0.00	0.00	1199	0.00	0.00	0.00	0.00	1200	0.00	0.00	0.00	0.00
1202	198.32	1000.94	160.30	1201	0.00	0.00	0.00	0.00	1202	0.00	0.00	0.00	0.00	1203	0.00	0.00	0.00	0.00
1205	198.32	1003.15	160.37	1204	0.00	0.00	0.00	0.00	1205	0.00	0.00	0.00	0.00	1206	0.00	0.00	0.00	0.00
1208	198.32	1005.35	160.45	1207	0.00	0.00	0.00	0.00	1208	0.00	0.00	0.00	0.00	1209	0.00	0.00	0.00	0.00
1211	198.32	1007.55	160.52	1210	0.00	0.00	0.00	0.00	1211	0.00	0.00	0.00	0.00	1212	0.00	0.00	0.00	0.00
1214	198.32	1009.75	160.59	1213	0.00	0.00	0.00	0.00	1214	0.00	0.00	0.00	0.00	1215	0.00	0.00	0.00	0.00
1217	198.32	1010.70	160.62	1216	0.00	0.00	0.00	0.00	1217	0.00	0.00	0.00	0.00	1218	0.00	0.00	0.00	0.00
1220	198.32	1011.66	160.65	1219	0.00	0.00	0.00	0.00	1220	0.00	0.00	0.00	0.00	1221	0.00	0.00	0.00	0.00
1223	198.32	1012.61	160.68	1222	0.00	0.00	0.00	0.00	1223	0.00	0.00	0.00	0.00	1224	0.00	0.00	0.00	0.00
1226	198.32	1013.56	160.71	1225	0.00	0.00	0.00	0.00	1226	0.00	0.00	0.00	0.00	1227	0.00	0.00	0.00	0.00
1229	198.32	1014.51	160.74	1228	0.00	0.00	0.00	0.00	1229	0.00	0.00	0.00	0.00	1230	0.00	0.00	0.00	0.00
1232	198.32	1015.47	160.77	1231	0.00	0.00	0.00	0.00	1232	0.00	0.00	0.00	0.00	1233	0.00	0.00	0.00	0.00
1235	198.32	1016.42	160.80	1234	0.00	0.00	0.00	0.00	1235	0.00	0.00	0.00	0.00	1236	0.00	0.00	0.00	0.00
1238	198.32	1017.37	160.83	1237	0.00	0.00	0.00	0.00	1238	0.00	0.00	0.00	0.00	1239	0.00	0.00	0.00	0.00
1241	198.32	1018.32	160.86	1240	0.00	0.00	0.00	0.00	1241	0.00	0.00	0.00	0.00	1242	0.00	0.00	0.00	0.00
1244	198.32	1019.28	160.89	1243	0.00	0.00	0.00	0.00	1244	0.00	0.00	0.00	0.00	1245	0.00	0.00	0.00	0.00
1247	198.32	1019.38	160.89	1246	0.00	0.00	0.00	0.00	1247	0.00	0.00	0.00	0.00	1248	0.00	0.00	0.00	0.00
1250	198.32	1019.75	160.90	1249	0.00	0.00	0.00	0.00	1250	0.00	0.00	0.00	0.00	1251	0.00	0.00	0.00	0.00
1253	198.32	1020.13	160.91	1252	0.00	0.00	0.00	0.00	1253	0.00	0.00	0.00	0.00	1254	0.00	0.00	0.00	0.00
1256	198.32	1020.23	160.92	1255	0.00	0.00	0.00	0.00	1256	0.00	0.00	0.00	0.00	1257	0.00	0.00	0.00	0.00
1259	198.32	1021.23	160.95	1258	0.00	0.00	0.00	0.00	1259	0.00	0.00	0.00	0.00	1260	0.00	0.00	0.00	0.00
1262	198.32	1022.23	160.98	1261	0.00	0.00	0.00	0.00	1262	0.00	0.00	0.00	0.00	1263	0.00	0.00	0.00	0.00
1265	198.32	1023.23	161.01	1264	0.00	0.00	0.00	0.00	1265	0.00	0.00	0.00	0.00	1266	0.00	0.00	0.00	0.00
1268	198.32	1024.23	161.04	1267	0.00	0.00	0.00	0.00	1268	0.00	0.00	0.00	0.00	1269	0.00	0.00	0.00	0.00
1271	198.32	1025.23	161.07	1270	0.00	0.00	0.00	0.00	1271	0.00	0.00	0.00	0.00	1272	0.00	0.00	0.00	0.00
1274	198.32	1026.23	161.10	1273	0.00	0.00	0.00	0.00	1274	0.00	0.00	0.00	0.00	1275	0.00	0.00	0.00	0.00
1277	198.32	1027.23	161.13	1276	0.00	0.00	0.00	0.00	1277	0.00	0.00	0.00	0.00	1278	0.00	0.00	0.00	0.00
1280	198.32	1028.23	161.16	1279	0.00	0.00	0.00	0.00	1280	0.00	0.00	0.00	0.00	1281	0.00	0.00	0.00	0.00
1283	198.32	1029.23	161.19	1282	0.00	0.00	0.00	0.00	1283	0.00	0.00	0.00	0.00	1284	0.00	0.00	0.00	0.00
1286	198.32	1030.23	161.22	1285	0.00	0.00	0.00	0.00	1286	0.00	0.00	0.00	0.00	1287	0.00	0.00	0.00	0.00
1289	198.32	1032.65	161.29	1288	0.00	0.00	0.00	0.00	1289	0.00	0.00	0.00	0.00	1290	0.00	0.00	0.00	0.00
1292	198.32	1035.08	161.36	1291	0.00	0.00	0.00	0.00	1292	0.00	0.00	0.00	0.00	1293	0.00	0.00	0.00	0.00
1295	198.32	1037.51	161.44	1294	0.00	0.00	0.00	0.00	1295	0.00	0.00	0.00	0.00	1296	0.00	0.00	0.00	0.00

Oyster Creek Raw Data for Thermal Stress at 210 seconds - No Sand

					Outside Nodes					Middle Nodes					Inside Nodes			
Node	X (inch)	Y (inch)	Theta (degrees)	Node	Radial SX (psi)	Meridional SY (psi)	Hoop SZ (psi)	SXY (psi)	Node	Radial SX (psi)	Meridional SY (psi)	Hoop SZ (psi)	SXY (psi)	Node	Radial SX (psi)	Meridional SY (psi)	Hoop SZ (psi)	SXY (psi)
1298	198.32	1039.94	161.51	1297	0.00	0.00	0.00	0.00	1298	0.00	0.00	0.00	0.00	1299	0.00	0.00	0.00	0.00
1301	198.32	1042.36	161.58	1300	0.00	0.00	0.00	0.00	1301	0.00	0.00	0.00	0.00	1302	0.00	0.00	0.00	0.00
1304	198.32	1044.79	161.65	1303	0.00	0.00	0.00	0.00	1304	0.00	0.00	0.00	0.00	1305	0.00	0.00	0.00	0.00
1307	198.32	1047.22	161.72	1306	0.00	0.00	0.00	0.00	1307	0.00	0.00	0.00	0.00	1308	0.00	0.00	0.00	0.00
1310	198.32	1049.65	161.78	1309	0.00	0.00	0.00	0.00	1310	0.00	0.00	0.00	0.00	1311	0.00	0.00	0.00	0.00
1313	198.32	1052.07	161.85	1312	0.00	0.00	0.00	0.00	1313	0.00	0.00	0.00	0.00	1314	0.00	0.00	0.00	0.00
1316	198.32	1054.50	161.92	1315	0.00	0.00	0.00	0.00	1316	0.00	0.00	0.00	0.00	1317	0.00	0.00	0.00	0.00
1319	198.32	1055.47	161.95	1318	0.00	0.00	0.00	0.00	1319	0.00	0.00	0.00	0.00	1320	0.00	0.00	0.00	0.00
1322	198.32	1056.43	161.97	1321	0.00	0.00	0.00	0.00	1322	0.00	0.00	0.00	0.00	1323	0.00	0.00	0.00	0.00
1325	198.32	1057.40	162.00	1324	0.00	0.00	0.00	0.00	1325	0.00	0.00	0.00	0.00	1326	0.00	0.00	0.00	0.00
1328	198.32	1058.36	162.03	1327	0.00	0.00	0.00	0.00	1328	0.00	0.00	0.00	0.00	1329	0.00	0.00	0.00	0.00
1331	198.32	1059.33	162.05	1330	0.00	0.00	0.00	0.00	1331	0.00	0.00	0.00	0.00	1332	0.00	0.00	0.00	0.00
1334	198.32	1060.29	162.08	1333	0.00	0.00	0.00	0.00	1334	0.00	0.00	0.00	0.00	1335	0.00	0.00	0.00	0.00
1337	198.32	1061.26	162.11	1336	0.00	0.00	0.00	0.00	1337	0.00	0.00	0.00	0.00	1338	0.00	0.00	0.00	0.00
1340	198.32	1062.22	162.13	1339	0.00	0.00	0.00	0.00	1340	0.00	0.00	0.00	0.00	1341	0.00	0.00	0.00	0.00
1343	198.32	1063.19	162.16	1342	0.00	0.00	0.00	0.00	1343	0.00	0.00	0.00	0.00	1344	0.00	0.00	0.00	0.00
1346	198.32	1064.15	162.18	1345	0.00	0.00	0.00	0.00	1346	0.00	0.00	0.00	0.00	1347	0.00	0.00	0.00	0.00
1349	198.32	1064.25	162.19	1348	0.00	0.00	0.00	0.00	1349	0.00	0.00	0.00	0.00	1350	0.00	0.00	0.00	0.00
1352	198.32	1064.50	162.19	1351	0.00	0.00	0.00	0.00	1352	0.00	0.00	0.00	0.00	1353	0.00	0.00	0.00	0.00
1355	198.32	1064.75	162.20	1354	0.00	0.00	0.00	0.00	1355	0.00	0.00	0.00	0.00	1356	0.00	0.00	0.00	0.00
1358	198.32	1064.85	162.20	1357	0.00	0.00	0.00	0.00	1358	0.00	0.00	0.00	0.00	1359	0.00	0.00	0.00	0.00
1361	198.32	1065.85	162.23	1360	0.00	0.00	0.00	0.00	1361	0.00	0.00	0.00	0.00	1362	0.00	0.00	0.00	0.00
1364	198.32	1066.85	162.26	1363	0.00	0.00	0.00	0.00	1364	0.00	0.00	0.00	0.00	1365	0.00	0.00	0.00	0.00
1367	198.32	1067.85	162.28	1366	0.00	0.00	0.00	0.00	1367	0.00	0.00	0.00	0.00	1368	0.00	0.00	0.00	0.00
1370	198.32	1068.85	162.31	1369	0.00	0.00	0.00	0.00	1370	0.00	0.00	0.00	0.00	1371	0.00	0.00	0.00	0.00
1373	198.32	1069.85	162.34	1372	0.00	0.00	0.00	0.00	1373	0.00	0.00	0.00	0.00	1374	0.00	0.00	0.00	0.00
1376	198.32	1070.85	162.36	1375	0.00	0.00	0.00	0.00	1376	0.00	0.00	0.00	0.00	1377	0.00	0.00	0.00	0.00
1379	198.32	1071.85	162.39	1378	0.00	0.00	0.00	0.00	1379	0.00	0.00	0.00	0.00	1380	0.00	0.00	0.00	0.00
1382	198.32	1072.85	162.42	1381	0.00	0.00	0.00	0.00	1382	0.00	0.00	0.00	0.00	1383	0.00	0.00	0.00	0.00
1385	198.32	1073.85	162.44	1384	0.00	0.00	0.00	0.00	1385	0.00	0.00	0.00	0.00	1386	0.00	0.00	0.00	0.00
1388	198.32	1074.85	162.47	1387	0.00	0.00	0.00	0.00	1388	0.00	0.00	0.00	0.00	1389	0.00	0.00	0.00	0.00
1391	198.32	1077.07	162.53	1390	0.00	0.00	0.00	0.00	1391	0.00	0.00	0.00	0.00	1392	0.00	0.00	0.00	0.00
1394	198.32	1079.28	162.59	1393	0.00	0.00	0.00	0.00	1394	0.00	0.00	0.00	0.00	1395	0.00	0.00	0.00	0.00
1397	198.32	1081.50	162.64	1396	0.00	0.00	0.00	0.00	1397	0.00	0.00	0.00	0.00	1398	0.00	0.00	0.00	0.00
1400	198.32	1083.71	162.70	1399	0.00	0.00	0.00	0.00	1400	0.00	0.00	0.00	0.00	1401	0.00	0.00	0.00	0.00
1403	198.32	1085.93	162.76	1402	0.00	0.00	0.00	0.00	1403	0.00	0.00	0.00	0.00	1404	0.00	0.00	0.00	0.00

Oyster Creek Raw Data for Thermal Stress at 210 seconds - No Sand

Node	X (inch)	Y (inch)	Theta (degrees)	Outside Nodes: Node	Outside Nodes: Radial SX (psi)	Outside Nodes: Meridional SY (psi)	Outside Nodes: Hoop SZ (psi)	Outside Nodes: SXY (psi)	Middle Nodes: Node	Middle Nodes: Radial SX (psi)	Middle Nodes: Meridional SY (psi)	Middle Nodes: Hoop SZ (psi)	Middle Nodes: SXY (psi)	Inside Nodes: Node	Inside Nodes: Radial SX (psi)	Inside Nodes: Meridional SY (psi)	Inside Nodes: Hoop SZ (psi)	Inside Nodes: SXY (psi)
1406	198.32	1088.14	182.81	1405	0.00	0.00	0.00	0.00	1406	0.00	0.00	0.00	0.00	1407	0.00	0.00	0.00	0.00
1409	198.32	1090.36	182.87	1408	0.00	0.00	0.00	0.00	1409	0.00	0.00	0.00	0.00	1410	0.00	0.00	0.00	0.00
1412	198.32	1092.57	182.92	1411	0.00	0.00	0.00	0.00	1412	0.00	0.00	0.00	0.00	1413	0.00	0.00	0.00	0.00
1415	198.32	1094.79	182.98	1414	0.00	0.00	0.00	0.00	1415	0.00	0.00	0.00	0.00	1416	0.00	0.00	0.00	0.00
1418	198.32	1097.00	183.03	1417	0.00	0.00	0.00	0.00	1418	0.00	0.00	0.00	0.00	1419	0.00	0.00	0.00	0.00
1421	198.32	1098.00	183.06	1420	0.00	0.00	0.00	0.00	1421	0.00	0.00	0.00	0.00	1422	0.00	0.00	0.00	0.00
1424	198.32	1099.00	183.08	1423	0.00	0.00	0.00	0.00	1424	0.00	0.00	0.00	0.00	1425	0.00	0.00	0.00	0.00
1427	198.32	1100.00	183.11	1426	0.00	0.00	0.00	0.00	1427	0.00	0.00	0.00	0.00	1428	0.00	0.00	0.00	0.00
1430	198.32	1101.00	183.13	1429	0.00	0.00	0.00	0.00	1430	0.00	0.00	0.00	0.00	1431	0.00	0.00	0.00	0.00
1433	198.32	1102.00	183.15	1432	0.00	0.00	0.00	0.00	1433	0.00	0.00	0.00	0.00	1434	0.00	0.00	0.00	0.00
1436	198.32	1103.00	183.18	1435	0.00	0.00	0.00	0.00	1436	0.00	0.00	0.00	0.00	1437	0.00	0.00	0.00	0.00
1439	198.32	1104.00	183.20	1438	0.00	0.00	0.00	0.00	1439	0.00	0.00	0.00	0.00	1440	0.00	0.00	0.00	0.00
1442	198.32	1105.00	183.23	1441	0.00	0.00	0.00	0.00	1442	0.00	0.00	0.00	0.00	1443	0.00	0.00	0.00	0.00
1445	198.32	1106.00	183.25	1444	0.00	0.00	0.00	0.00	1445	0.00	0.00	0.00	0.00	1446	0.00	0.00	0.00	0.00
1448	198.32	1107.00	183.28	1447	0.00	0.00	0.00	0.00	1448	0.00	0.00	0.00	0.00	1449	0.00	0.00	0.00	0.00
1451	198.47	1108.25	183.29	1450	0.00	0.00	0.00	0.00	1451	0.00	0.00	0.00	0.00	1452	0.00	0.00	0.00	0.00
1454	198.63	1109.50	183.31	1453	0.00	0.00	0.00	0.00	1454	0.00	0.00	0.00	0.00	1455	0.00	0.00	0.00	0.00
					97	94	88	97		101	101	86	98		96	96	96	93
					1072.89	11000.93	12454.55	2643.90		-391.95	974.74	12806.75	-727.93		289.00	-9856.70	-13918.42	-564.42

OYSTER CREEK NUCLEAR LICENSING

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SUBJECT: Drywell Stability Analysis (Without Sand), Rev. 2

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December 2, 1992

5000-92-3084
C321-92-2295

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, D.C. 20555

Gentlemen:

Subject: Oyster Creek Nuclear Generating Station (OCNGS)
Docket No. 50-219
Facility Operating License No. DPR-16
Oyster Creek Drywell Containment -
Drywell Stability Analysis (Without Sand), Revision 2.

Reference: GPUN Letter C321-92-2008/5000-92-2093 dated January 16, 1992 - Oyster Creek Drywell Stability Analyses (With and Without Sand), GE Reports Index No. 9-2 and 9-4, Revision 1.

The referenced letter provided Revision 1 of GPU Nuclear's ASME Section VIII evaluation of the Oyster Creek Drywell for the without sand stability analysis, GE Report Index 9-4. This letter provides you with Revision 2 to this evaluation.

This revision incorporates changes resulting from an internal review which identified the need for mesh refinement in the finite element model used in the stability analysis. The revised calculated capacity remains in compliance with all required ASME Code provisions.

If you have any questions or comments on this submittal, please contact Mr. Michael Laggart, Manager, Corporate Nuclear Licensing at (201) 316-7968.

Very truly yours,

J. C. DeVine, Jr.
Vice President and Director
Technical Functions

cc: Administrator, Region 1
Senior Resident Inspector
Oyster Creek NRC Project Manager

DRF# 00664
INDEX 9-4, REV. 2

AN ASME SECTION VIII EVALUATION OF THE OYSTER CREEK DRYWELL FOR WITHOUT SAND CASE PART 2 STABILITY ANALYSIS

(Revision 2)

November 1992

prepared for

GPU Nuclear Corporation
Parsippany, New Jersey

prepared by

GE Nuclear Energy
San Jose, California

AN ASME SECTION VIII EVALUATION OF THE OYSTER CREEK DRYWELL FOR WITHOUT SAND CASE PART 2 STABILITY ANALYSIS (Revision 2)

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1. INTRODUCTION

1.1 General

To address local wall thinning of the Oyster Creek drywell, GPUN has prepared a supplementary report to the Code stress report of record [1-1] which is divided into two parts. Part 1 includes all of the Code stress analysis results other than the buckling capability for the drywell shell [1-2]. Part 2 addresses the buckling capability of the drywell shell shown in Figure 1-1 [1-3]. The supplementary report for the degraded drywell is for the present configuration (with sand support in the lower sphere). One option which is being considered by GPUN to mitigate further corrosion in the sandbed region is to remove the sand. Reference 1-4 and this report evaluate the influence of removing the sand on the code stress analysis and buckling evaluation, respectively. Buckling of the entire drywell shell is considered in this analysis with the sandbed region being the area of primary concern.

1.2 Report Outline

Section 2 of this report outlines the methodology used in the buckling capability evaluation. Finite element modeling, analysis and results are described in section 3. Evaluation of the allowable compressive buckling stresses and comparisons with the calculated compressive stresses for the limiting load combinations are covered in section 4. Section 5 presents the summary of results and conclusions.

1.3 References

1-1 "Structural Design of the Pressure Suppression Containment Vessels," by Chicago Bridge & Iron Co.,Contract # 9-0971, 1965.

1-2 "An ASME Section VIII Evaluation of the Oyster Creek Drywell - Part 1 Stress Analysis," GE Report No. 9-1, DRF# 00664, November 1990, prepared for GPUN.

1-3 "An ASME Section VIII Evaluation of the Oyster Creek Drywell - Part 2 Stability Analysis," GE Report No. 9-2, DRF# 00664, November 1990, prepared for GPUN.

1-4 "An ASME Section VIII Evaluation of the Oyster Creek Drywell - Part 1 Stress Analysis," GE Report No. 9-3, DRF# 00664, February 1991, prepared for GPUN.

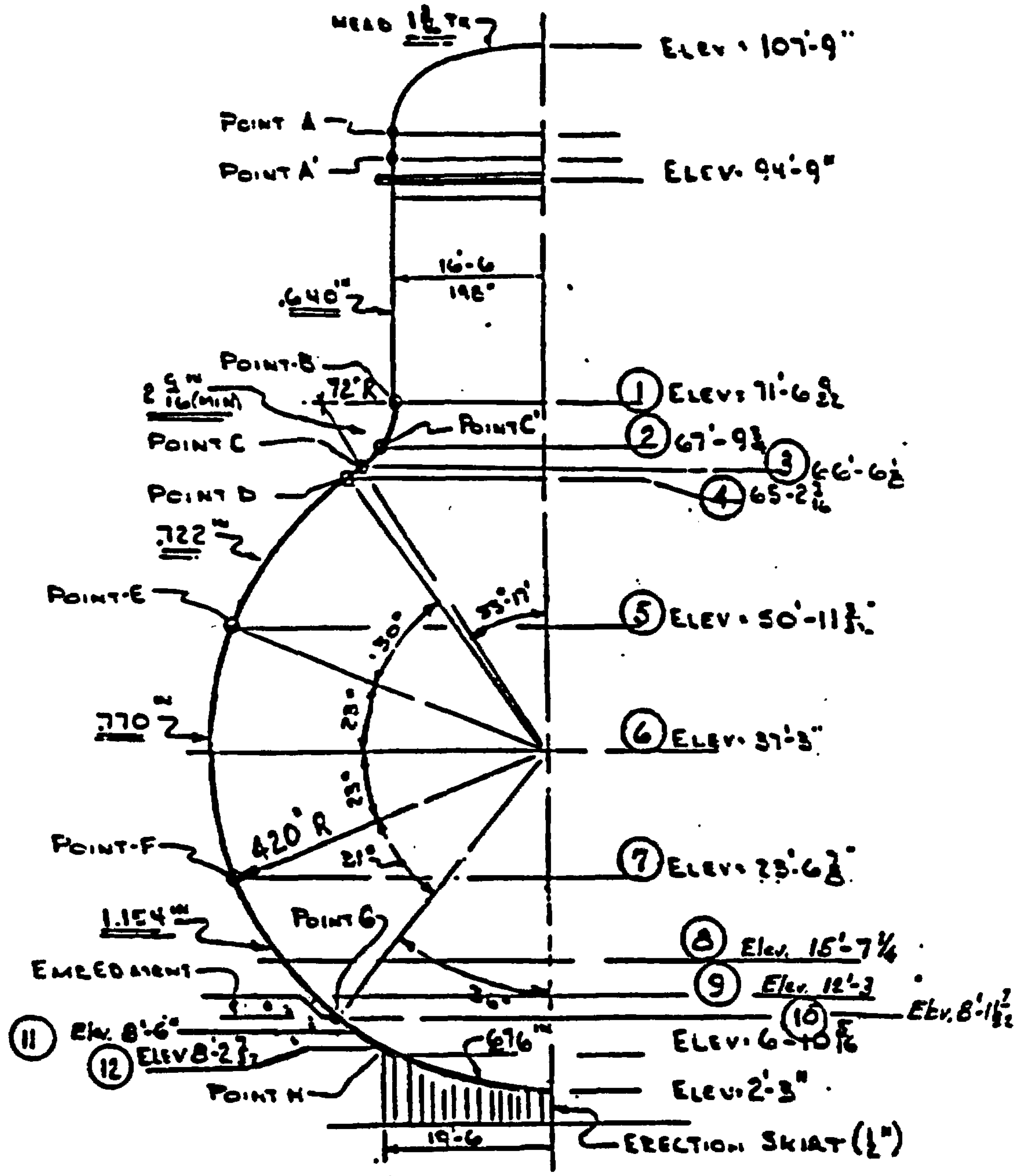


Figure 1-1 Drywell Configuration

2. BUCKLING ANALYSIS METHODOLOGY

2.1 Basic Approach

The basic approach used in the buckling evaluation follows the methodology outlined in the ASME Code Case N-284 [2-1 and 2-2]. Following the procedure of this Code Case, the allowable compressive stress is evaluated in three steps.

In the first step, a theoretical elastic buckling stress, σ_{ie}, is determined. This value may be calculated either by classical buckling equations or by finite element analysis. Since the drywell shell geometry is complex, a three dimensional finite element analysis approach is followed using the eigenvalue extraction technique. More details on the eigenvalue determination are given in Section 3.

In the second step, the theoretical elastic buckling stress is modified by the appropriate capacity and plasticity reduction factors. The capacity reduction factor, α_i, accounts for the difference between classical buckling theory and actual tested buckling stresses for fabricated shells. This difference is due to imperfections inherent in fabricated shells, not accounted for in classical buckling theory, which can cause significant reductions in the critical buckling stress. Thus, the elastic buckling stress for fabricated shells is given by the product of the theoretical elastic buckling stress and the capacity reduction factor, i.e., $\sigma_{ie}\alpha_i$. When the elastic buckling stress exceeds the proportional limit of the material, a plasticity reduction factor, η_i, is used to account for non-linear material behavior. The inelastic buckling stress for fabricated shells is given by $\eta_i\alpha_i\sigma_{ie}$.

In the final step, the allowable compressive stress is obtained by dividing the buckling stress calculated in the second step by the safety factor, FS:

$$\text{Allowable Compressive Stress} = \eta_i\alpha_i\sigma_{ie}/FS$$

In Reference 2-1, the safety factor for the Design and Level A & B service conditions is specified as 2.0. A safety factor of 1.67 is specified for Level C service conditions (such as the post-accident condition).

The determination of appropriate values for capacity and plasticity reduction factors is discussed next.

2.2 Determination of Capacity Reduction Factor

The capacity reduction factor, α_i, is used to account for reductions in actual buckling strength due to the existence of geometric imperfections. The capacity reduction factors given in Reference 2-1 are based on extensive data compiled by Miller [2-3]. The factors appropriate for a spherical shell geometry such as that of the drywell in the sandbed region, are shown in Figure 2-1 (Figure 1512-1 of Reference 2-1). The tail (flat) end of the curves are used for unstiffened shells. The curve marked 'Uniaxial compression' is applicable since the stress state in the sandbed region is compressive in the meridional direction but tensile in the circumferential direction. From this curve, α_i is determined to be 0.207.

The preceding value of the capacity reduction factor is very conservative for two reasons. First, it is based on the assumption that the spherical shell has a uniform thickness equal to the reduced thickness. However, the drywell shell has a greater thickness above the sandbed region which would reinforce the sandbed region. Second, it is assumed that the circumferential stress is zero. The tensile circumferential stress has the effect of rounding the shell and reducing the effect of imperfections introduced during the fabrication and construction phase. A modification of the α_i value to account for the presence of tensile circumferential stress is discussed in Subsection 2.3.

The capacity reduction factor values given in Reference 2-1 are applicable to shells which meet the tolerance requirements of NE-4220 of Section III [2-4]. Reference 2-5 compares the tolerance requirements of NE-4220 to the requirements to which the Oyster Creek drywell shell was fabricated. The comparison shows that the Oyster Creek drywell shell was erected to the tolerance requirements of NE-4220. Therefore, although the Oyster Creek drywell is not a Section III, NE vessel, it is justified to use the approach outlined in Code Case N-284.

2.3 Modification of Capacity Reduction Factor for Hoop Stress

The orthogonal tensile stress has the effect of rounding fabricated shells and reducing the effect of imperfections on the buckling strength. The Code Case N-284 [2-1 and 2-2] notes in the last paragraph of Article 1500 that, "The influence of internal pressure on a shell structure may reduce the initial imperfections and therefore higher values of capacity reduction factors may be acceptable. Justification for higher values of α_i must be given in the Design report."

The effect of hoop tensile stress on the buckling strength of cylinders has been extensivelly documented [2-6 through 2-11]. Since the methods used in accounting for the effect of tensile hoop stress for the cylinders and spheres are similar, the test data and the methods for the cylinders are first reviewed. Harris, et al [2-6] presented a comprehensive set of test data, including those from References 2-7 and 2-8, which clearly showed that internal pressure in the form of hoop tension, increases the axial buckling stress of cylinders. Figure 2-2 shows a plot of the test data showing the increase in buckling stress as a function of nondimensional pressure. This increase in buckling capacity is accounted for by defining a separate reduction factor, α_p. The capacity reduction factor α_i can then be modified as follows:

$$\alpha_{i,mod} = \alpha_i + \alpha_p$$

The buckling stress in uniaxial compression for a cylinder or a sphere of uniform thickness with no internal pressure is given by the following:

$$S_c = (0.605)(\alpha_i)Et/R$$
$$= (0.605)(0.207)\ Et/R$$

Where, 0.605 is a constant, 0.207 is the capacity reduction factor, α_i, and E,t and R are Young's Modulus, wall thickness and radius, respectively. In the presence of a tensile stress such as that produced by an internal pressure, the buckling stress is given as follows:

$$S_{c,mod} = (0.605)(\alpha_i + \alpha_p)Et/R$$
$$= (0.605)(0.207 + \alpha_p)Et/R$$
$$= [(0.605)(0.207) + \Delta C]\ Et/R$$

Where ΔC is $\alpha_p/0.605$ and is given for cylindrical geometries in the graphical form in Figure 2-3. As can be seen in Figure 2-3, ΔC is a function of the parameter $X=(p/4E)(2R/t)^2$, where ,p, is the internal pressure. Miller [2-12] gives the following equation that fits the graphical relationship between X and ΔC shown in Figure 2-3:

$$\Delta C = \alpha_p/0.605 = 1.25/(5+1/X)$$

The preceding approach pertains to cylinders. Along the similar lines, Miller [2-13] has developed an approach for spheres as described next.

The non-dimensional parameter X is essentially $(\sigma_\theta/E)(R/t)$. Since in the case of a sphere, the hoop stress is one-half of that in the cylinder, the parameter X is redefined for spheres as follows:

$$X_{(sphere)} = (p/8E)(2R/t)^2$$

When the tensile stress magnitude, S, is known, the equivalent internal pressure can be calculated using the expression:

$$p = 2tS/R$$

Based on a review of spherical shell buckling data [2-14, 2-15], Miller [2-13] proposed the following equation for ΔC:

$$\Delta C_{(sphere)} = 1.06/(3.24 + 1/X)$$

The modified capacity reduction factor, $\alpha_{i,mod}$, for the drywell geometry was obtained as follows:

$$\alpha_{i,mod} = 0.207 + \Delta C_{(sphere)}/0.605$$

2.4 Determination of Plasticity Reduction Factor

When the elastic buckling stress exceeds the proportional limit of the material, a plasticity reduction factor, η_i, is used to account for the non-linear material behavior. The inelastic buckling stress for fabricated shells is given by $\eta_i \alpha_i \sigma_{ie}$. Reference 2-2 gives the mathematical expressions shown below [Article -1611 (a)] to calculate the plasticity reduction factor for the meridional direction elastic buckling stress. Δ is equal to $\alpha_i \sigma_{ie}/\sigma_y$ and σ_y is the material yield strength. Figure 2-4 shows the relationship in graphical form.

$$\eta_i = \begin{cases} 1.0 & \text{if } \Delta \le 0.55 \\ (0.45/\Delta) + 0.18 & \text{if } 0.55 < \Delta \le 1.6 \\ 1.31/(1+1.15\Delta) & \text{if } 1.6 < \Delta \le 6.25 \\ 1/\Delta & \text{if } \Delta > 6.25 \end{cases}$$

2.5 References

2-1 ASME Boiler and Pressure Vessel Code Case N-284, "Metal Containment Shell Buckling Design Methods, Section III, Division 1, Class MC", Approved August 25, 1980.

2-2 Letter (1985) from C.D. Miller to P. Raju; Subject: Recommended Revisions to ASME Code Case N-284.

2-3 Miller, C.D., "Commentary on the Metal Containment Shell Buckling Design Methods of the ASME Boiler and Pressure Vessel Code," December 1979.

2-4 ASME Boiler & Pressure Vessel Code, Section III, Nuclear Power Plant Components.

2-5 "Justification for Use of Section III, Subsection NE, Guidance in Evaluating the Oyster Creek Drywell," Appendix A to letter dated December 21, 1990 from H.S. Mehta of GE to S.C. Tumminelli of GPUN.

2-6 Harris, L.A., et al, "The Stability of Thin-Walled Unstiffened Circular Cylinders Under Axial Compression Including the Effects of Internal Pressure," Journal of the Aeronautical Sciences, Vol. 24, No. 8 (August 1957), pp. 587-596.

2-7 Lo, H., Crate, H., and Schwartz, E.B., "Buckling of Thin-Walled Cylinder Under Axial Compression and Internal Pressure," NACA TN 2021, January 1950.

2-8 Fung, Y.C., and Sechler, E.E., "Buckling of Thin-Walled Circular Cylinders Under Axial Compression and Internal Pressure," Journal of the Aeronautical Sciences, Vol. 24, No. 5, pp. 351-356, May 1957.

2-9 Baker, E.H., et al., "Shell Analysis Manual," NASA, CR-912 (April 1968).

2-10 Bushnell, D., "Computerized Buckling Analysis of Shells," Kluwer Academic Publishers, 1989 (Chapter 5).

2-11 Johnson, B.G., "Guide to Stability Design Criteria for Metal Structures," Third Edition (1976), John Wiley & Sons.

2-12 Miller, C.D., "Effects of Internal Pressure on Axial Compression Strength of Cylinders," CBI Technical Report No. 022891, February 1991.

2-13 Miller, C.D., "Evaluation of Stability Analysis Methods Used for the Oyster Creek Drywell," CBI Technical Report Prepared for GPU Nuclear Corporation, September 1991.

2-14 Odland, J., "Theoretical and Experimental Buckling Loads of Imperfect Spherical Shell Segments," Journal of Ship Research, Vol. 25, No.3, September 1981, pp. 201-218.

2-15 Yao, J.C., "Buckling of a Truncated Hemisphere Under Axial Tension," AIAA Journal, Vol. 1, No. 10, October 1963, pp. 2316-2319.

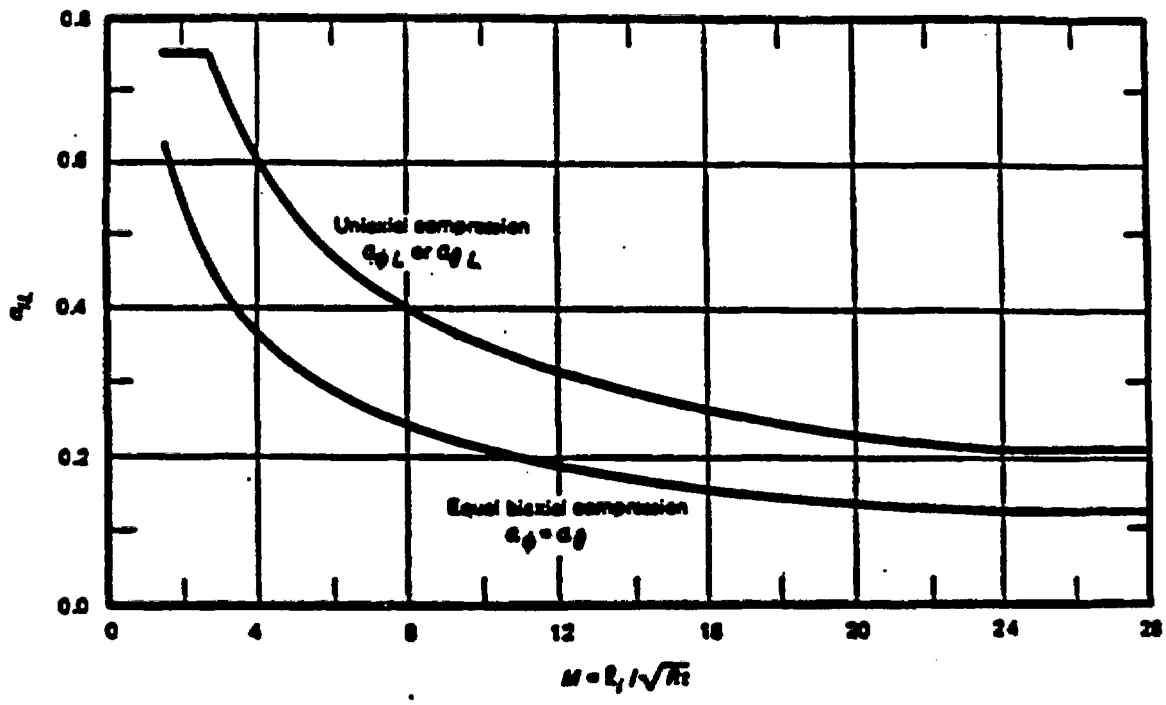


Figure 2-1 Capacity Reduction Factors for Local Buckling of Stiffened and Unstiffened Spherical Shells

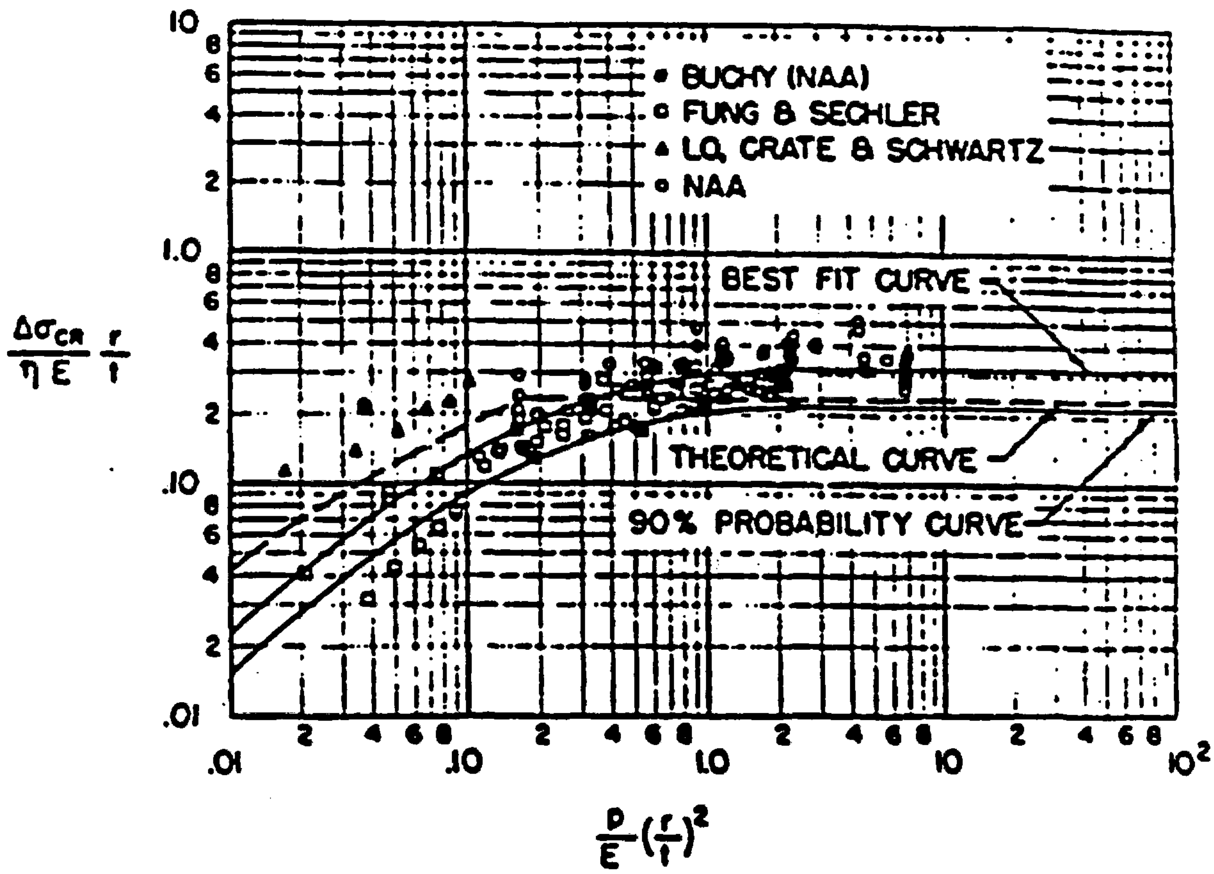


Figure 2-2 Experimental Data Showing Increase in Compressive Buckling Stress Due to Internal Pressure (Reference 2-6)

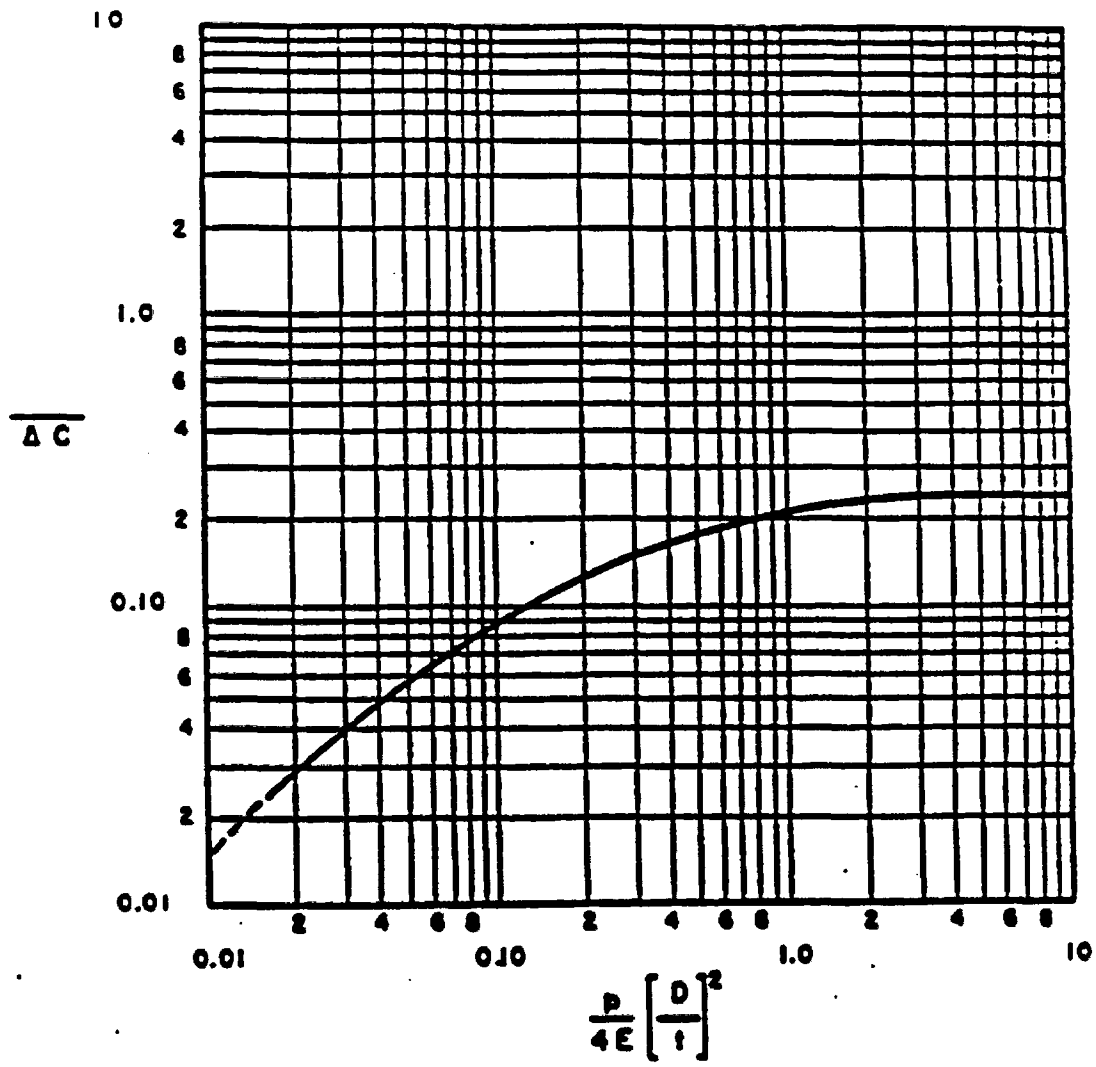


Figure 2-3 Design Curve to Account for Increase in Compressive Buckling Stress Due to Internal Pressure (Reference 2-11)

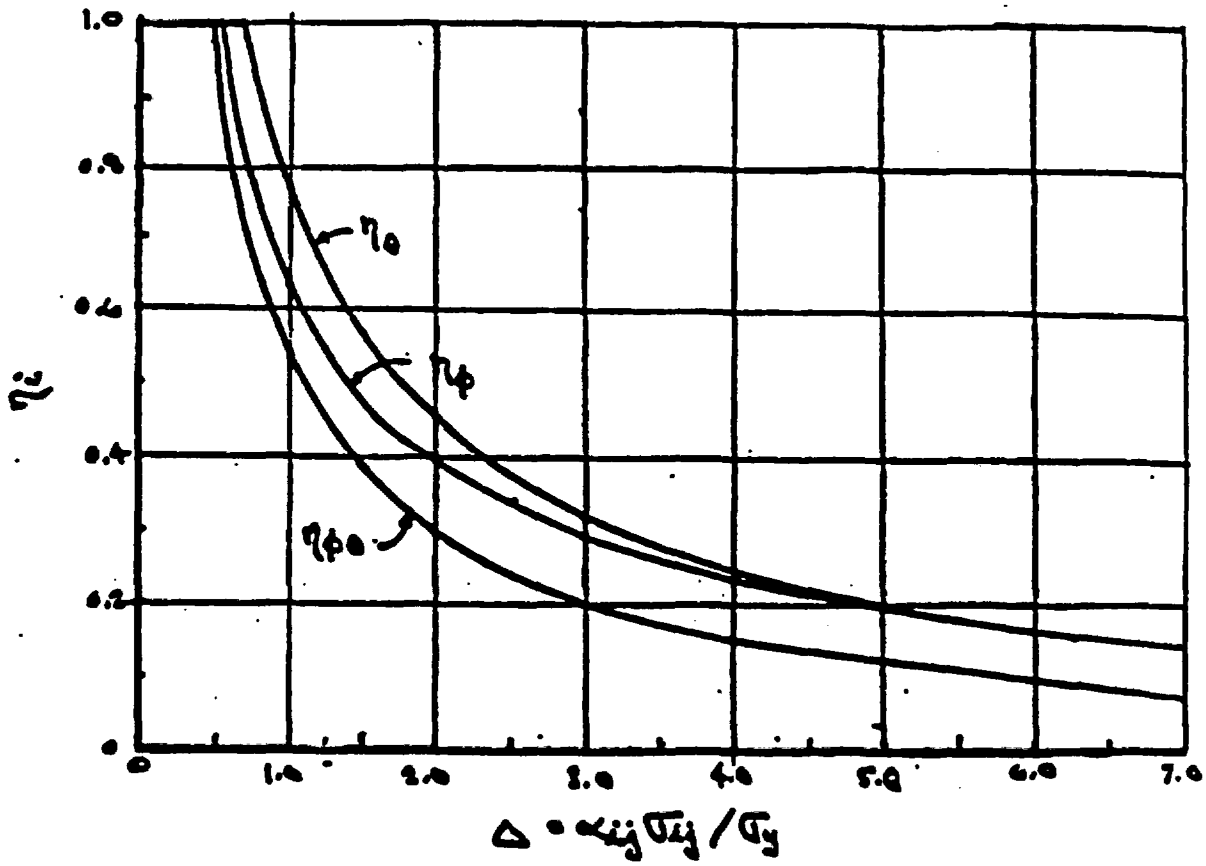


Figure 2-4 Plasticity Reduction Factors for Inelastic Buckling

3. FINITE ELEMENT MODELING AND ANALYSIS

3.1 Finite Element Buckling Analysis Methodology

This evaluation of the Oyster Creek Drywell buckling capability uses the Finite Element Analysis (FEA) program ANSYS [Reference 3-1]. The ANSYS program uses a two step eigenvalue formulation procedure to perform linear elastic buckling analysis. The first step is a static analysis of the structure with all anticipated loads applied. The structural stiffness matrix, [K], the stress stiffness matrix, [S], and the applied stresses, σ_{ap}, are developed and saved from this static analysis. A buckling pass is then run to solve for the eigenvalue or load factor, λ, for which elastic buckling is predicted using the equation:

$$([K] + \lambda [S]) \{u\} = 0$$

where: λ is the eigenvalue or load factor.
$\{u\}$ is the eigenvector representing the buckled shape of the structure.

This load factor is a multiplier for the applied stress state at which the onset of elastic buckling will theoretically occur. All applied loads (pressures, forces, gravity, etc...) are scaled equally. For example, a load factor of 4 would indicate that the structure would buckle for a load condition four times that defined in the stress pass. The critical stress, σ_{cr}, at a certain location of the structure is thus calculated as:

$$\sigma_{cr} = \lambda \sigma_{ap}$$

This theoretical elastic buckling stress is then modified by the capacity and plasticity reduction factors to determine the predicted buckling stress of the fabricated structure as discussed in Section 2. This stress is further reduced by a factor of safety to determine the allowable compressive stress.

3.2 Finite Element Model

The Oyster Creek drywell has been previously analyzed using a simplified axisymmetric model to evaluate the buckling capability in the sandbed region [Reference 3-2]. This type of analysis conservatively neglects the vents and reinforcements around the vents which significantly increase the stiffness of the shell near the sandbed region. In order to more accurately determine the buckling capability of the drywell, a three dimensional finite element model is developed.

The geometry of the Oyster Creek drywell is shown in Figure 3-1. Taking advantage of symmetry of the drywell with 10 vents, a 36° section is modeled. Figure 3-2 illustrates the finite element model of the drywell. This model includes the drywell shell from the base of the sandbed region to the top of the elliptical head and the vent and vent header. The torus is not included in this model because the bellows provide a very flexible connection which does not allow significant structural interaction between the drywell and torus.

Figure 3-3 shows a more detailed view of the lower section of the drywell model. The various colors on Figures 3-2 and 3-3 represent the different shell thicknesses of the drywell and vent. Nominal or as-designed thicknesses, summarized in Table 3-1, are used for the drywell shell for all regions other than the sandbed region. The sandbed region shown in blue in Figure 3-3 is considered to have a thickness of 0.736 inch. This is the 95% confidence projected thickness to outage 14R. Figure 3-4 shows the view from the inside of the drywell with the gussets and the vent jet deflector.

The drywell and vent shell are modeled using the 3-dimensional plastic quadrilateral shell (STIF43) element. Although this element has plastic capabilities, this analysis is conducted using only elastic behavior. This element type was chosen over the elastic quadrilateral shell (STIF63) element because it is better suited for modeling curved surfaces.

At a distance of 76 inches from the drywell shell, the vent is simplified using beam elements. The transition from shell to beam elements is made by extending rigid beam elements from a node along the centerline of the vent radially outward to each of the shell nodes of the vent. ANSYS STIF4 beam elements are then connected to this centerline node to model the axial and bending stiffness of the vent and header. Spring (STIF14) elements are used to model the vertical header supports inside the torus. ANSYS STIF4 beam elements are also used to model the stiffeners in the cylindrical region of the upper drywell. The section properties of these stiffeners are summarized in Table 3-2.

The mesh size in the sandbed region of the model was refined for the purpose of buckling evaluation. The mesh refinement was conducted as follows. Buckling analyses of flat plate finite element models with different mesh sizes were conducted and the calculated load factors were compared with the available theoretical values. The analyses considered both the fixed and free edge boundary conditions. The results of these analyses showed that with a 3"x3" mesh, the finite element predicted load factors were within a few percent of the theoretical values. Figure 3-5 shows the results of one of the flat plate analyses. Based on these analyses, it was concluded that an appropriate mesh size is achieved when the element size in the sandbed region is ≈ 3"x3". Figure 3-6 shows the view of the refined mesh. As discussed in Subsection 3.6, the refined mesh was important for the buckling analysis but had little effect on the stress magnitudes in the sandbed region.

3.3 Drywell Materials

The drywell shell is fabricated from SA-212, Grade B high tensile strength carbon-silicon steel plates for boilers and other pressure vessels ordered to SA-300 specifications. The mechanical properties for this material at room temperature are shown in Table 3-3. These are the properties used in the finite element analysis. For the perforated vent jet deflector, the material properties were modified to account for the reduction in stiffness due to the perforations.

3.4 Boundary Conditions

There are two sets of boundary conditions, one for the stress analysis and the other for the buckling analysis. The stress analysis boundary conditions are discussed first.

3.4.1 Boundary Conditions for Stress Analysis

Symmetric boundary conditions are defined for both edges of the 36° drywell model for the static stress analysis as shown in Figure 3-7. This allows the nodes at this boundary to expand radially outward from the drywell centerline and vertically, but not in the circumferential direction. Rotations are also fixed in two directions to prevent the boundary from rotating out of the plane of symmetry. Nodes at the bottom edge of the drywell are fixed in all directions to simulate the fixity of the shell within the concrete foundation. Nodes at the end of the header support spring elements are also fixed.

3.4.2 Boundary Conditions for Buckling Analysis

Three sets of boundary conditions are used at the edges of the pie slice model: symmetric at the both edges (sym-sym), symmetric at one edge and asymmetric at the other edge (sym-asym), and asymmetric at the both edges (asym-asym). This is required to capture all possible buckling mode shapes that the model is able to predict. Figure 3-8 graphically illustrates the various boundary conditions. With the symmetric boundary conditions, the nodes at the edges can displace radially but the rotation is not allowed. In the asymmetric boundary conditions, the nodes at the edges are allowed to rotate but the radial displacement is not allowed. The load factors were determined for each of the three sets of boundary conditions and the one with the smallest value was used for the Code margin evaluation.

3.5 Loads

The loads are applied to the drywell finite element model in the manner which most accurately represents the actual loads anticipated on the drywell. Details on the application of loads are discussed in the following paragraphs.

3.5.1 Load Combinations

All load combinations to be considered on the drywell are summarized on Table 3-4. The most limiting load combinations in terms of possible buckling are those which cause the most compressive stresses in the sandbed region. Many of the design basis load combinations include high internal pressures which would create tensile stresses in the shell and help prevent buckling. The most severe design load combination identified for the buckling analysis of the drywell is the refueling condition (Case IV). This load combination consists of the following loads:

Dead weight of vessel, penetrations, compressible material, equipment supports and welding pads.
Live loads of welding pads and equipment door
Weight of refueling water
External Pressure of 2 psig
Seismic inertia and deflection loads for unflooded condition

The normal operation condition with seismic is very similar to this condition, however, it will be less severe due to the absence of the refueling water and equipment door weight.
The most severe load combination for the emergency condition is for the post-accident (Case VI) load combination including:

Dead weight of vessel, penetrations, compressible material and equipment supports
Live load of personnel lock
Hydrostatic Pressure of Water for Drywell Flooded to 74'-6"
External Pressure of 2 psig
Seismic inertia and deflection loads for flooded condition

The application of these loads is described in more detail in the following sections.

3.5.2 Gravity Loads

The gravity loads include dead weight loads of the drywell shell, weight of the compressible material and penetrations and live loads. The drywell shell loads are imposed on the model by defining the weight density of the shell material and applying a vertical acceleration of 1.0 g to simulate gravity. The ANSYS program automatically distributes the loads consistent with the mass and acceleration. The compressible material weight of 10 lb/ft^2 is added by adjusting the weight density of the shell to also include the compressible material. The adjusted weight densities for the various shell thicknesses are summarized in Table 3-5. The compressible material is assumed to cover the entire drywell shell (not including the vent) up to the elevation of the flange.

The additional dead weights, penetration weights and live loads are applied as additional nodal masses to the model. As shown on Table 3-6 for the refueling case, the total additional mass is summed for each 5 foot elevation of the drywell. The total is then divided by 10 for the 36° section assuming that the mass is evenly distributed around the perimeter of the drywell. The resulting mass is then applied uniformly to a set of nodes at the desired elevation as shown on Table 3-6. These applied masses automatically impose gravity loads on the drywell model with the defined acceleration of 1g. The same method is used to apply the additional masses to the model for the post-accident case as summarized in Table 3-7.

3.5.3 Pressure Loads

The 2 psi external pressure load for the refueling case is applied to the external faces of all of the drywell and vent shell elements. The compressive axial stress at the transition from vent shell to beam elements is simulated by applying equivalent axial forces to the nodes of the shell elements.

Considering the post-accident case, the drywell is assumed to be flooded to elevation 74'-6" (894 inches). Using a water density of

62.3 lb/ft^3 (0.0361 lb/in^3), the pressure gradient versus elevation is calculated as shown in Table 3-8. The hydrostatic pressure at the bottom of the sandbed region is calculated to be 28.3 psi. According to the elevation of the element centerline, the appropriate pressures are applied to the inside surface of the shell elements.

3.5.4 Seismic Loads

Seismic stresses have been calculated for the Oyster Creek Drywell in Part 1 of this report, Reference 3-3. Meridional stresses are imposed on the drywell during a seismic event due to a 0.058" deflection of the reactor building and due to horizontal and vertical inertial loads on the drywell.

The meridional stresses due to a seismic event are imposed on the 3-D drywell model by applying downward forces at four elevations of the model (A: 23'-7",B: 37'-3",C: 50'-11" and D: 88'-9") as shown on Figure 3-9. Using this method, the meridional stresses calculated in Reference 3-3 are duplicated at four sections of the drywell including 1) the mid-elevation of the sandbed region, 2) 17.25° below the equator, 3) 5.75° above the equator and 4) just above the knuckle region. These four sections were chosen to most accurately represent the load distribution in the lower drywell while also providing a reasonably accurate stress distribution in the upper drywell.

To find the correct loads to match the seismic stresses, the total seismic stress (due to reactor building deflection and horizontal and vertical inertia) are obtained from Reference 3-3 at the four sections of interest. The four sections and the corresponding meridional stresses for the refueling and post-accident seismic cases are summarized in Table 3-9.

Unit loads are then applied to the 3-D model in separate load steps at each elevation shown in Figure 3-9. The resulting stresses at the four sections of interest are then averaged for each of the applied unit loads. By solving four equations with four unknowns, the correct loads are determined to match the stresses shown in Table 3-9 at the four sections. The calculation for the correct loads are shown on Tables 3-10 and 3-11 for the refueling and post-accident cases, respectively.

3.6 Stress Results

The resulting stresses for the two load combinations described in section 3.5 are summarized in this section. The mesh refinement produced less than 1% change in the calculated stress magnitudes from those obtained with the previous mesh in which the elements in the sandbed region were approx. 12"x12". The stresses reported in these Subsections are based on the refined mesh model.

3.6.1 Refueling Condition Stress Results

The resulting stress distributions for the refueling condition are shown in Figures 3-10 through 3-13. The red colors represent the most tensile stresses and the blue colors, the most compressive. Figures 3-10 and 3-11 show the meridional stresses for the entire drywell and lower drywell. The circumferential stresses for the same areas are shown on Figures 3-12 and 3-13. The resulting average meridional stress at the mid-elevation of the sandbed region was found to be;

$$\sigma_{Rm} = -7588 \text{ psi}$$

The circumferential stress averaged from the bottom to the top of the sandbed region is;

$$\sigma_{Rc} = 4510 \text{ psi}$$

3.6.2 Post-Accident Condition Stress Results

The application of all of the loads described for the post-accident condition results in the stress distributions shown in Figures 3-14 through 3-17. The red colors represent the most tensile stresses and the blue colors, the most compressive. Figures 3-14 and 3-15 show the meridional stresses for the entire drywell and lower drywell. The circumferential stresses for the same areas are shown on Figures 3-16 and 3-17. The resulting average meridional stress at mid-elevation of the sandbed region was found to be;

$$\sigma_{PAm} = -12000 \text{ psi}$$

The circumferential stress averaged from the bottom to the top of the sandbed region is;

$$\sigma_{PAc} = +20210 \text{ psi}$$

3.7 Theoretical Elastic Buckling Stress Results

After the completion of stress runs for the Refueling and Post-Accident load combinations, the eigenvalue buckling runs are made as described in Section 3.1. This analysis determines the theoretical elastic buckling loads and buckling mode shapes.

3.7.1 Refueling Condition Buckling Results

The first buckling analysis was conducted using the sym-sym boundary conditions. The lowest (i.e., first) load factor for this case was found to be 6.14 with the critical buckling occurring in the sandbed region. The critical buckling mode shape is shown in Figure 3-18. The red color indicates sections of the shell which displace radially outward and the blue, those areas which displace inward.

The first six buckling modes were computed in this eigenvalue buckling analysis with no buckling modes found outside the sandbed region for a load factor as high as 8.89. Therefore, buckling is not a concern outside of the sandbed region.

The lowest load factors for the sym-asym and asym-asym boundary conditions were determined to be 6.23 and 7.22, respectively. Figure 3-19 shows the buckling mode shape with sym-asym boundary conditions. It is clear from these load factor values that the sym-sym boundary condition load factor of 6.14 is the lowest one. Multiplying the load factor of 6.14 by the average meridional stress from section 3.6.1, the theoretical elastic buckling stress is found to be;

$$\sigma_{Rie} = 6.14 \times (7588 \text{ psi}) = 46590 \text{ psi}$$

3.7.2 Post-Accident Condition Buckling Results

Considering the post-accident case with symmetric boundary conditions, the load factor was calculated as 4.085. The sym-asym boundary conditions gave a load factor of 4.206 for the first mode. Based on the refueling condition buckling analyses, it was concluded that the load factor for the asym-asym condition will be higher than both the sym-sym and sym-asym load factors. Thus, the sym-sym boundary conditions gave the lowest load factor and thus are controlling. The critical mode shape for the sym-sym boundary conditions is shown in Figure 3-20. As expected, this mode shape is associated with the sandbed region.

Multiplying the load factor of 4.085 by the applied stress from section 3.6.2 results in a theoretical elastic buckling stress of

$$\sigma_{PAie} = 4.085 \times (12000 \text{ psi}) = 49020 \text{ psi}$$

3.8 References

3-1 DeSalvo, G.J., Ph.D, and Gorman, R.W., "ANSYS Engineering Analysis System User's Manual, Revision 4.4," Swanson Analysis Systems, Inc., May 1, 1989.

3-2 GPUN Specification SP-1302-53-044, Technical Specification for Primary Containment Analysis - Oyster Creek Nuclear Generating Station; Rev. 2, October 1990.

3-3 "An ASME Section VIII Evaluation of the Oyster Creek Drywell - Part 1 Stress Analysis," GE Report No. 9-1, DRF # 00664, November 1990, prepared for GPUN.

Table 3-1

Oyster Creek Drywell Shell Thicknesses

Section	Thickness (in.)
Sandbed Region	0.736 *
Lower Sphere	1.154
Mid Sphere	0.770
Upper Sphere	0.722
Knuckle	2.5625
Cylinder	0.640
Reinforcement Below Flange	1.250
Reinforcement Above Flange	1.500
Elliptical Head	1.1875
Ventline Reinforcement	2.875
Gussets	0.875
Vent Jet Deflector	2.500
Ventline Connection	2.500
Upper Ventline	0.4375
Lower Ventline	0.250

* 95% confidence projected thickness to 14R.

Table 3-2

Cylinder Stiffener Locations and Section Properties

Elevation (in)	Height (in)	Width (in)	Area (in^2)	Bending Inertia (in^4) Horizontal	Vertical
966.3	0.75	6.0	4.5	13.5	0.211
1019.8	0.75	6.0	4.5	13.5	0.211
1064.5	0.50	6.0	3.0	9.0	0.063
1113.0(1)	2.75 1.00	7.0 7.38	26.6	387.5	12.75
1131.0	1.0	12.0	12.0	144.0	1.000

(1) - This stiffener is made up of 2 beam sections, one 2.75x7" and one 1.0x7.375"

Table 3-3

Material Properties for SA-212 Grade B Steel

Material Property	Value
Young's Modulus	29.6×10^6 psi
Yield Strength	38000 psi
Poisson's Ratio	0.3
Density	0.283 lb/in^3

Table 3-4

Oyster Creek Drywell Load Combinations

CASE I - INITIAL TEST CONDITION
Deadweight + Design Pressure (62 psi) + Seismic (2 x DBE)

CASE II - FINAL TEST CONDITION
Deadweight + Design Pressure (35 psi) + Seismic (2 x DBE)

CASE III - NORMAL OPERATING CONDITION
Deadweight + Pressure (2 psi external) + Seismic (2 x DBE)

CASE IV - REFUELING CONDITION
Deadweight + Pressure (2 psi external) + Water Load + Seismic (2 x DBE)

CASE V - ACCIDENT CONDITION
Deadweight + Pressure(62 psi @ 175°F or 35 psi @ 281°F) + Seismic (2 x DBE)

CASE VI - POST ACCIDENT CONDITION
Deadweight + Water Load @ 74'6" + Seismic (2 x DBE)

Table 3-5

Adjusted Weight Densities of Shell to Account for Compressible Material Weight

Shell Thickness (in.)	Adjusted Weight Density (lb/in^3)
1.154	0.343
0.770	0.373
0.722	0.379
2.563	0.310
0.640	0.392
1.250	0.339

Table 3-6

Oyster Creek Drywell Additional Weights - Refueling Condition

ELEVATION (feet)	DEAD WEIGHT (lbf)	PENETR. WEIGHT (lbf)	& MISC. LOADS (lbf)	TOTAL LOAD (lbf)	5 FOOT RANGE LOAD	LOAD PER 36 DEG. (lbf)	# OF ELEMENTS	NODES OF APPLICATION	LOAD PER FULL NODE (lbf)	LOAD PER HALF NODE (lbf)
15.56	50000			50000						
16		168100		168100						
20		11200		11200						
** 15-20					229300	22930	6	116-119	3822	1911
22#	556000			556000						
** 21-25#					556000	55600	8	161-169	6950	3475
26		11100		11100						
30	64100	51500		115600						
30.25	105000		100000	205000						
** 26-30					331700	33170	8	179-187	4146	2073
31		16500		16500						
32		750		750						
33		15450		15450						
34		28050		28050						
35		1500		1500						
** 31-35					62250	6225	8	188-196	778	389
36		1550		1550						
40	41000	43350		84350						
** 36-40					85900	8590	8	197-205	1074	537
50#	1102000			1102000						
** 45-50#					1102000	110200	8	418-426	13775	6888
54		7850		7850						
** 51-55					7850	785	8	436-444	98	49
56	56400		24000	80400						
60	95200	700	20000	115900						
** 56-60					196300	19630	8	454-462	2454	1227
65	52000		20000	72000						
** 61-65					72000	7200	8	472-480	900	450
70		5750		5750						
** 66-70					5750	575	8	508-516	72	36
73		8850		8850						
** 71-75					8850	885	8	526-534	111	55
82.17	21650			21650						
** 81-85					21650	2165	8	553-561	271	135
87		1000		1000						
90		15000		15000						
** 86-90					16000	1600	8	571-579	200	100
93.75	20700			20700						
94.75#			698000	698000						
95.75	20100			20100						
** 91-96					738800	73880	8	589-597	9235	4618
TOTALS:	2184150	388200	862000	3434350	3434350	343435				

- LOAD TO BE APPLIED IN VERTICAL DIRECTION ONLY.

& - MISCELLANEOUS LOADS INCLUDE 698000 LB WATER WEIGHT AT 94.75 FT. ELEVATION 100000 LB EQUIPMENT DOOR WEIGHT AT 30.25 FT. ELEVATION AND WELD PAD LIVE LOADS OF 24000, 20000 AND 20000 AT 56, 60 AND 65 FT. ELEVATIONS

REFWGT.WK1

Table 3-7

Oyster Creek Drywell Additional Weights - Post-Accident Condition

ELEVATION (feet)	DEAD WEIGHT (lbf)	PENETR. WEIGHT (lbf)	& MISC. LOADS (lbf)	TOTAL LOAD (lbf)	5 FOOT RANGE LOAD	LOAD PER 36 DEG. (lbf)	# OF ELEMENTS	NODES OF APPLICATION	LOAD PER FULL NODE (lbf)	LOAD PER HALF NODE (lbf)
15.56	50000			50000						
16		168100		168100						
20		11200		11200						
** 15-20					229300	22930	6	116-119	3822	1911
22#	556000			556000						
** 21-25#					556000	55600	8	161-169	6950	3475
26		11100		11100						
30	64100	51500		115600						
30.25	105000			105000						
** 26-30					231700	23170	8	179-187	2896	1448
31		16500		16500						
32		750		750						
33		15450		15450						
34		28050		28050						
35		1500		1500						
** 31-35					62250	6225	8	188-196	778	389
36		1550		1550						
40	41000	43350		84350						
** 36-40					85900	8590	8	197-205	1074	537
50#	1102000			1102000						
** 45-50#					1102000	110200	8	418-426	13775	6888
54		7850		7850						
** 51-55					7850	785	8	436-444	98	49
56	56400			56400						
60	95200	700		95900						
** 56-60					152300	15230	8	454-462	1904	952
65	52000			52000						
** 61-65					52000	5200	8	472-480	650	325
70		5750		5750						
** 66-70					5750	575	8	508-516	72	36
73		8850		8850						
** 71-75					8850	885	8	526-534	111	55
82.17	21650			21650						
** 81-85					21650	2165	8	553-561	271	135
87		1000		1000						
90		15000		15000						
** 86-90					16000	1600	8	571-579	200	100
93.75	20700			20700						
95.75	20100			20100						
** 91-96					40800	4080	8	589-597	510	255
TOTALS:	2184150	388200	0	2572350	2572350	257235				

- LOAD TO BE APPLIED IN VERTICAL DIRECTION ONLY.
& - NO MISCELLANEOUS LOADS FOR THIS CONDITION.

FLOODWGT.WK1

Table 3-8

Hydrostatic Pressures for Post-Accident, Flooded Condition

WATER DENSITY: 62.32 lb/ft3
0.03606 lb/in3

FLOODED ELEV: 74.5 ft
894 inches

ELEMENTS ABOVE NODES	ANGLE ABOVE EQUATOR (degrees)	ELEVATION (inch)	DEPTH (inch)	PRESSURE (psi)	ELEMENTS
27	-53.32	110.2	783.8	28.3	1-12
40	-51.97	116.2	777.8	28.1	13-24
53	-50.62	122.4	771.6	27.8	25-36
66	-49.27	128.8	765.2	27.6	37-48
79	-47.50	137.3	756.7	27.3	49-51, 61-66 ,55-57
92	-46.20	143.9	750.1	27.1	52-54, 138-141 ,58-60
102	-44.35	153.4	740.6	26.7	142-147, 240-242, 257-259
108	-41.89	166.6	727.4	26.2	148-151, 243, 256
112	-39.43	180.2	713.8	25.7	152-155, 244, 255
116	-36.93	194.6	699.4	25.2	156-159, 245, 254
120	-34.40	209.7	684.3	24.7	160-165, 246, 253
124	-31.87	225.2	668.8	24.1	166-173, 247, 252
130	-29.33	241.3	652.7	23.5	174-183, 248-251
138	-26.80	257.6	636.4	23.0	184-195
148	-24.27	274.4	619.6	22.3	196-207
161	-20.13	302.5	591.5	21.3	208-215
170	-14.38	342.7	551.3	19.9	216-223
179	-8.63	384.0	510.0	18.4	224-231
188	-2.88	425.9	468.1	16.9	232-239
197	2.88	468.1	425.9	15.4	430-437
400	8.63	510.0	384.0	13.8	438-445
409	14.38	551.3	342.7	12.4	446-453
418	20.13	591.5	302.5	10.9	454-461
427	25.50	627.8	266.2	9.6	462-469
436	30.50	660.2	233.8	8.4	470-477
445	35.50	690.9	203.1	7.3	478-485
454	40.50	719.8	174.2	6.3	486-493
463	45.50	746.6	147.4	5.3	494-501
472	50.50	771.1	122.9	4.4	502-509
481	54,86	790.5	103.5	3.7	510-517
490	-	805.6	88.4	3.2	518-525
499	-	820.7	73.3	2.6	526-533
508	-	835.7	58.3	2.1	534-541
517	-	850.8	43.2	1.6	542-549
526	-	885.3	8.7	0.3	550-557
-	-	187.3	706.7	25.5	340-399 (Ventline)

FLOODP.WK1

Table 3-9

Meridional Seismic Stresses at Four Sections

Section	Elevation (inches)	2-D Shell Model Node	Meridional Stresses Refueling (psi)	Meridional Stresses Post-Accident (psi)
A) Middle of Sandbed	119	32	1258	1288
B) 17.25° Below Equator	323	302	295	585
C) 5.75° Above Equator	489	461	214	616
D) Above Knuckle	1037	1037	216	808

Table 3-10

Application of Loads to Match Seismic Stresses - Refueling Case

COMPRESSIVE STRESSES FROM 2-D ANALYSIS		2-D SEISMIC STRESSES AT SECTION (psi)			
	SECTION:	1	2	3	4
	2-D NODE:	32	302	461	1037
	ELEV:	119.3"	322.5"	489.1"	912.3"
0.058" SEISMIC DEFLECTION:		788.67	155.54	103.46	85.31
HORIZ. PLUS VERTICAL SEISMIC INERTIA:		469.55	139.44	110.13	130.21
TOTAL SEISMIC COMPRESSIVE STRESSES:		1258.22	294.98	213.59	215.52

3-D INPUT LOAD SECTION	INPUT 3-D UNIT LOAD DESCRIPTION		3-D STRESSES AT SECTION (psi)			
		SECTION:	1	2	3	4
		3-D NODES:	53-65	170-178	400-408	526-534
		ELEV:	119.3"	322.5"	489.1"	912.3"
A	1000 lbs at nodes 563 through 569		85.43	37.94	34.94	55.23
B	500 lbs at 427&435, 1000 lbs at 428-434		89.88	39.92	36.76	0.00
C	500 lbs at 197&205, 1000 lbs at 198-204		97.64	43.37	0.00	0.00
D	500 lbs at 161&169, 1000 lbs at 162-168		89.85	0.00	0.00	0.00
	DESIRED COMPRESSIVE STRESSES (psi):		1258.22	294.98	213.59	215.52

3-D INPUT LOAD SECTION	LOAD TO BE APPLIED TO MATCH 2-D STRESSES		RESULTING STRESSES AT SECTION (psi)			
A	3902.2		333.37	148.05	136.34	215.52
B	2101.4		188.87	83.89	77.25	0.00
C	1453.6		141.93	63.04	0.00	0.00
D	6611.6		594.05	0.00	0.00	0.00
		SUM:	1258.22	294.98	213.59	215.52

SEISUNFL.WK1

Table 3-11

Application of Loads to Match Seismic Stresses - Post-Accident Case

COMPRESSIVE STRESSES FROM 2-D ANALYSIS		2-D SEISMIC STRESSES AT SECTION (psi)			
	SECTION:	1	2	3	4
	2-D NODE:	32	302	461	1037
	ELEV:	119.3"	322.5"	489.1"	912.3"
0.058" SEISMIC DEFLECTION:		788.67	155.54	103.46	85.31
HORIZ. PLUS VERTICAL SEISMIC INERTIA:		499.79	429.39	512.76	723.14
TOTAL SEISMIC COMPRESSIVE STRESSES:		1288.46	584.93	616.22	808.45

3-D INPUT LOAD SECTION	INPUT 3-D UNIT LOAD DESCRIPTION		3-D STRESSES AT SECTION (psi)			
		SECTION:	1	2	3	4
		3-D NODES:	53-65	170-178	400-408	526-534
		ELEV:	119.3"	322.5"	489.1"	912.3"
A	1000 lbs at nodes 563 through 569		85.43	37.94	34.94	55.23
B	500 lbs at 427&435, 1000 lbs at 428-434		89.88	39.92	36.76	0.00
C	500 lbs at 197&205, 1000 lbs at 198-204		97.64	43.37	0.00	0.00
D	500 lbs at 161&169, 1000 lbs at 162-168		89.85	0.00	0.00	0.00
	DESIRED COMPRESSIVE STRESSES (psi):		1288.46	584.93	616.22	808.45

3-D INPUT LOAD SECTION	LOAD TO BE APPLIED TO MATCH 2-D STRESSES		RESULTING STRESSES AT SECTION (psi)			
A	14637.9		1250.51	555.36	511.45	808.45
B	2850.2		256.17	113.78	104.77	0.00
C	-1941.7		-189.58	-84.21	0.00	0.00
D	-318.8		-28.64	0.00	0.00	0.00
		SUM:	1288.46	584.93	616.22	808.45

SEISFL.WK1

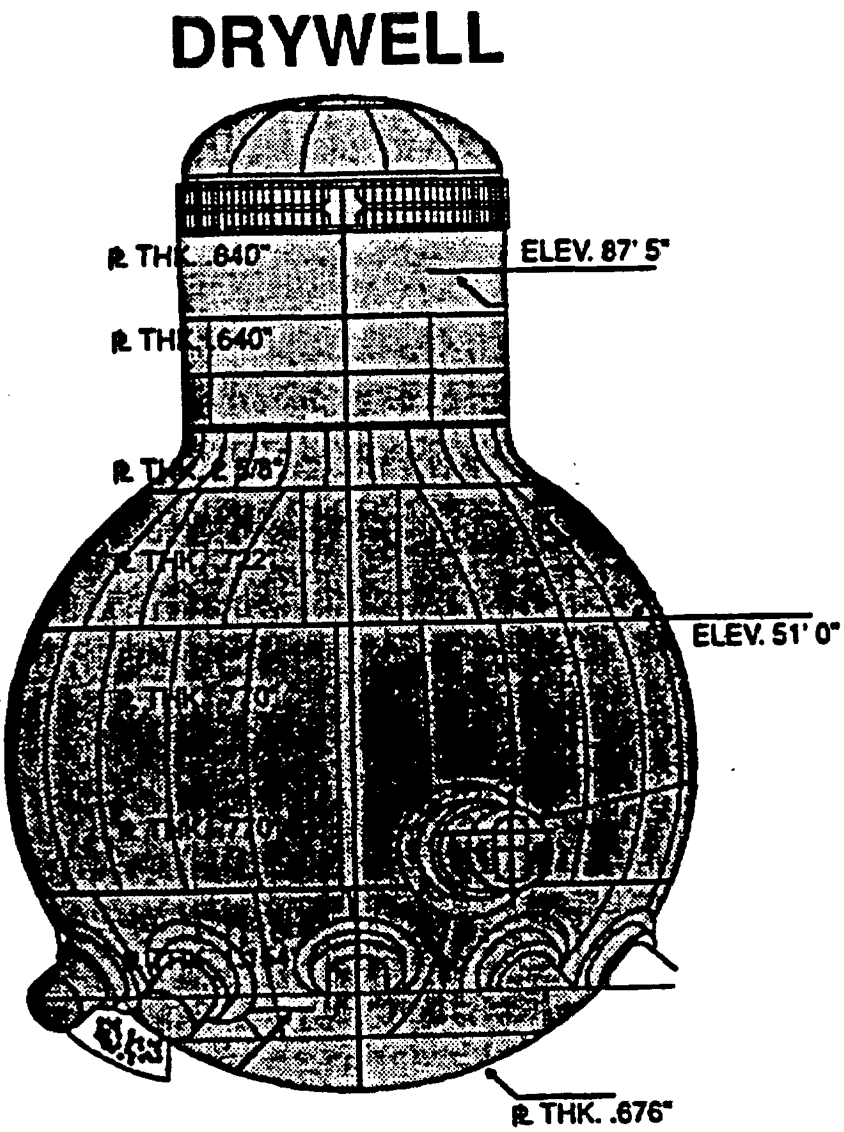


Figure 3-1. Oyster Creek Drywell Geometry

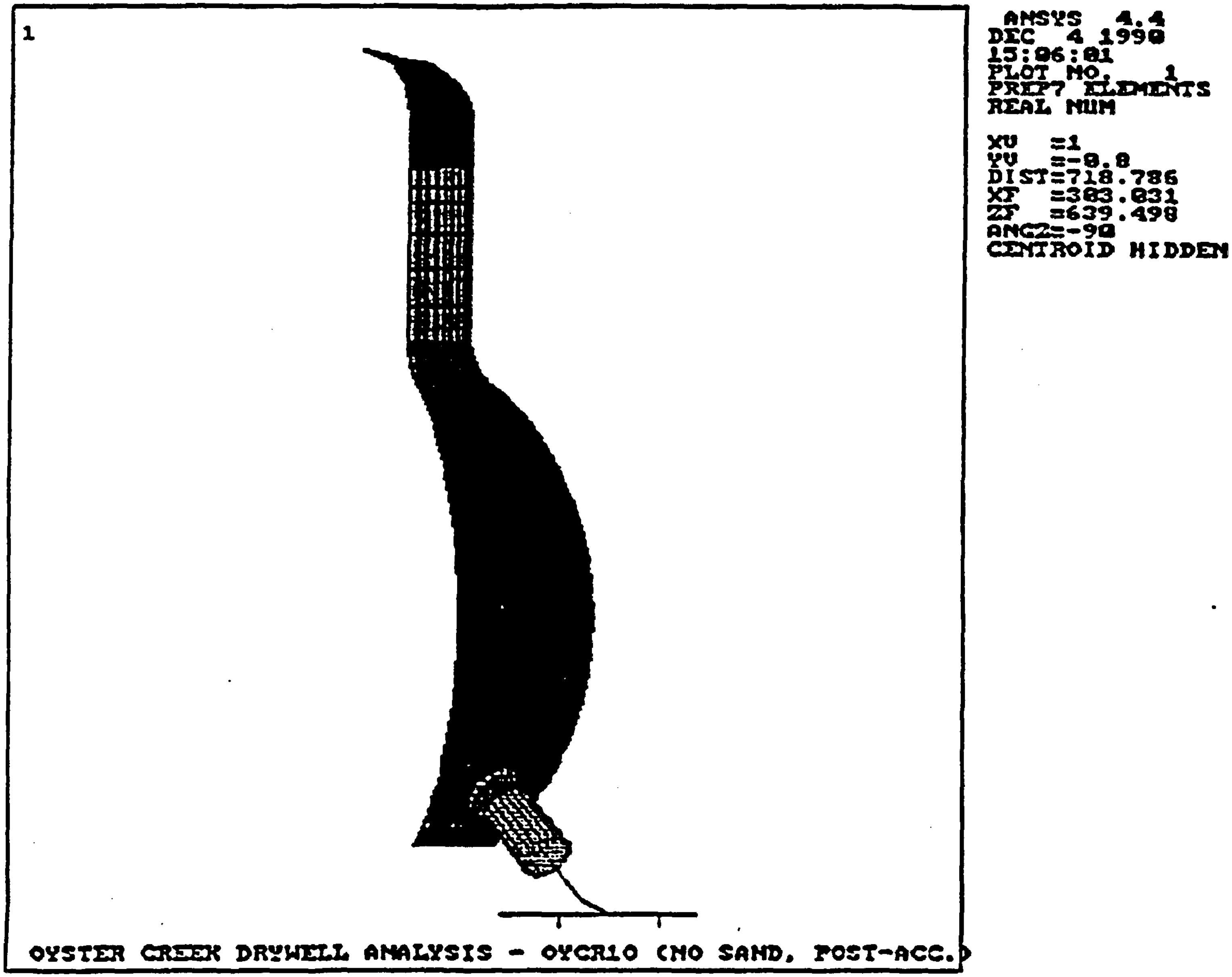


Figure 3-2. Oyster Creek Drywell 3-D Finite Element Model

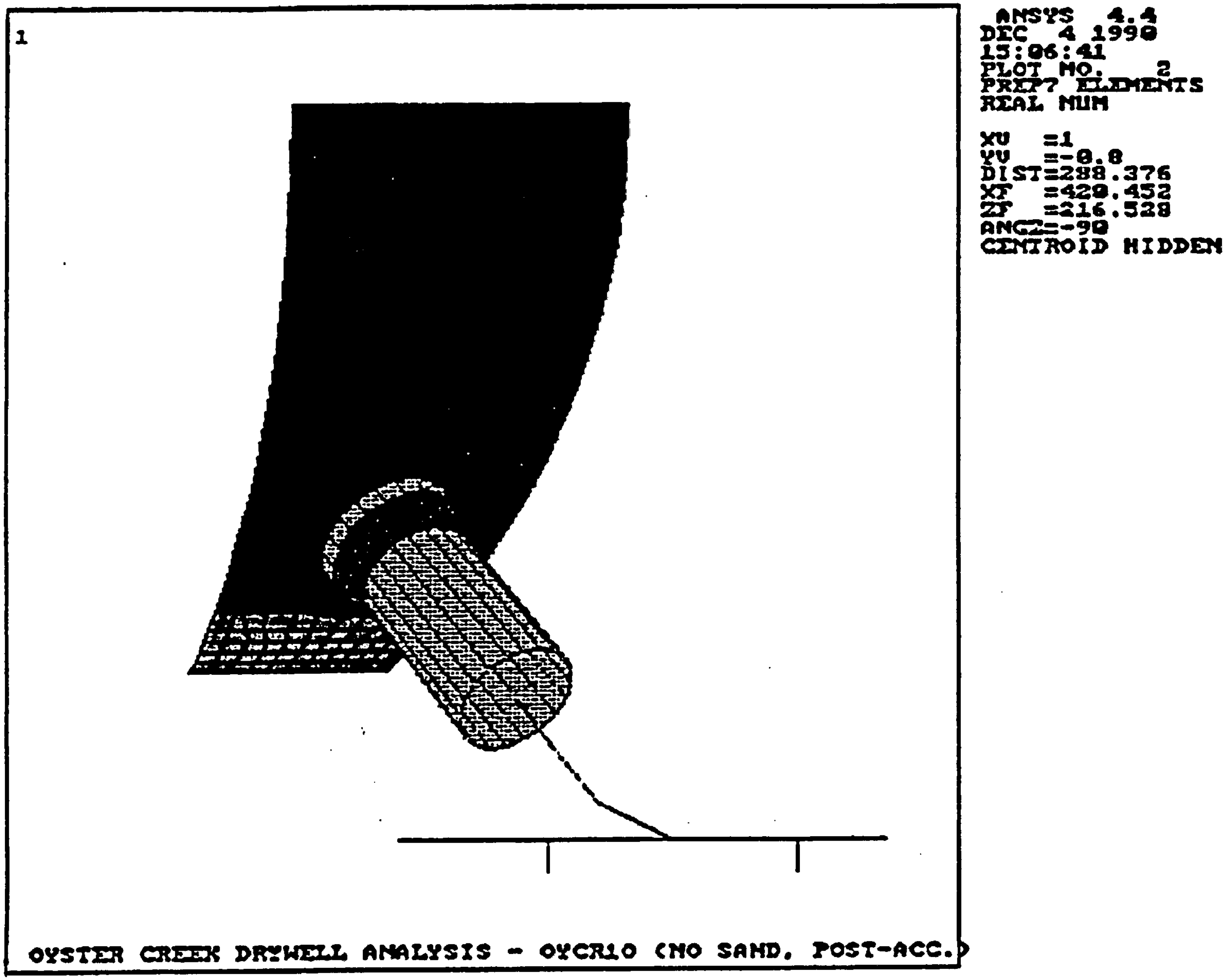


Figure 3-3. Closeup of Lower Drywell Section of FEM (Outside View)

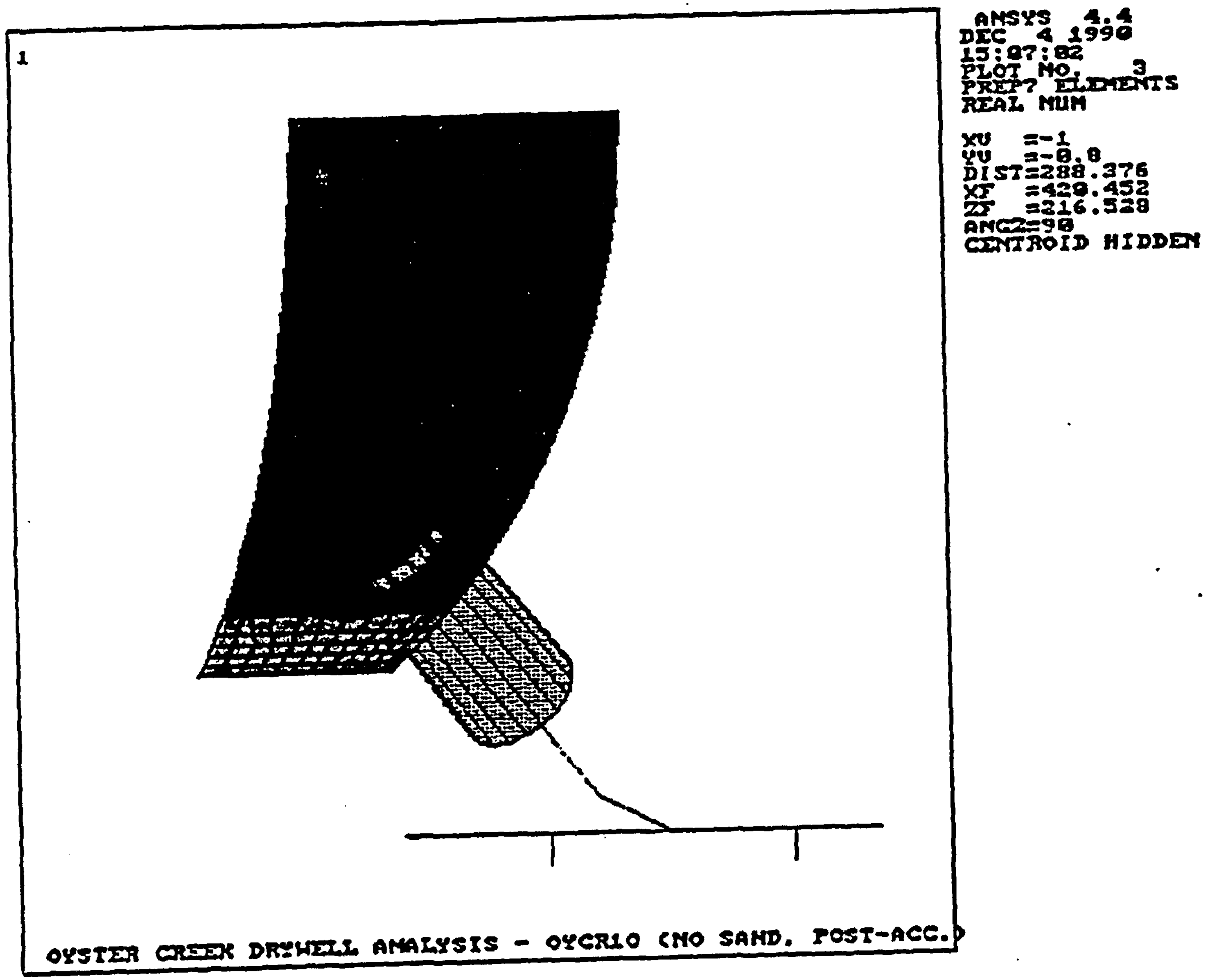


Figure 3-4. Closeup of Lower Drywell Section of FEM (Inside View)

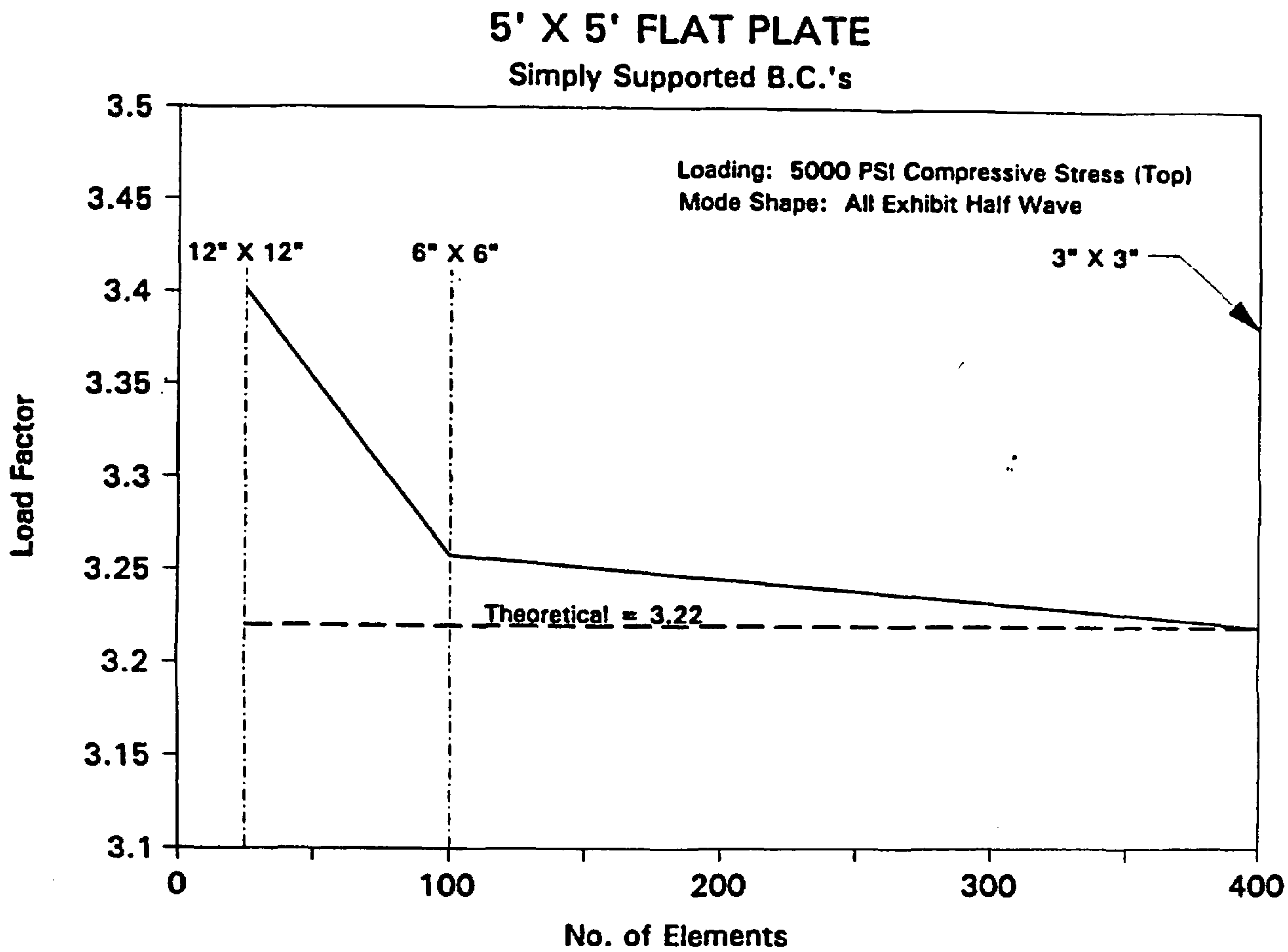


Figure 3-5. Flat Plate Buckling Analysis Results for Free Edge Boundary Conditions

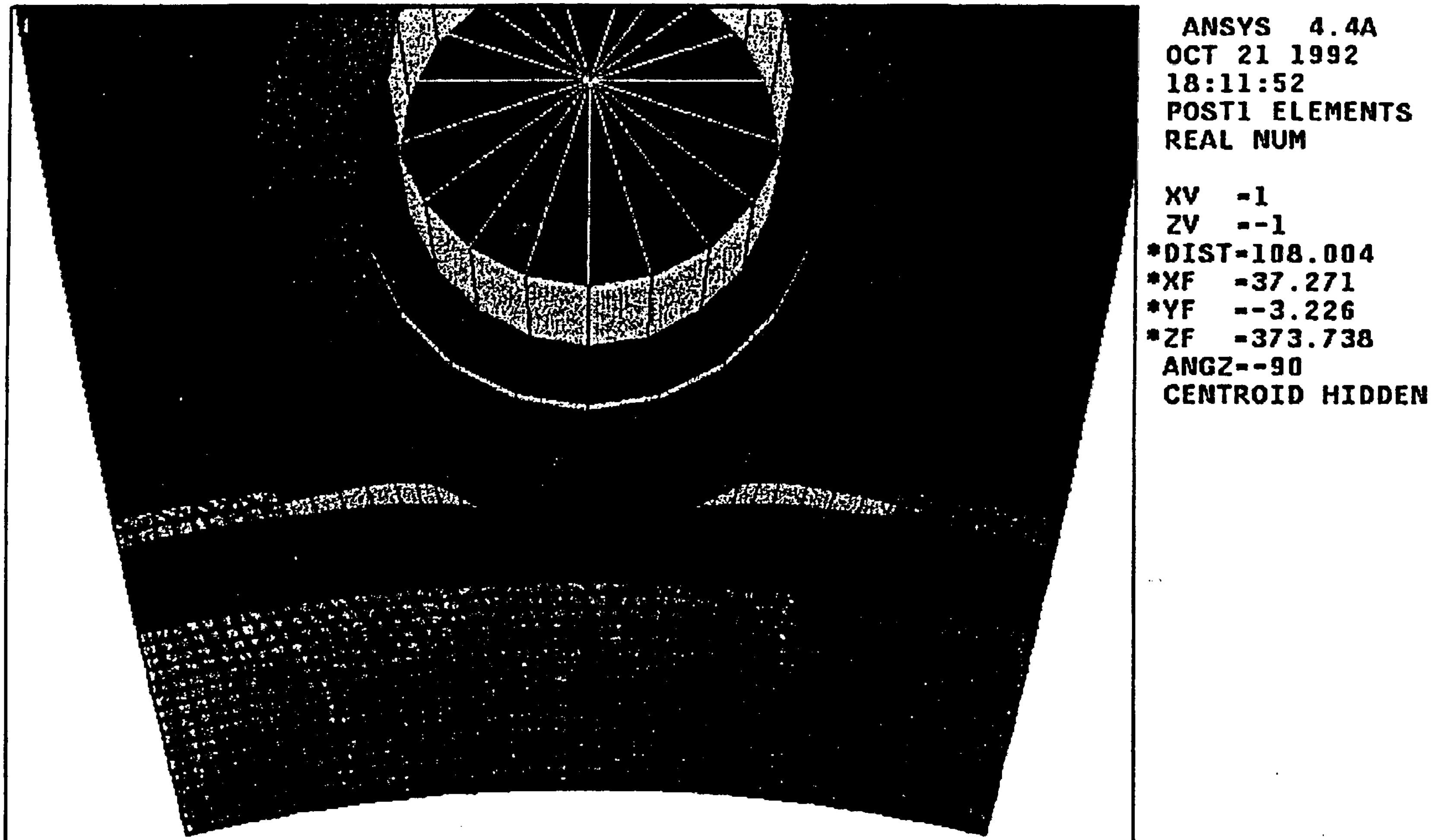


Figure 3-6 View of Refined Mesh in the Sandbed Region

OYSTER CREEK DRYWELL REFINED MODEL

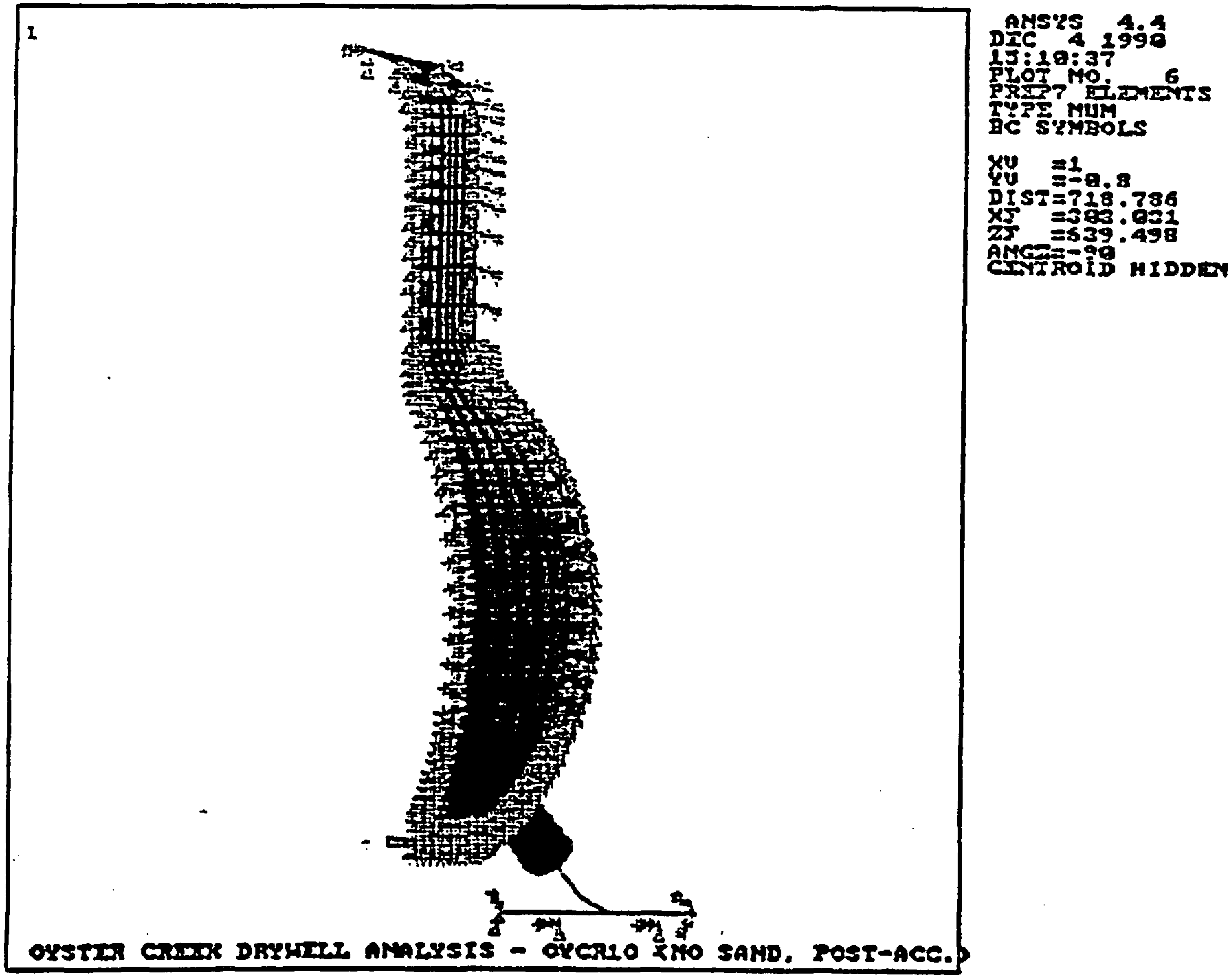
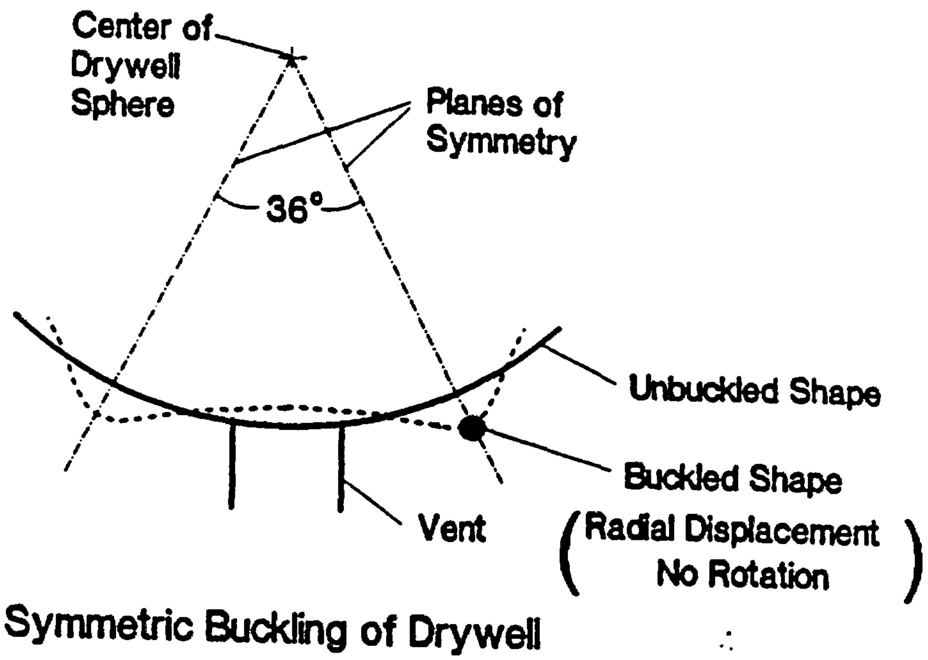
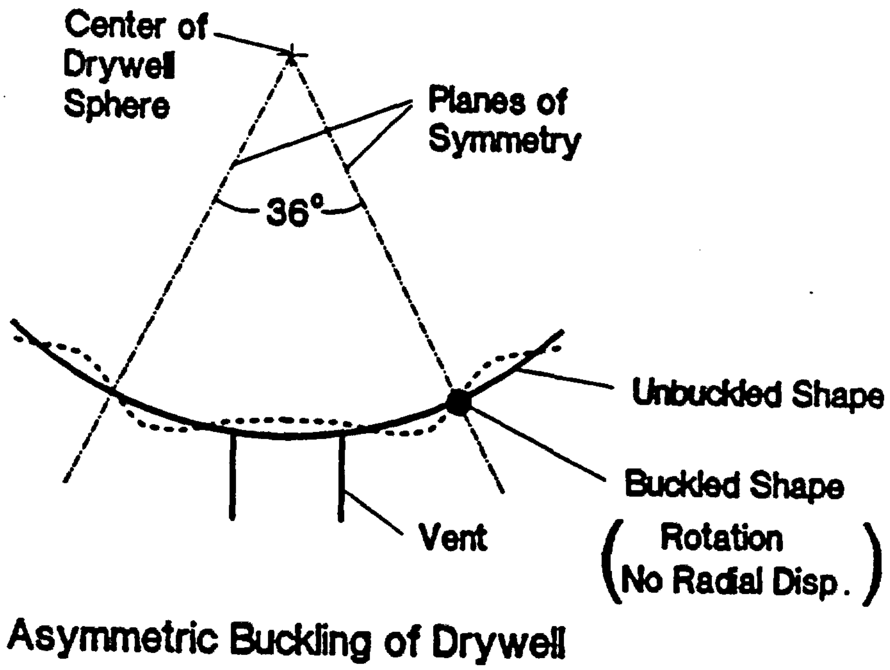


Figure 3-7 Symmetric Boundary Conditions for Stress Analysis





SYM.DRW

Figure 3-8 Symmetric and Asymmetric Buckling Modes

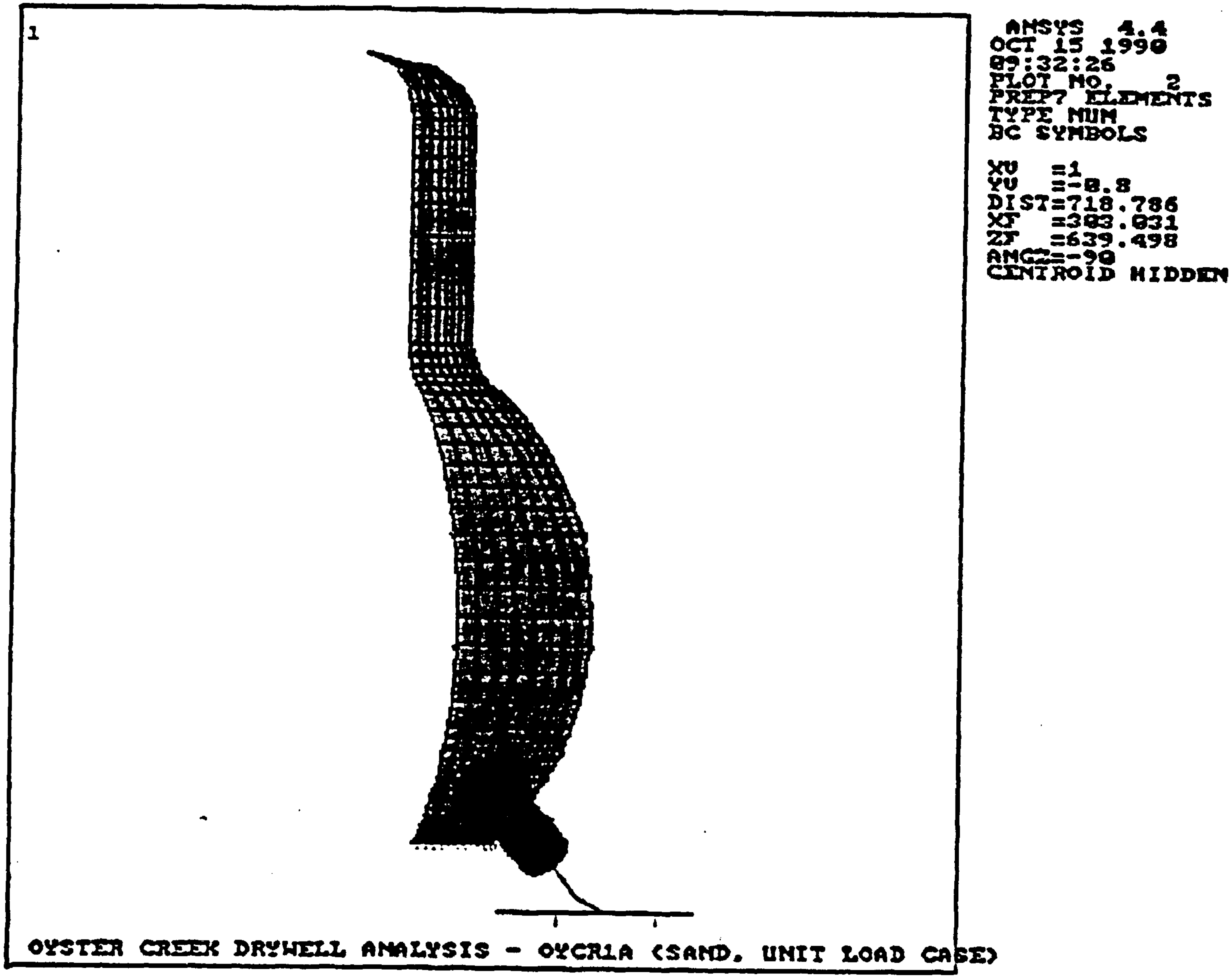


Figure 3-9 Application of Loading to Simulate Seismic Bending

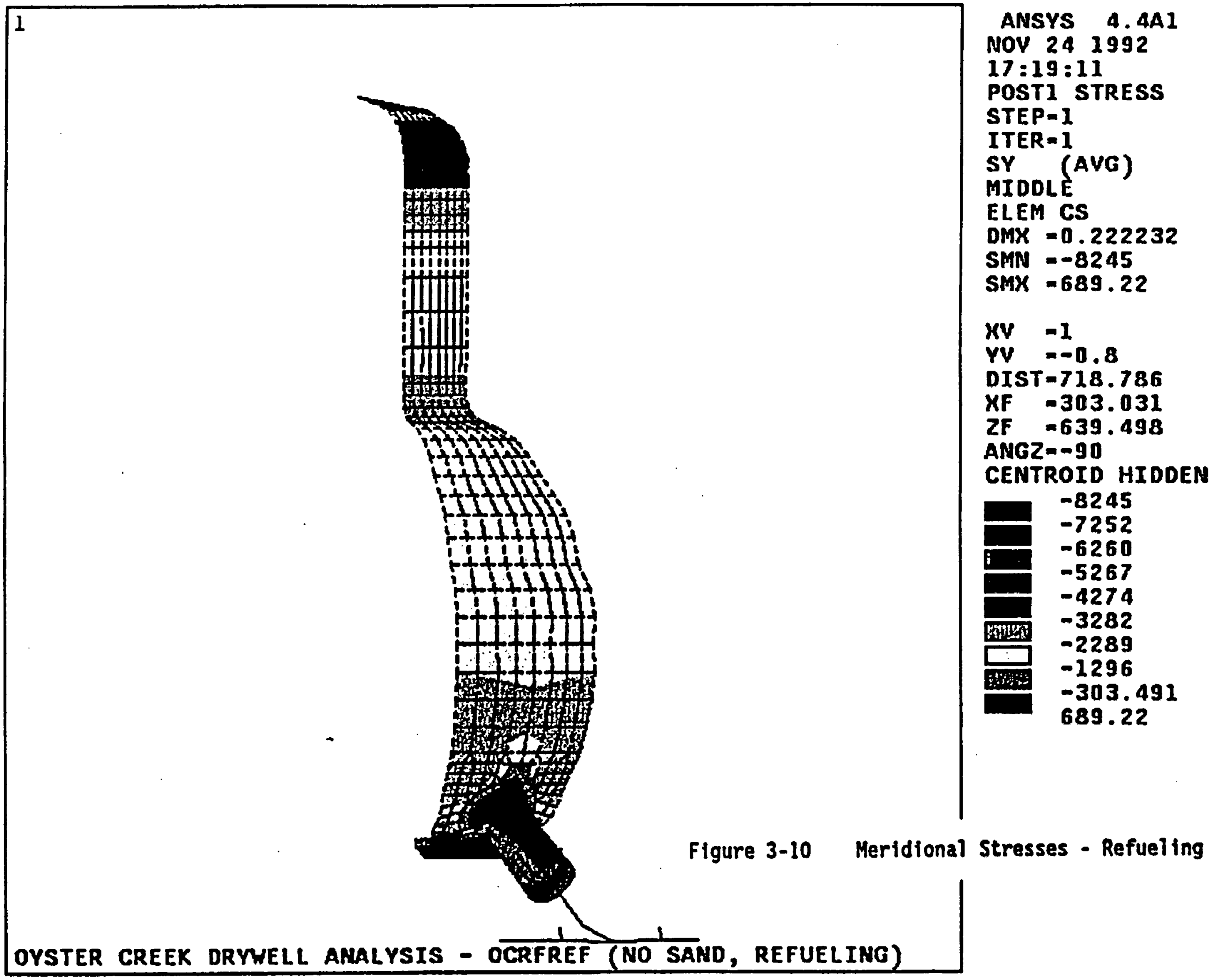


Figure 3-10 Meridional Stresses - Refueling Case

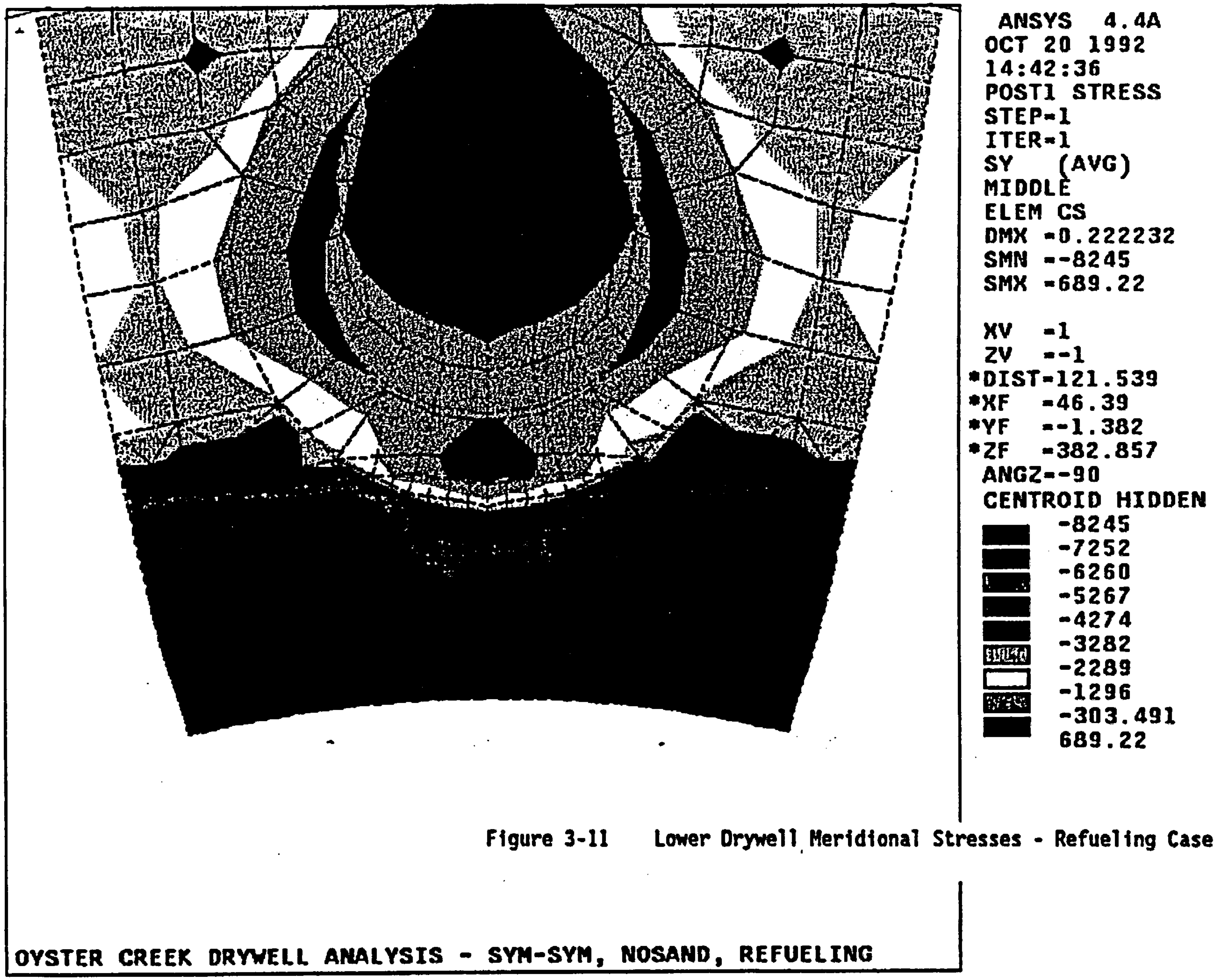


Figure 3-11 Lower Drywell Meridional Stresses - Refueling Case

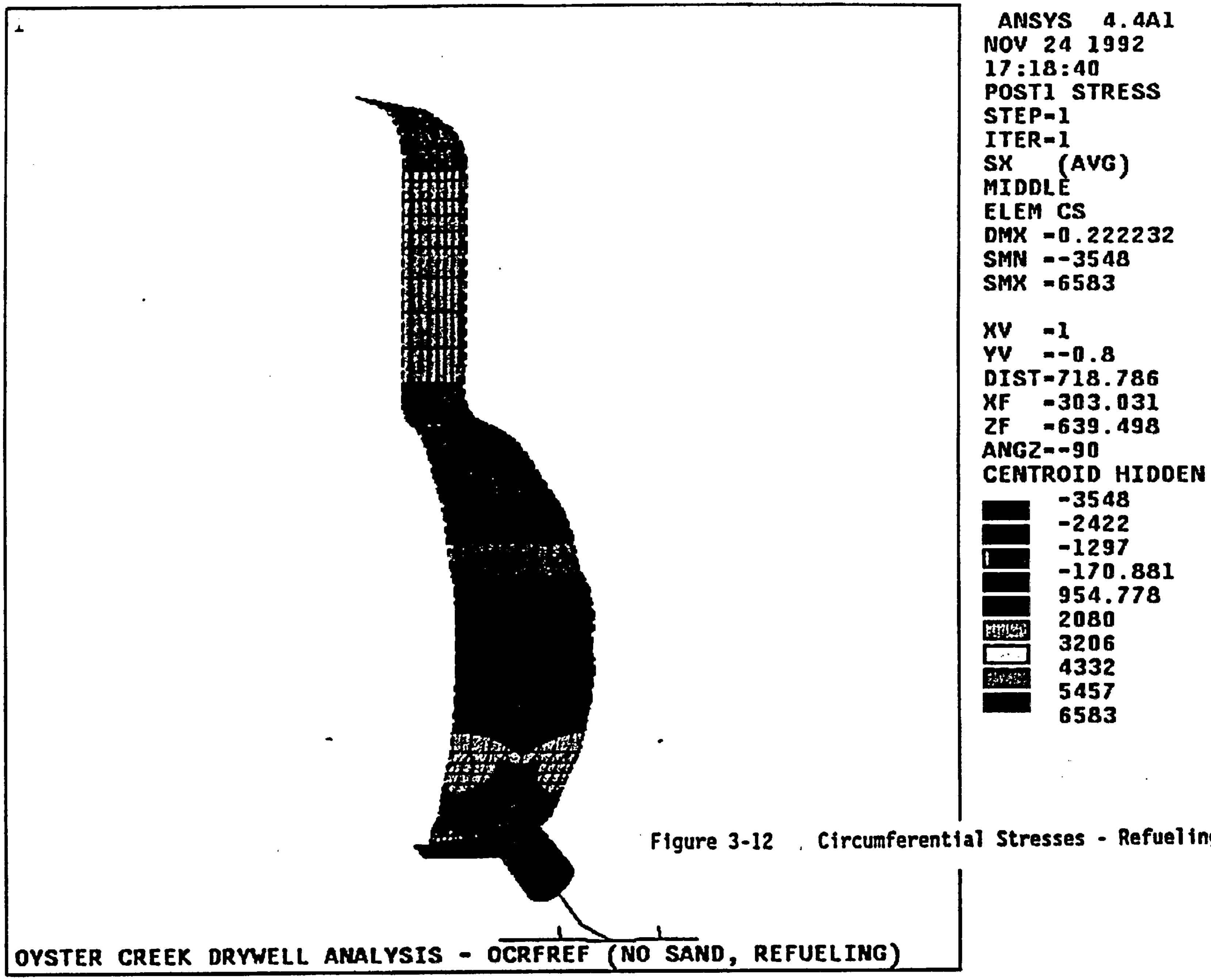


Figure 3-12 Circumferential Stresses - Refueling Case

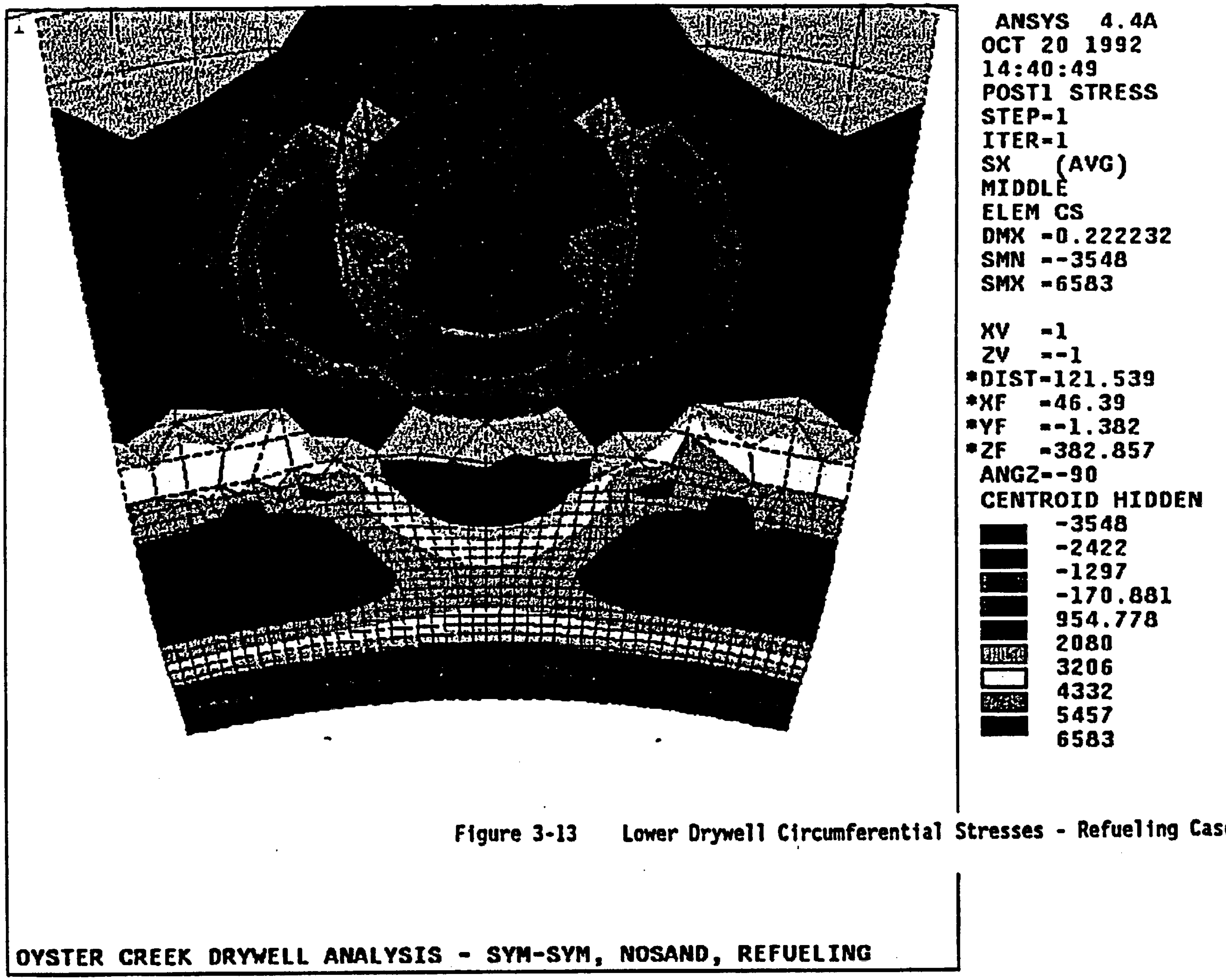


Figure 3-13 Lower Drywell Circumferential Stresses - Refueling Case

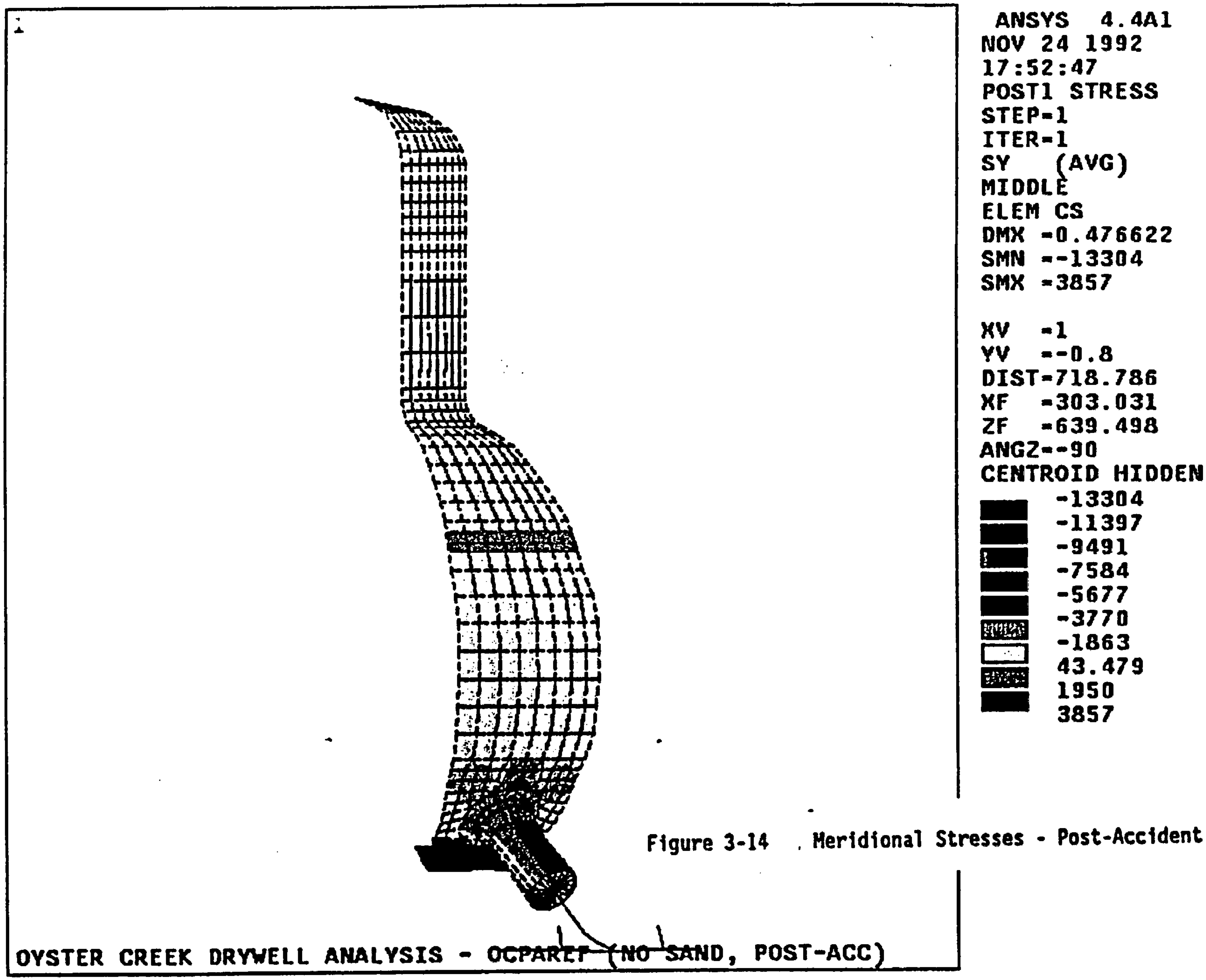


Figure 3-14 Meridional Stresses - Post-Accident Case

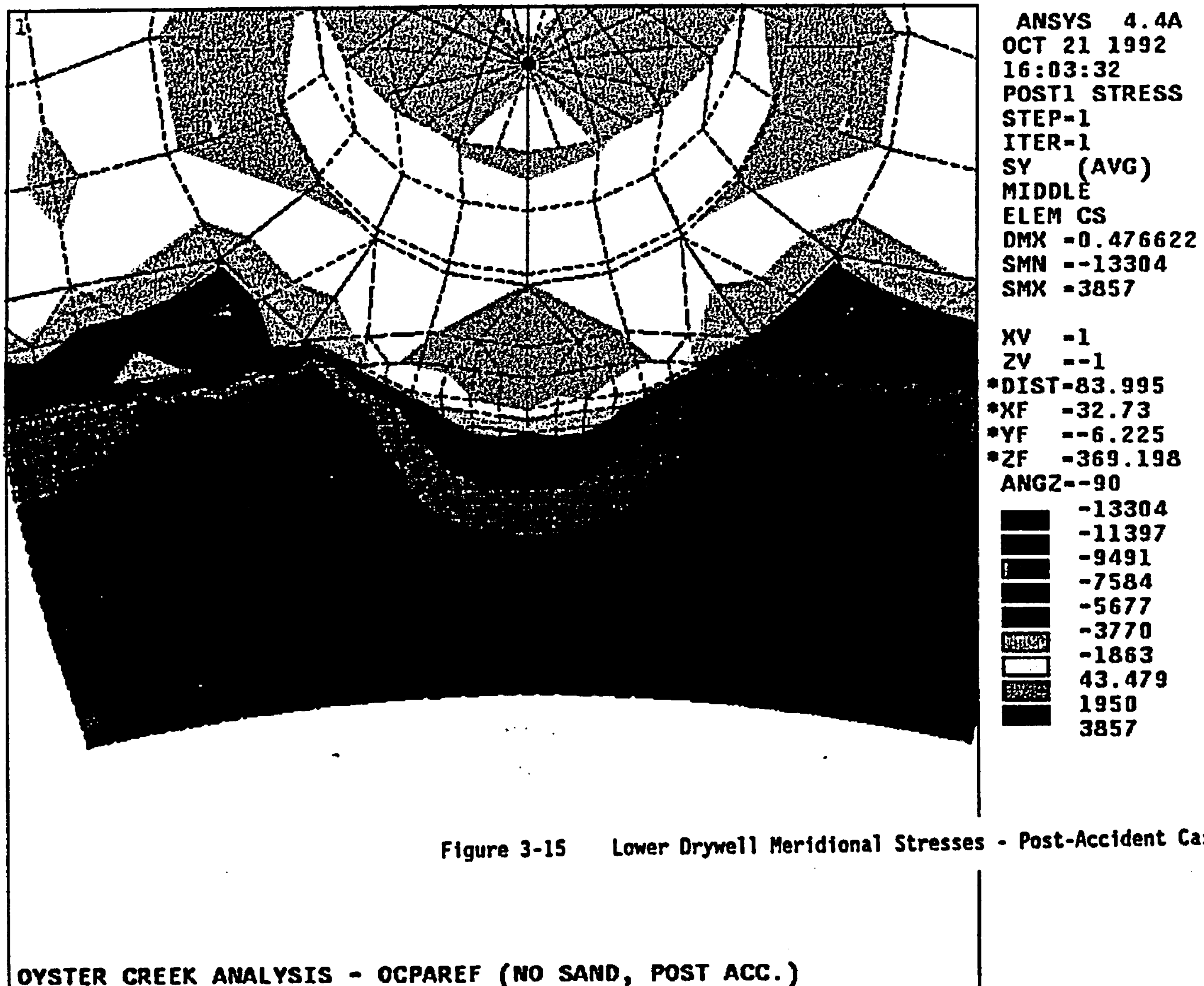


Figure 3-15 Lower Drywell Meridional Stresses - Post-Accident Case

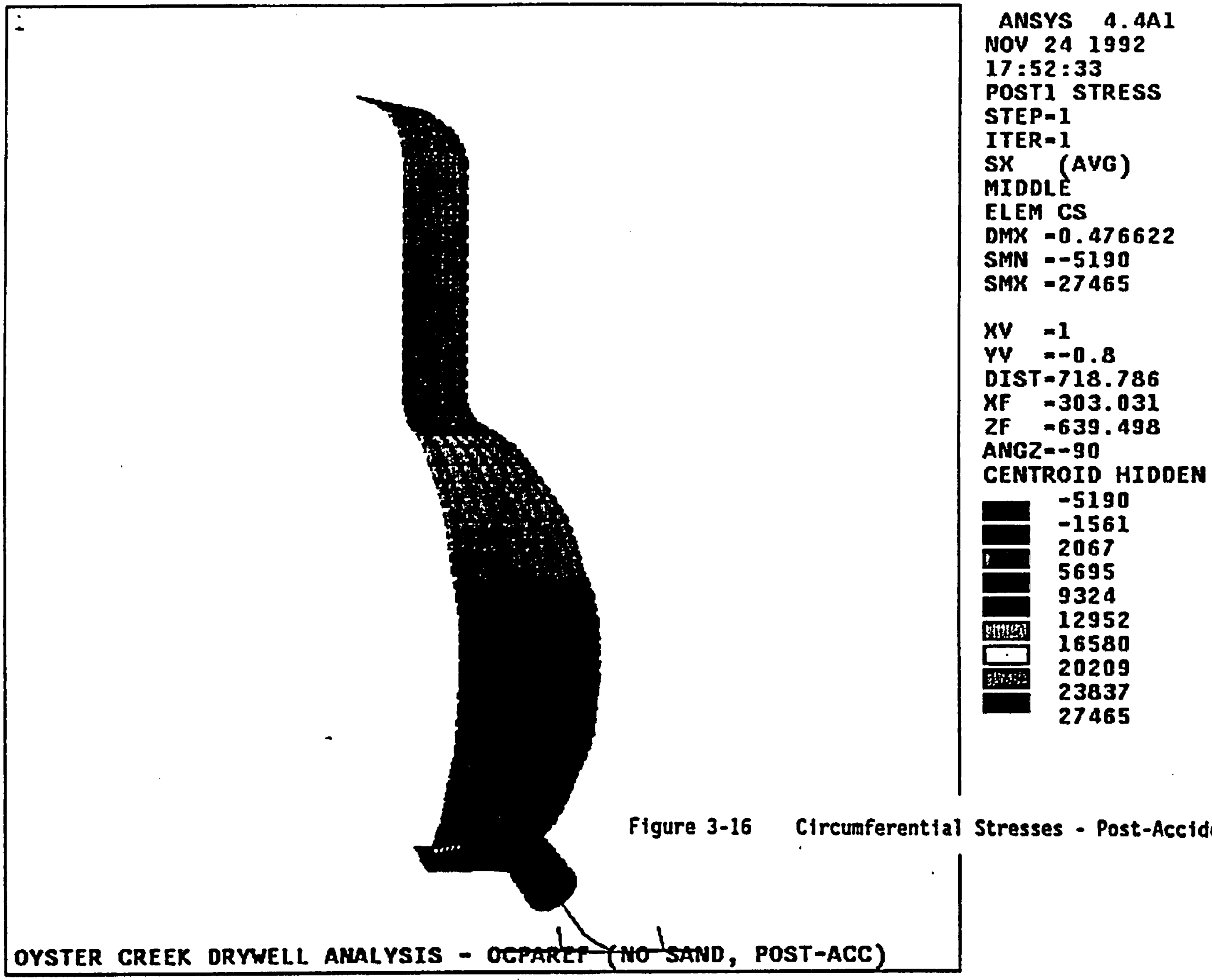


Figure 3-16 Circumferential Stresses - Post-Accident Case

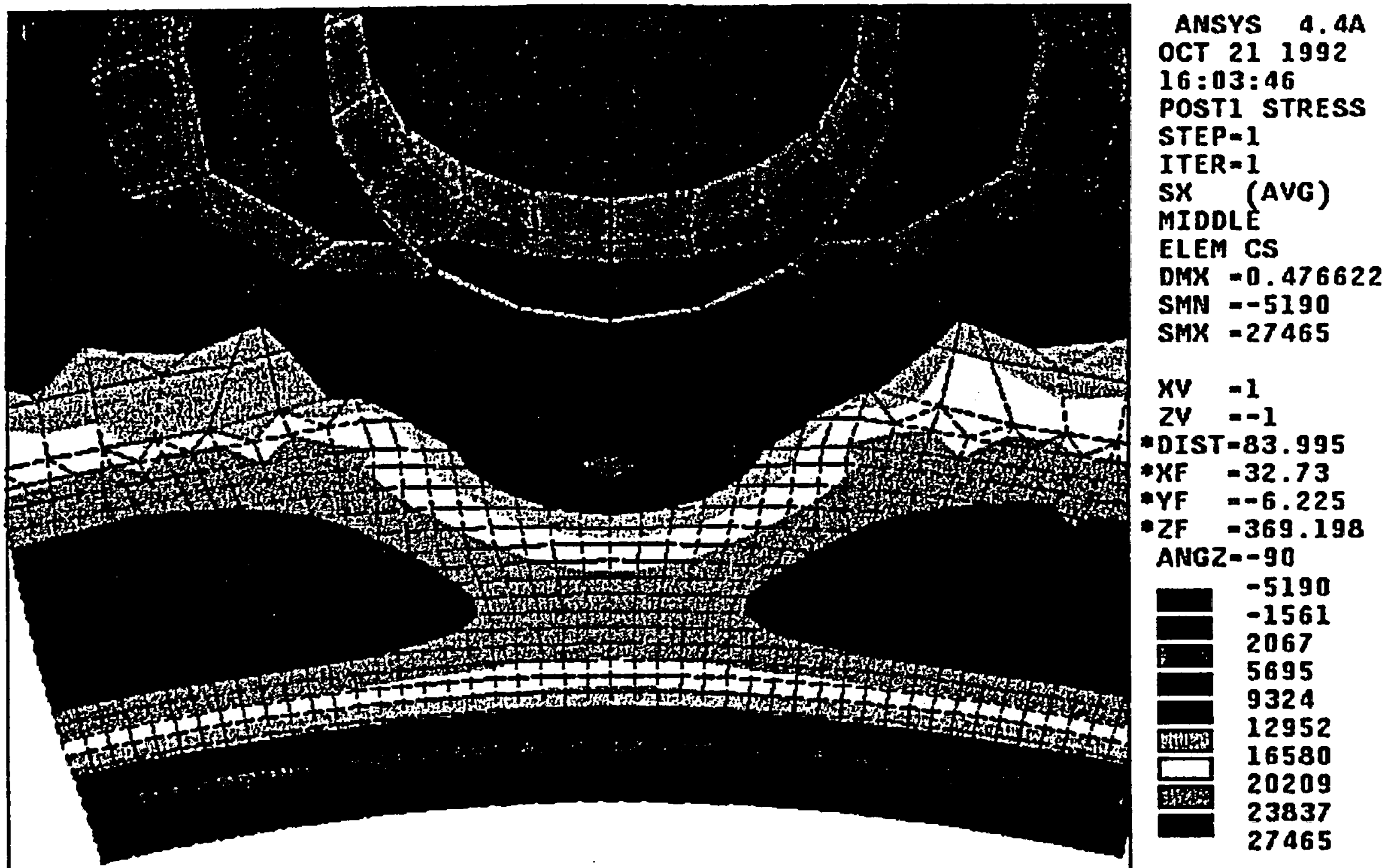


Figure 3-17 Lower Drywell Circumferential Stresses - Post-Accident Case

OYSTER CREEK ANALYSIS - OCPAREF (NO SAND, POST ACC.)

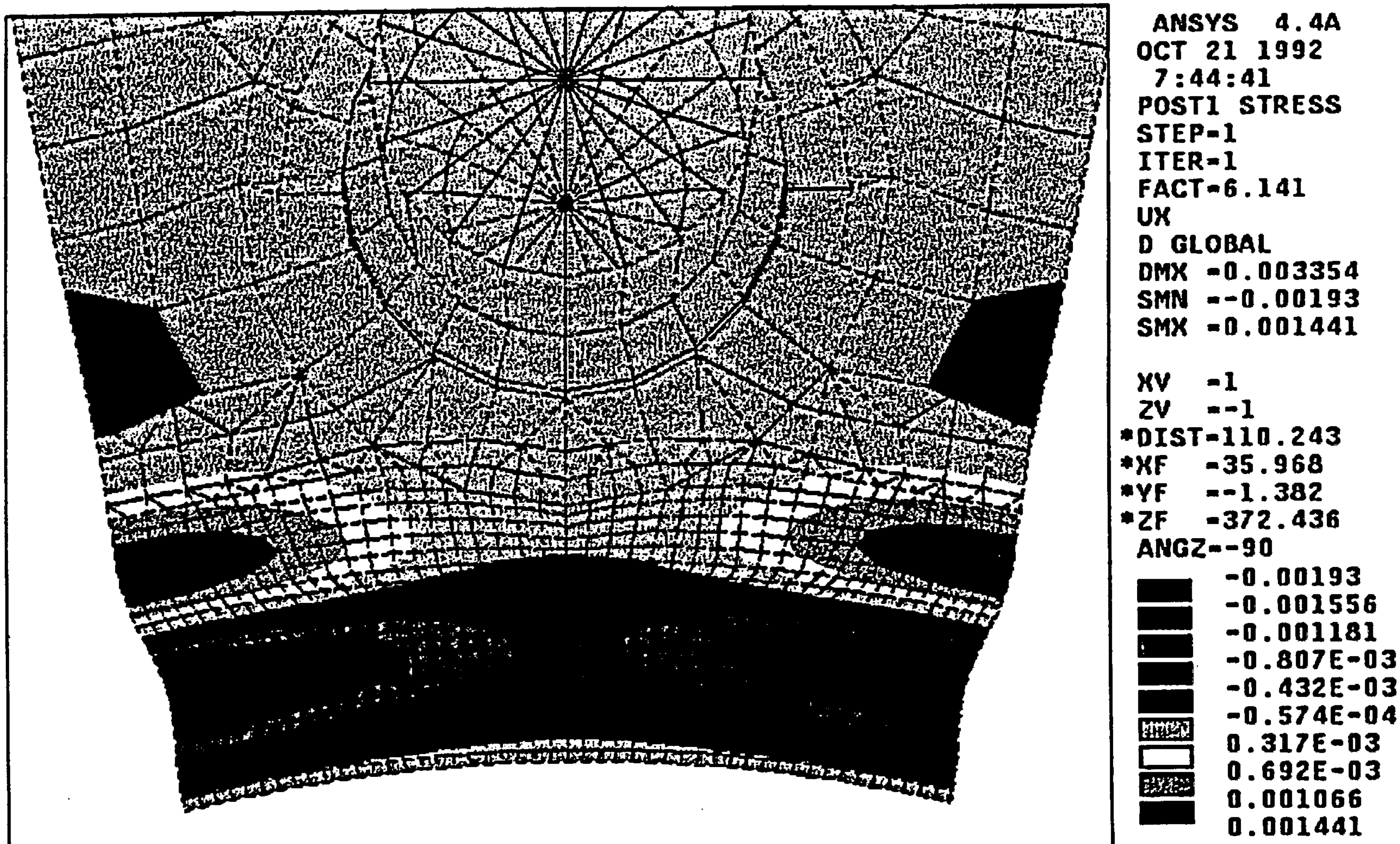


Figure 3-18 Sym-Sym Buckling Mode Shape - Refueling Case

OYSTER CREEK DRYWELL ANALYSIS - OCRFREF SYM-SYM (NO SAND, REFUELING)

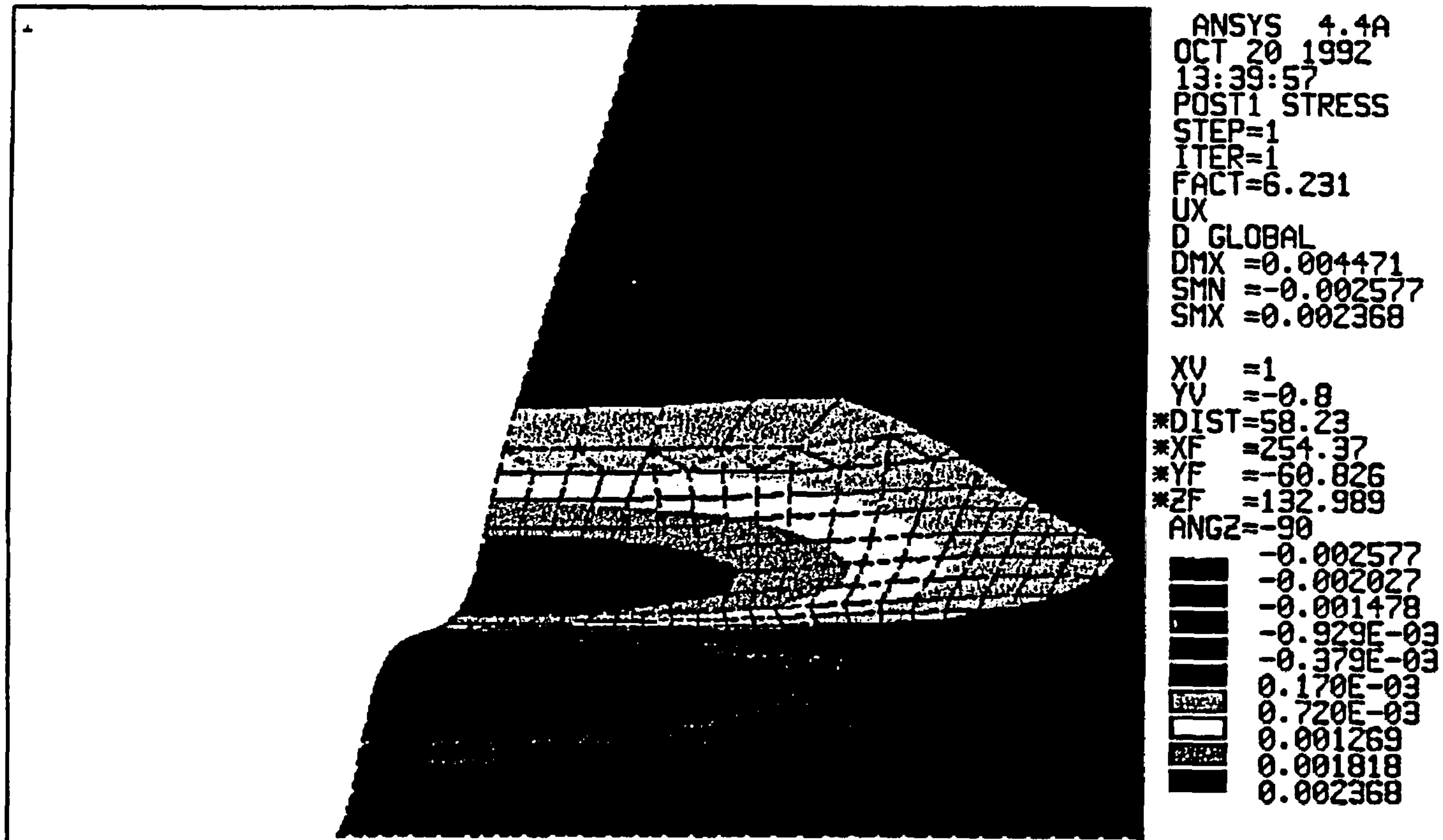


Figure 3-19 Sym-Asym Buckling Mode Shape - Refueling Case

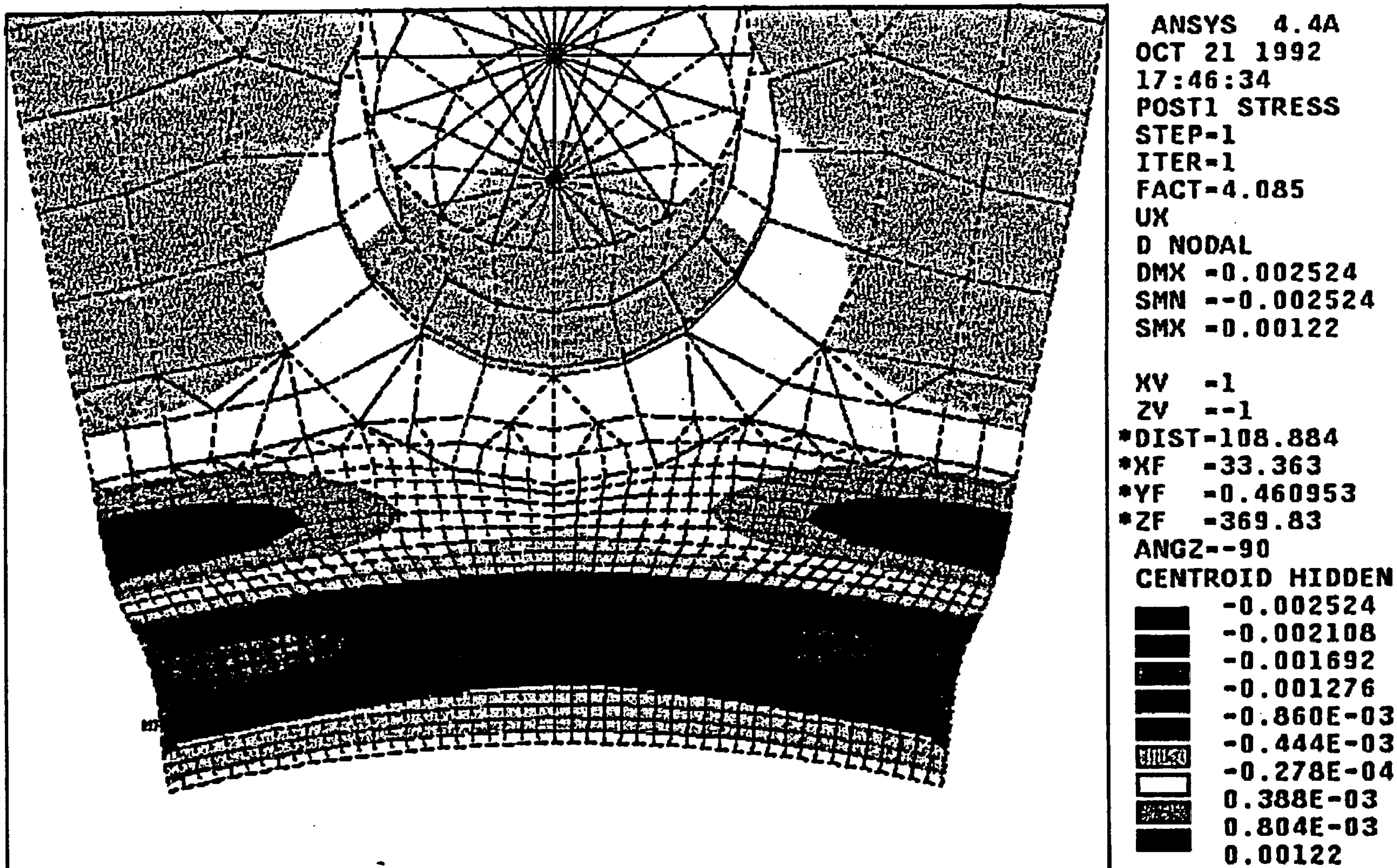


Figure 3-20 Sym-Sym Buckling Mode Shape - Post Accident Case

OYSTER CREEK DRYWELL ANALYSIS, OCPARFBK, SYM-SYM, NO SAND

4. ALLOWABLE BUCKLING STRESS EVALUATION

Applying the methodology described in Section 2 for the modification of the theoretical elastic buckling stress, the allowable compressive stresses are now calculated. Tables 4-1 and 4-2 summarize the calculation of the allowable buckling stresses for the Refueling and Post-Accident conditions, respectively. The modified capacity reduction factors are first calculated as described in sections 2.2 and 2.3. After reducing the theoretical instability stress by this reduction factor, the plasticity reduction factor is calculated and applied. The resulting inelastic buckling stresses are then divided by the factor of safety of 2.0 for the Refueling case and 1.67 for the Post-Accident case to obtain the final allowable compressive stresses.

The allowable compressive stress for the Refueling case is 7.59 ksi. Since the applied compressive stress is also 7.59 ksi, it indicates that the safety factor is equal to the Code required value of 2.0. The calculated allowable value of 7.59 ksi is conservative since the knockdown factors were calculated conservatively and a uniformly corroded thickness of sandbed is assumed. The allowable compressive stress for the Post-Accident, flooded case is 12.93 ksi as compared to the applied compressive stress of 12.0 ksi. Therefore, for both cases, the drywell meets the required ASME Code safety factors.

Table 4-1

Calculation of Allowable Buckling Stresses - Refueling Case

Parameter	Value
Theoretical Elastic Instability Stress, σ_{ie} (ksi)	46.59
Capacity Reduction Factor, α_i	0.207
Circumferential Stress, σ_c (ksi)	4.51
Equivalent Pressure, p (psi)	15.81
"X" Parameter	0.087
ΔC	0.072
Modified Capacity Reduction Factor, $\alpha_{i,mod}$	0.326
Elastic Buckling Stress, $\sigma_e = \alpha_{i,mod}\ \sigma_{ie}$ (ksi)	15.18
Proportional Limit Ratio, $\Delta = \sigma_e / \sigma_y$	0.40
Plasticity Reduction Factor, η_i	1.00
Inelastic Buckling Stress, $\sigma_i = \eta_i\ \sigma_e$ (ksi)	15.18
Code Factor of Safety, FS	2.0
Allowable Compressive Stress, $\sigma_{all} = \sigma_i/FS$ (ksi)	7.59
Applied Compressive Meridional Stress, σ_m (ksi)	7.59

Table 4-2

Calculation of Allowable Buckling Stresses - Post-Accident Case

Parameter	Value
Theoretical Elastic Instability Stress, σ_{ie} (ksi)	49.020
Capacity Reduction Factor, α_i	0.207
Circumferential Stress, σ_c (ksi)	20.21
Equivalent Pressure, p (psi)	70.84
"X" Parameter	0.39
ΔC	0.183
Modified Capacity Reduction Factor, $\alpha_{i,mod}$	0.509
Elastic Buckling Stress, $\sigma_e = \alpha_{i,mod}\ \sigma_{ie}$ (ksi)	24.94
Proportional Limit Ratio, $\Delta = \sigma_e / \sigma_y$	0.656
Plasticity Reduction Factor, η_i	0.866
Inelastic Buckling Stress, $\sigma_i = \eta_i\ \sigma_e$ (ksi)	21.59
Code Factor of Safety, FS	1.67
Allowable Compressive Stress, $\sigma_{all} = \sigma_i / FS$ (ksi)	12.93
Applied Compressive Meridional Stress, σ_m (ksi)	12.0

5. SUMMARY AND CONCLUSIONS

The results of this buckling analysis for the refueling and post-accident load combinations are summarized in Table 5-1. The applied and allowable compressive meridional stresses shown in Table 5-1 are for the sandbed region which is the most limiting region in terms of buckling. This analysis demonstrates that the Oyster Creek drywell has adequate margin against buckling with no sand support for an assumed sandbed shell thickness of 0.736 inch. This thickness is the 95% confidence projected thickness for the 14R outage. Therefore, for both cases, the drywell meets the required ASME Code safety factors.

Table 5-1

Buckling Analysis Summary

	Load Combination	
	Refueling	Post-Accident
Service Condition	Design	Level C
Factor of Safety Applied	2.00	1.67
Applied Compressive Meridional Stress (ksi)	7.59	12.0
Allowable Compressive Meridional Stress (ksi)	7.59	12.93
Actual Buckling Safety Factor	2.00	1.80

MPR ASSOCIATES, INC.

SELECTION OF CANDIDATE COATINGS AND STEEL CLEANING/PREPARATION METHODS FOR THE OYSTER CREEK DRYWELL EXTERIOR IN THE SAND BED AREA

MPR REPORT 1275

March 10, 1992

Prepared for GPUN
by MPR Associates, Inc.
Washington, D.C.

1050 CONNECTICUT AVENUE, N.W. WASHINGTON, D.C. 20036 202-659-2320

CONTENTS

Section 1

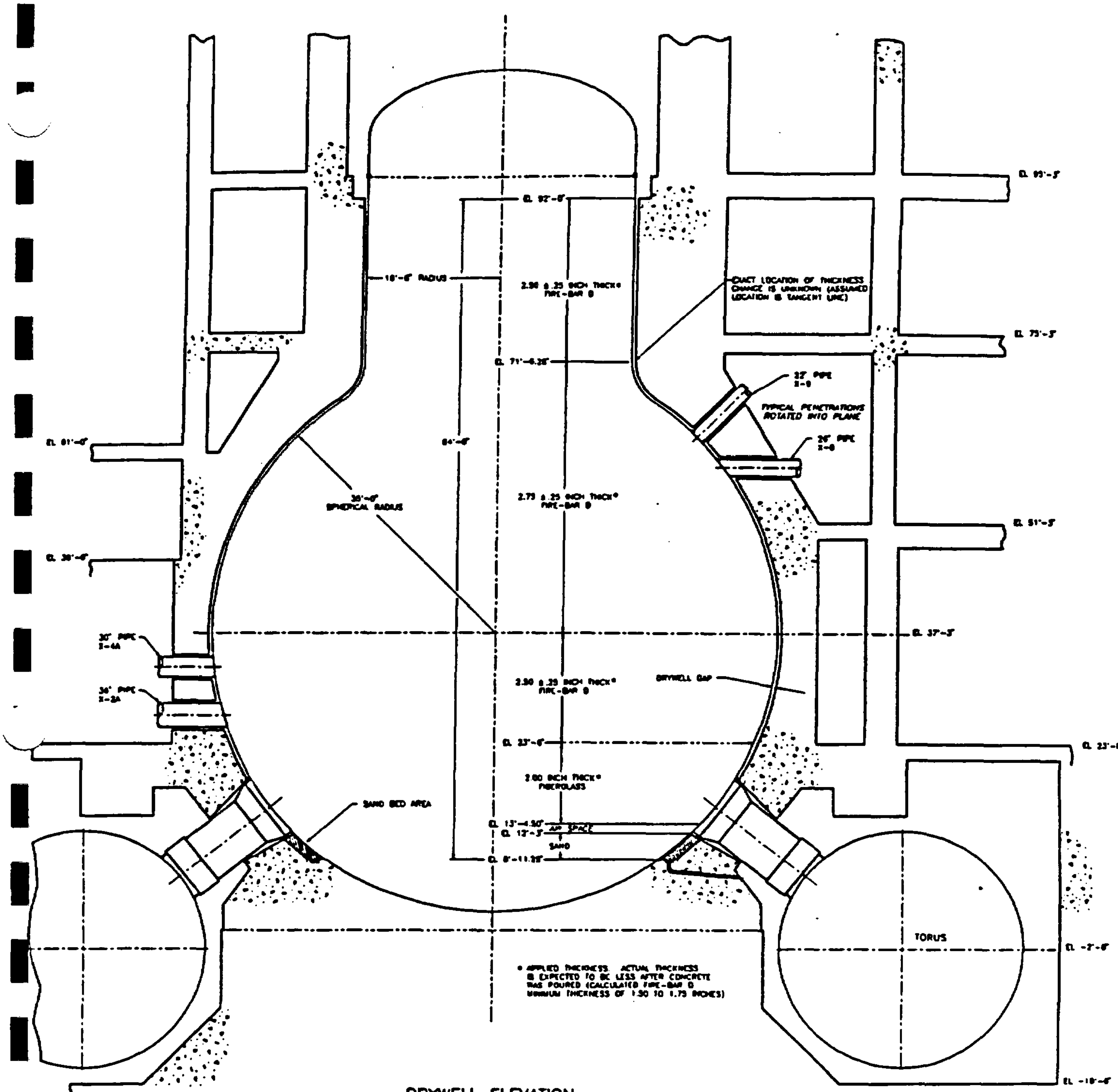
INTRODUCTION

BACKGROUND

The Oyster Creek nuclear power station has been experiencing corrosion of the carbon steel drywell where the steel is exposed to water and contaminants in the gap between the drywell and the concrete reactor building. The most severe corrosion has occurred near the bottom of the drywell where sand is in contact with the steel (Figures 1 and 2). To arrest corrosion of the drywell in this sand bed area, GPUN plans to remove the sand and then inspect, clean, and coat the steel. Cleaning and coating the steel are to be performed manually by workers in the sand bed with the power plant not operating. It is currently planned that workers would access the empty sand bed through access holes bored through the concrete shield wall (Figure 3).

SCOPE

This report documents the selection of specific coatings for possible use on the drywell exterior. Also, this report documents the preliminary selection of cleaning and surface preparation methods for the rusted and painted drywell steel. The specific cleaning and preparation steps actually used at Oyster Creek may differ based on actual surface conditions found once the sand is removed and the steel inspected.



DRYWELL ELEVATION
LOOKING NORTH

MATERIAL VOLUMES:

- FIRE-BAR D 2700 FT^3
- FIBERGLASS 290 FT^3
- SAND 850 FT^3

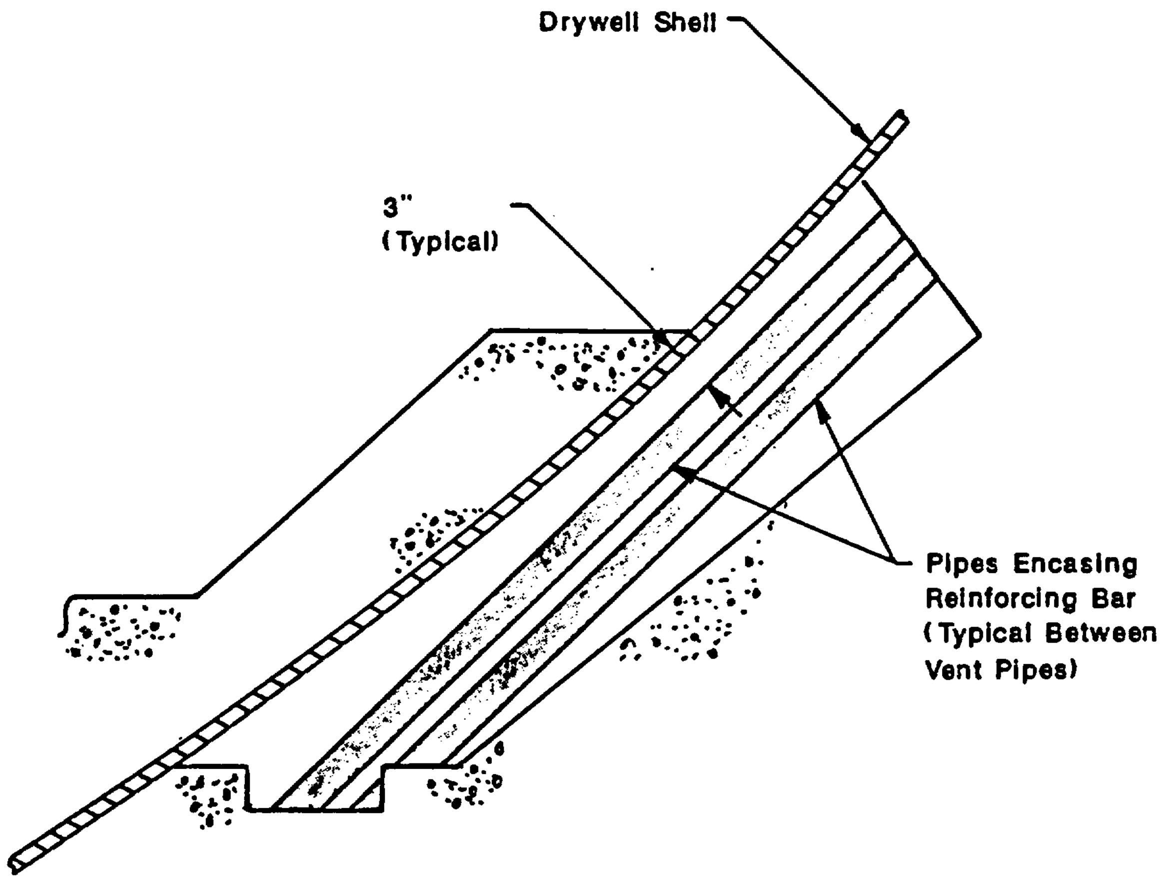
SCALE FEET

OYSTER CREEK DRYWELL LOCATION OF GAP MATERIALS

FIGURE 1

MPR ASSOCIATES
F-83-142-24
9/18/91

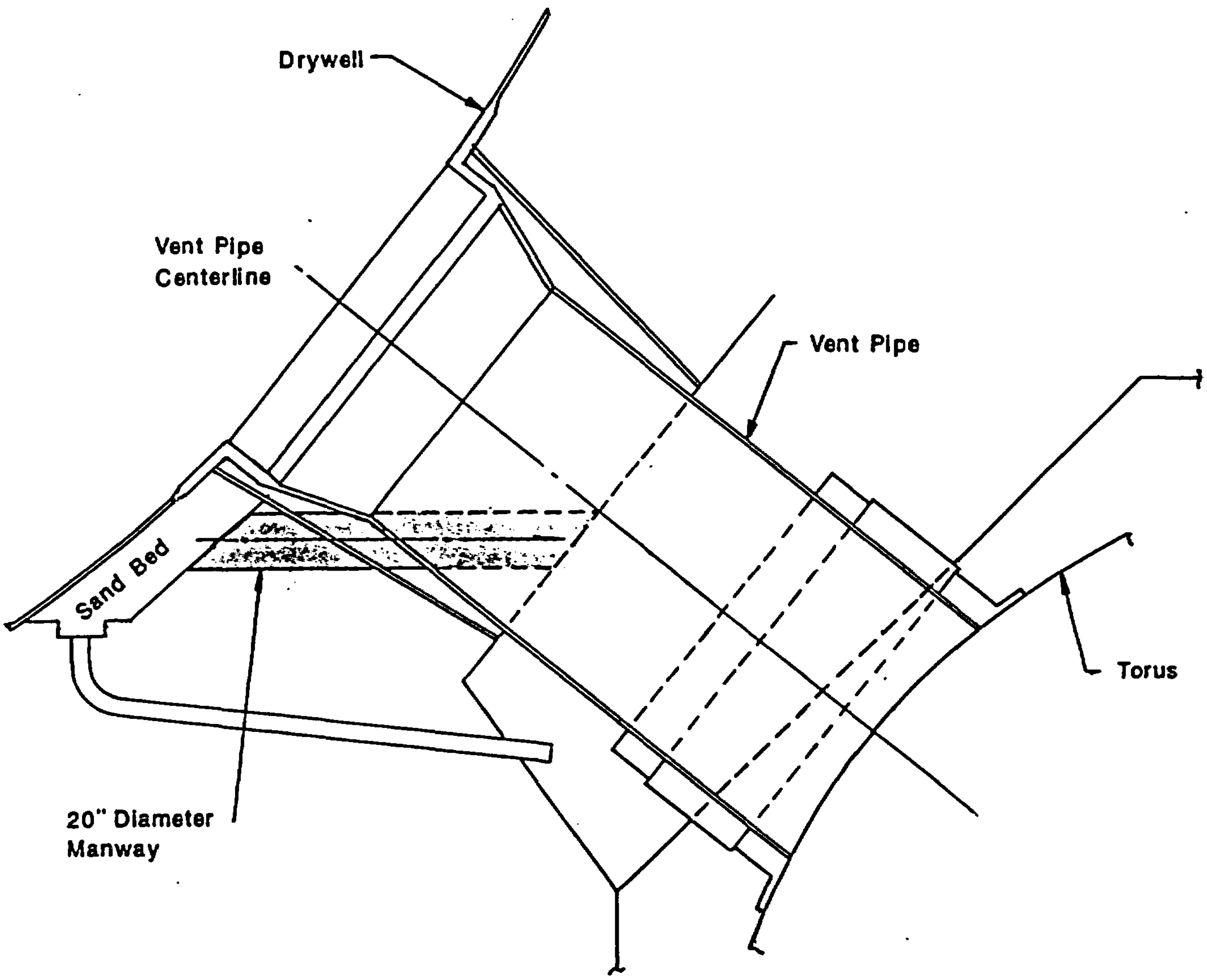
MPR ASSOCIATES
F-83-155-1
12/27/91



SECTION VIEW OF SAND BEND AREA
AT REINFORCING BARS

FIGURE 2

MPR ASSOCIATES
F-83-155-2
3/4/92



ELEVATION

MANWAY BORED THROUGH SHIELD WALL
APPROXIMATE LOCATION

FIGURE 3

Section 2

CONCLUSIONS AND RECOMMENDATIONS

1. We conclude that the most surface-tolerant coatings available should be considered in anticipation of imperfect surface preparation work in the confined work space of the sand bed. Specifically, coatings rated by their manufacturer for maintenance painting on surfaces prepared by hand cleaning (per SSPC-SP2) should be considered. At the same time, surface preparation methods should be selected to achieve the best surface preparation possible, with SSPC-SP2 as the minimum.

2. Five sources of coating recommendations were reviewed. From that review we conclude that the following categories of coatings should be tested for possible use on the drywell:

   - High-build, surface tolerant epoxy,
   - High-build, surface tolerant epoxy with urethane topcoats,
   - Solvent-free (water-base) coatings,
   - Solvent-borne, air drying paint, and
   - Non-hardening, waxy coating with corrosion inhibitors.

   Each type of coating is intended for use on imperfectly prepared, rusted steel surfaces. The epoxies are the preferred coatings for the drywell exterior, but are difficult to apply and repair. Surface-tolerant epoxies with urethane topcoats have the potential to provide the longest service life. A solvent-free coating system already approved for use at Oyster Creek is included in case ventilation and breathing air issues become difficult to resolve. A solvent-borne, air drying paint which was tested by the California Department of Transportation performed as well as epoxies in a twenty-five month test in salt air environment and was easier to apply and repair; this coating is included to provide an alternative to the epoxies.

Compared with epoxy coatings, nonhardening, waxy coatings provide poor rust protection. If manways are bored through the reactor building shield wall to provide manual access to the drywell steel, some long-lived coating such as epoxy should be used. However, if manways are not bored, for whatever reason, nonhardening coatings might be attractive since they could be sprayed onto the drywell through existing access holes in a relatively uncontrolled way. If needed, this type of coating can be removed later with a high pressure water jet. Accordingly, we conclude that one nonhardening waxy coating should be considered and tested. It should be tested in the form of a thick, sprayed coating on thick, rust scale on uncleaned steel test samples. Corrosion rates for these samples should be compared with similar test samples without any coating.

3. The surface cleaning, conditioning, and coating steps that will probably be used to coat the drywell exterior are summarized in Table 2-1 for reference. The general approach is to remove the rust, degrease the entire surface (rusted areas and areas of intact old paint), and then brush or roller apply two or three coats of paint to the entire surface.

Table 2-1

CLEANING AND COATING APPROACH
FOR THE
DRYWELL EXTERIOR IN THE SAND BED:
BASELINE AND ALTERNATE APPROACHES

	Baseline Approach	Alternate Approach
Clean	• Remove thick, scaly rust, and loose paint from drywell using "heavy duty roto-peen" equipment. This electric tool uses flexible flaps with tungsten carbide shot attached to the ends. The flaps are loaded on a hub and its rotation impacts the shot against the drywell.	• Remove thick, scaly rust from drywell using air-driven shot-blast process. Use vacuum-blast style head to collect shot, rust, and paint. Use size S-280 steel shot. Note: Blast nozzles without vacuum recovery are much smaller and easier to handle. This type of nozzle on extension handles may be preferred in reinforcing bar areas.
	• Vacuum debris from sand bed.	• Same as at left.
	• Solvent clean the entire steel surface by wiping with cloths soaked in cleaner to remove oil and grease. Use a solvent recommended by the coating vendor and approved by GPUN.	• Same as at left.
	• Use wire brushes and abrasive pads driven manually and by power tools to clean rusted areas and to remove loose paint in accordance with SSPC-SP2/SP3.	• Use vacuum-blast system to shot-blast rusted areas and areas with loose paint. Blast to create 1.5 to 2.5 mil surface profile and cleanliness in accordance with SSPC-SP6; i.e. Commercial Blast Clean.
	• Vacuum debris from sand bed.	• Same as at left.
	• Notes: 1. Some customized cleaning tools will be needed to reach drywell surfaces in front of reinforcing bars. 2. These cleaning steps leave intact red lead-linseed oil paint in places.	• Same as at left.
Condition	• Grind smooth any burrs, sharp edges or corners at welds and at transitions between rusted and unrusted areas. Some customized tools may be needed to grind drywell surfaces in front of reinforcing bars.	• Same as at left.

	Baseline Approach	Alternate Approach
Condition (cont.)	• If grinding creates a smooth surface, roughen surface by roto-peening.	• If grinding creates a smooth surface, roughen surface by shot-blasting to create a surface profile.
	• Vacuum sand, rust, and paint debris out of sandbed and off of drywell surface.	• Same as at left.
	• Clean the entire steel surface by wiping with cloths soaked with warm water to remove chlorides, sulphates, dust, and other contaminants. Immediately wipe the surface dry with clean cloths.	• Same as at left.
Pretreat	• None	• None
Prime	• After all bays have been cleaned and conditioned, manually roll and brush-apply an epoxy primer to the entire surface. Ensure that the overlapping coat between adjoining bays is applied ("tied-in") within 24 hours of applying the undercoat (or as otherwise required by the coating manufacturer). The paint is to be prepared and applied under the direction of a representative of the coating vendor.	• Same as at left.
Topcoat	• After all bays have been primed, manually roll and brush-apply an epoxy topcoat. Ensure that the topcoat is applied between 6 and 24 hours after the prime coat. Ensure that the overlapping coat between adjoining bays is overlapped ("tied-in") within 24 hours (or as otherwise required by the coating manufacturer). The paint is to be prepared and applied under the direction of a representative of the coating vendor.	• Same as at left.

Table 2-2

CANDIDATE COATING SYSTEMS

Coating System Designation	Coating Manufacturer	Prime Coat		Finish Coats		Total DFT Mils
		Product Name, Color	DFT(1) Mils	Product Name, Color	DFT Mils	
High-Build, Surface-Tolerant Epoxy						
A	Carboline	Carboline 801, white	5-6	Carboline 801, light gray	5-6	10-12
B	Devoe	Bar-Rust 235, buff	2-3	Bar-Rust 235, haze gray	3-5	5-8
C(2)	Devoe (formerly Devoe Napko)	Preprime 167 (formerly Preprime 467), Clear	1-2	Devran 184 (formerly Chemfast 100), aluminum gray	3-10	4-12
D	Porter International	Interplus 770, off-white	3	Interplus 770, light gray	5	8
E	Porter International	Magna-Mastic 7900, aluminum	5-6	Magna-Mastic 7900, aluminum	5-6	10-12
High-Build, Surface-Tolerant Epoxy with Urethane Top Coats						
F	Porter International	Magna-Mastic 7900 (Epoxy), aluminum	5-6	Mid-coat; Hythane 4600 Series (acrylic urethane), white 4610 Topcoat: Hythane super 8600 series (polyester urethane), light gray	2 4	11-12
Solvent-Free (Water-Base) Coatings						
G(3)	Keeler & Long	Aqua Kolor Primer 9400 Series (latex acrylic), white	2-3	Hydro-Poxy Enamel H-Series (water based epoxy), gray	2-3	4-6
Solvent-Borne, Air Drying Paint						
H	Nonproprietary Formula	CALTRANS Specification PB201, modified (High Solids, Phenolic Red Primer), white	2	CALTRANS Specification PB201, modified, light gray	2	4
Non-Hardening, Waxy Coating with Corrosion Inhibitors						
I(4)	PRAXIS	Prax-Ten Sealer, tan	5	Prax-Ten Sealer, gray	5	10

NOTES:
(1) DFT = Dry Film Thickness
(2) GPUN Coating System CS-13 used on Torus Exterior
(3) GPUN Coating System CS-22 for coating repair inside the Radiation Controlled Area at Oyster Creek
(4) The non-hardening, waxy coating would be used only if manways are not bored through the drywell shield wall. This coating should be given an additional test comparing corrosion rates with this coating on thick, rust scale as compared with no coating.

Section 3

DISCUSSION

CONSTRAINTS

Access to Steel

Tools and workers are expected to access the sand bed through new, 20" diameter holes bored through the shield wall. A maximum of ten holes will be bored, one at each bay. It is planned that holes will be bored only at areas where the drywell exterior has significant corrosion. The approximate location and orientation of the hole is shown in Figure 3.

Within areas that are significantly corroded, portions of the surface may be inaccessible for thorough cleaning and coating. In particular, the surfaces near the pipe segments encasing reinforcing bars in the sand bed may be difficult to access (Figure 2). The drywell surface in front of the reinforcing bars is about six feet wide.

The area above the sand bed will not be cleaned and coated. Fabrication drawings show a steel grout plate installed at the top of the sand bed. The gap between the grout plate and drywell is shown as 3/4 of an inch on fabrication drawings. The drywell surface above the grout plate is not accessible; the gap between the drywell and shield wall is small (about two inches or less) and filled with semi-rigid fiberglass insulation panels. The area below the sand bed will not be cleaned and coated; the steel is embedded in concrete below the sand bed.

Original Steel Coating and Compatibility of New Coating

Construction specifications for the drywell called for the exterior surface in the sand bed area to be solvent cleaned to remove any grease and oil, wire brushed, and then primed with one coat of red lead base paint. The FSAR (Update 5) indicates that the paint was procured per Federal Specification TT-P-86c, Type 1, which is a red lead-linseed oil paint.

Reference 5 states that the primer was a Carboline product (red lead primer).

TT-P-86c explains that Type 1 paint is intended for use on bridges, similar structural steel, and other ferrous metal surfaces. It is suitable for priming and body coats, either in the shop or the field, where good resistance to the corrosive effects of usual atmospheric environments is required. The vehicle, being all linseed oil, offers the best opportunity to wet the metal surface and therefore to obtain an intimate bond of the paint with the surface despite the presence of small amounts of corrosion products found impractical to remove.

A new coating applied over the red lead primer could fail due to solvents in the new coating softening and lifting the old paint or by the new paint shrinking and mechanically pulling the old paint off the steel. Lab tests for compatibility can be performed, and in-situ tests are required by GPUN coating standards (Reference 6.) One coating vendor (Porter International) recommends applying an in-situ test patch over a 25 square-foot area and allowing it to cure for several weeks to check compatibility. The preferred approach is to remove all old paint wherever possible to obtain the best possible performance from the new coating.

<u>Present Condition of Coating and Steel</u>

The current condition of the drywell surface in the sand bed area has been checked by performing ultrasonic thickness measurements from the inside of the drywell, and by cutting a number of two-inch diameter plugs from the drywell. These measurements and samples have shown that the majority of the drywell surface in the sand bed area is still at its original thickness and no corrosion has occurred; these areas are probably still coated with red lead primer paint although the paint may be degraded. However, there is uniform rusting (as opposed to pitting) over approximately 20 percent of the circumference between elevations 10′ and 12′. The available information suggests there are four or five patches in which the surface is heavily rusted. Each patch appears to be about two feet wide in the vertical direction and on the order of ten to twenty feet long in the horizontal direction. These rusted surfaces are very rough, but not deeply pitted. Enlarged photographs of the corroded sample surfaces indicate surface roughnesses of about 1 to 3 mils in the good steel beneath the rust.

Limitations on Surface Cleaning and Conditioning Methods

The surface preparation methods should minimize the removal of intact steel to avoid thinning the drywell.

The preparation methods should make it possible to recover any materials used in cleaning (e.g., sand, shot, water, etc.) from the sand bed and to recover material removed from the drywell surface (e.g., rust and lead from the existing coating). The amount of contaminated waste should be minimized.

The preparation method should minimize noise generation. For some surface preparation methods, workers inside the sand bed, as well as those inside the drywell performing outage work other than cleaning and coating, may be required to wear hearing protection.

Limitations on Coating Application Methods

Ventilation: Air flow out of the sand bed area will have to be maintained to keep the levels of any airborne solvents low to promote curing of the coating, to maintain visibility, to eliminate any combustion hazards and, if paint is spray applied, to contain any overspray. Ventilation is also needed to maintain a safe breathing atmosphere, and comfortable working temperatures. Also, Reference 6 (GPUN Specification for Application and Repair of Coatings) requires that air hoods be worn by all workers working in confined or enclosed areas, except where nontoxic, nonexplosive coating materials are employed. Coatings and application methods that reduce the need for ventilation and air hoods are preferred.

Tie-in of Newly Painted Areas: Although the total surface area to be coated is relatively small (about 1000 square feet), it will probably be coated one bay at a time. Accordingly, the coating and application method selected should allow long periods of time (for example, 24 hours or more) between coating adjoining areas. If an acceptable coating can be identified, it will allow one painting crew to work at a reasonable pace using one set of equipment. If possible, a coating should be selected that has no maximum time limit on tie-in since unexpected delays will occur during coating application.

Multiple Layers of Coating: As with tie-in of uncoated areas, application of multiple coats can create timing problems. Due to the difficulty of access and the high potential for delays during this work, a coating system which permits long times between coating steps should be selected.

SELECTION OF CLEANING AND CONDITIONING METHODS

The life of a protective coating depends primarily upon the degree of surface preparation and, to a lesser extent, on the aggressiveness of the environment and the type of coating being used.

Protective coatings adhere by means of:

- molecular attraction at the coating/substrate interface, and
- mechanical attachment or anchoring of the coating to the substrate.

For the best possible coating adhesion, both effects must be present; the surface must be clean and have some roughness (i.e., surface profile). Active rust, greases, oils, moisture, unsound coatings, and other forms of surface contamination defeat adhesion. The various levels of surface preparation described by SSPC Specifications are listed in Table 3-1. In general, very clean surfaces (blast clean to white metal, SSPC-SP10 or better) are required for any coating in immersion service. Less surface preparation is required for surfaces exposed to air and infrequent spray or splash, such as the drywell exterior. The various cleaning and roughening techniques available are compared in Table 3-2. The surface cleaning and roughening steps selected for the drywell are described below.

The thick layer of rust known to exist in some areas on the drywell exterior could be removed with manual and pneumatic descaling tools. Care must be taken with these tools since they can cut into the surface of the base steel, removing sound metal and leaving sharp burrs where the paint will fail prematurely. Tools must be sharp or they may drive rust and scale into the surface (Reference 1).

Alternatively, the scale could be removed with electric motor driven, "heavy duty roto-peening" tools. These tools use tungsten carbide shot attached to the ends of flaps. The flaps are loaded on a hub and its rotation impacts the shot against the workpiece. This tool will not gouge the base steel and will create an anchor profile suitable for coating application. Also, needle guns and/or air driven shot-blast could be used to remove the heavy rust-scale.

Surfaces suspected of being contaminated with oils or greases are normally solvent cleaned or steam cleaned prior to any abrasive blasting; power tool cleaning or shot-blasting do not remove grease or oil. There is no evidence that oil or grease has been introduced into the sand bed area since plant construction (other than the linseed oil in the original paint). Also, reports describing the steel plugs removed from the drywell in the sand bed region did not indicate any evidence of oil or grease. However, during sand removal in 1991, compressed air from the plant's service air system is being used to move sand. This air may have oil in it and may deposit it on the drywell steel. Accordingly, a degreasing step is probably required in the surface preparation of the drywell exterior.

A grinding step may be needed to eliminate burrs, sharp edges at welds, and sharp edges at transitions between rusted and unrusted areas. These surface imperfections can degrade coating performance. It is not anticipated that there will be deep pits in the steel: enlarged photographs of the corroded samples removed from the drywell did not indicate pitting.

In unrusted areas coated with old, intact paint, it would be easiest to coat over the old paint to avoid lead handling issues and to reduce work in the sand bed. However, among the vendors recommending epoxy to recoat the drywell, one cautioned that epoxy is not compatible with red lead paint; the epoxy may cause the red lead to debond from the steel as the epoxy cures and shrinks. This vendor recommended removing the red-lead paint by cleaning the steel in accordance with SSPC-SP6 (Commercial Blast Clean using abrasives). It may be possible to remove most of the old paint using abrasive blasting or a roto-peen style cleaning tool; however, it is likely that some existing paint will remain in difficult to access spots. Also, the new coating will have to overlap with old paint at the top and bottom of the sand bed.

A final cleaning step is a fresh water wash to remove chlorides and sulphates from the steel surface. Local deposits of these contaminants on previously rusted, cleaned steel contribute to the shorter coating life observed with maintenance painting as compared with painting of new steel surfaces (Reference 13). This water wash should be performed by wiping with clean, wet cloths followed by immediate drying with clean cloths.

Table 3-1

SUMMARY OF SSPC SURFACE PREPARATIONS

SSPC SPECIFICATION		DESCRIPTION
Solvent Cleaning	SP1	Removal of oil, grease, dirt, soil, salts, and contaminants by cleaning with solvent, vapor, alkali, emulsion, or steam.
Hand Tool Cleaning	SP2	Removal of loose rust, loose mill scale, and loose paint to degree specified, by hand chipping, scraping, sanding, and wire brushing.
Power Tool Cleaning	SP3	Removal of loose rust, loose mill scale, and loose paint to degree specified by power tool chipping, descaling, sanding, wire brushing, and grinding.
Power Tool Cleaning to Bare Metal	SP-11-87T	Complete removal of all rust, scale, and paint by power tools, with resultant surface profile.
Brush-off Blast Cleaning	SP7	Blast cleaning of all except tightly adhering residues of mill scale, rust, and coatings, exposing numerous evenly distributed flecks of underlying metal.
Commercial Blast Cleaning	SP6	Blast cleaning until at least two-thirds of the surface area is free of all visible residues. (For rather severe conditions of exposure.)
Near-White Blast Cleaning	SP10	Blast cleaning nearly to White Metal cleanliness, until at least 95% of the surface area is free of all visible residues. (For high humidity, chemical atmosphere, marine, or other corrosive environments.)
White Metal Blast Cleaning	SP5	Removal of all visible rust, mill scale, paint, and foreign matter by blast cleaning by wheel or nozzle (dry or wet) using sand, grit, or shot. (For very corrosive atmospheres where high cost of cleaning is warranted.)
Pickling	SP8	Complete removal of rust and mill scale by acid pickling, duplex pickling, or electrolytic pickling.

Table 3-2

COMPARISON OF CLEANING METHODS

TYPE	DESCRIPTION	ADVANTAGES	DISADVANTAGES
Chemical	Etch/Rust Removal	• Effectively removes rust and other contaminants • Can achieve surface etch	• Hard to control intensity and duration of etch -- could accidentally remove steel • Excess chemicals could seep into crevice between drywell and embedment concrete and be hard to remove or neutralize • Chemical disposal
	Rust Conversion	• Only wire brush or brush-off blasting is required	
Mechanical (Power Tools)	Sanding: belt, disc, flap wheel	• Could fit into 3" clearance near rebar pipes	• Slower than blasting • Operator must maintain pressure against surface
	Wire brush	• Effectively removes loose rust	• Only achieves SP-3 finish • Operator must maintain pressure against surface
Dry Blasting	Steel shot	• Achieves surface etch • Does not remove steel • Fast	• Shot not removed from sand bed may be of different galvanic potential than drywell, and could lead to corrosion if left to contact with drywell steel • Severe shot blasting creates compressive surface stresses and can deform plate; intensity of blast process should be controlled
	Steel grit	• Achieves surface etch • Fast • Grit produces more angular surface profile than shot	• Grit not removed from sand bed may be of different galvanic potential than drywell, and could lead to corrosion if left in contact with drywell steel • Some steel will be removed

Table 3-2

COMPARISON OF CLEANING METHODS

TYPE	DESCRIPTION	ADVANTAGES	DISADVANTAGES
Dry Blasting (Continued)	Sand blast	• Achieves surface etch • Economical • Spent sand could be removed in same manner as original sand	• Must block air paths to contain airborne silica • Some steel will be removed • Creates dust that coats steel and must be wiped off before coating is applied
	Blast with other abrasives: slag, garnet, etc.	• Achieves surface etch • Denser abrasives cut faster than sand	• Other abrasives may not be as chemically inert as sand • Some steel will be removed
	Heavy duty roto-peen	• Removes heavy rust scale • Achieves surface etch (profile) • Reduces waste by eliminating loose shot	• Commercially available, standard equipment may not fit between drywell and piper encasing reinforcing bars.
	Dry Ice (CO_2)	• CO_2 sublimates on impact with blast surface and requires no cleanup	• Does not etch steel surface • Relatively large particles require large nozzle • May displace oxygen and create hazardous atmosphere • Slower than other abrasives--unclear whether CO_2 blast is aggressive enough to remove thick rust and scale

Table 3-2

COMPARISON OF CLEANING METHODS

TYPE	DESCRIPTION	ADVANTAGES	DISADVANTAGES
Water Blasting	Water blast without abrasive (20,000 psi)	• Can remove heavy, scaly rust (Reference 11) • Spent water will be easier to remove from sand bed than dry abrasives • Little, if any steel will be removed • No dust • Removes oil, grease, and rust • Removes chemical deposits (Reference 13)	• Increases waste to process/dispose • Requires workers to wear plastic anti-contamination clothing which increases worker overheating and fatigue • Raises concern over injury from water jet cutting into workers • Does not etch steel surface • Must add rust inhibitors which are compatible with coating • Fiberglass board in drywell gap above sand bed may become soaked and extend drying time. • Air drying will be required before coating application • Has the potential to cut concrete at base of sand bed • Raises concerns about contaminants concentrating in concrete against drywell at base of sand bed. • Rust-scale pieces could become projectiles within sand bed • Does not eliminate operator fatigue: reaction force is 50 to 100 pounds
	Water blast with abrasive (10,000 psi)	• Achieves surface etch • Spent water will be easier to remove from sand bed than dry abrasives	• Suspended abrasives will settle in sand bed and require vacuuming for removal • See "Water Blast without Abrasive" for other disadvantages.

SELECTION OF COATING APPLICATION METHODS

The available options for applying coatings to the drywell exterior are compared in Table 3-3. The preferred method is rollers and brushes. This eliminates much equipment (pumps, spray nozzles, hoses), which should eliminate potential problems with hardware reliability and expense. Also, use of rollers and brushes will allow several crews to paint simultaneously to ensure that limits on tie-in and recoat times are met. Furthermore, rollers and brushes allow paint to be worked into irregular surfaces which will exist in rusted areas of the drywell.

The high solids, surface-tolerant epoxies, are most easily applied by airless spray or air-assisted airless spray. Manufacturers of a numbers of these epoxies claim that the coatings can also be applied by roller or brush, with the precaution that care must be used to obtain proper and uniform film thickness. Some sources indicate that roller/brush application can be very difficult and fatiguing (Reference 14). In the testing of one surface tolerant epoxy at CALTRANS, laboratory application by brush could not be done without generating runs and sags that were uniformly distributed over the test panels (Reference 2).

Table 3-3

Comparison of Coating Application Techniques

Coating Application Technique	Description	Advantages	Disadvantages
Airless Spray	Commercially available paint spray nozzle attached to extendable handle	• Minimum overspray • Fast • Eliminates concerns over contaminants in air supply (e.g., oil and water)	• Overspray would land and dry on unpainted steel, causing problems with adherence of paint applied later.
Air Driven Spray	Commercially available paint spray nozzle attached to extendable handle	• Fast	• Overspray would land and dry on unpainted steel, causing problems with adherence of paint applied later. • Considerable overspray • Contaminants, such as oil and water, in air supply can degrade paint performance

Table 3-3

Comparison of Coating Application Techniques

Coating Application Technique	Description	Advantages	Disadvantages
Flood and Drain Sand Bed	Flood the entire sand pocket with paint and then drain, leaving a layer of paint on all surfaces.	• Complete coverage	• Waste volume (8,000 gallons) per coat - Purchase Cost: 500 times more paint than direct application - Disposal Cost: Uncertain • It may be difficult to extend epoxy pot life such that cavity can be reliably filled and drained before curing initiates. As an alternative, heat curing-epoxy might be used, however, it may be impractical to heat drywell steel to curing temperature. • Temporary seals would have to be developed and installed in cathodic protection holes and vent pipe penetrations.
Flood with Foamed Paint	Flood the same pocket with foamed paint (and/or foam it in place) to coat all surfaces, then stop injecting air/nitrogen to allow foam to dissipate.	• Reduced waste volume	• This may be a new paint technology requiring development effort. • Temporary seals would have to be installed in cathodic protection holes and vent pipe penetrations.

Table 3-3

Comparison of Coating Application Techniques

Coating Application Technique	Description	Advantages	Disadvantages
Brush or Roller		• No overspray • Simple technology • Brush application allows paint to be forced into crevices in rough surfaces.	• Slower than spray methods

SELECTION OF CANDIDATE COATING SYSTEMS

Steel Structures Painting Council (SSPC) Coating Suggestions

Table 3-4 summarizes painting system suggestions from the Steel Structures Painting Council (SSPC). After sand removal, the portion of drywell exterior within the sand bed will fit conservatively into the SSPC "Environmental Zone 2A," which is steel frequently wet by fresh water splash or spray. For this environment SSPC suggests the following paint systems:

- Vinyl
- Chlorinated Rubber
- Coal Tar Epoxy
- Epoxy

Vinyl paints and chlorinated rubber coatings generally have lower temperature rating than epoxies: 150°F is typical, compared with 200 to 375°F for epoxies. Although the 150°F rating exceeds the 120°F maximum drywell temperature, it provides less margin than epoxy. Also, vinyl paints and chlorinated rubber paints are not generally recommended for hand or power tool cleaned surfaces. Accordingly, these paints are not selected as candidates for use on the drywell exterior.

Coal tar epoxies are not suitable for application over hand or power tool cleaned surfaces (References 1 and 4). Accordingly, they are not selected as candidates.

Epoxy coatings are available in "surface-tolerant" forms intended for hand or power tool cleaned surfaces with tightly adherent rust. In a survey of seven coating vendors, four recommended surface-tolerant epoxies. In tests performed by the California Department of Transportation on previously painted, rusted steel prepared by wire brushing, epoxies as a group performed better than other types of coatings. Accordingly, epoxies should be selected as a candidates for application to the drywell exterior. Epoxies are available in waterborne and solvent-borne forms. The surface-tolerant epoxies are solvent-borne. This is discussed further in the next section.

TABLE 3-4

TYPICAL SSPC PAINTING SYSTEMS FOR ENVIRONMENTAL ZONES

(TAKEN FROM REFERENCE 1)

Environmental Zone	Zone Conditions	Painting System Suggestions (1)
0	Dry interiors where structural steel is imbedded in concrete, encased in masonry, or protected by membrane or non-corrosive contact type fireproofing.	Leave unpainted
1A	Interior, normally dry (or temporary protection). Very mild (oil base paints now last ten years or more).	PS 18, Latex PS 7, One-Coat
1B	Exterior, normally dry (includes most areas where oil base paints now last six years or more).	PS 1, Oil Base PS 18, Latex
2A	Frequently wet by fresh water. Involves condensation, splash, spray or frequent immersion. (Oil base paints now last 5 years or less.)	PS 4, Vinyl PS 11, Coal Tar Epoxy PS 13, Epoxy PS 15, Chl. Rub.
2B	Frequently wet by salt water. Involves condensation, splash, spray or frequent immersion. (Oil base paints now last 3 years or less.)	PS 12, Zinc-Rich PS 4, Vinyl PS 11, Coal Tar Epoxy PS 13, Epoxy
2C	Fresh water immersion	PS 4, Vinyl PS 11, Coal Tar Epoxy
2D	Salt water immersion	PS 4, Vinyl PS 11, Coal Tar Epoxy
3A	Chemical exposure, acidic (pH 2.0 to 5.0)	PS 4, Vinyl PS 11, Coal Tar Epoxy PS 15, Chl. Rub.
3B	Chemical exposure, neutral (pH 5.0 to 10.0)	PS 12, Zinc-Rich Coal Tar Epoxy PS 15, Chl. Rub. PS 4, Vinyl
3C	Chemical exposure, alkaline (pH 10.0 to 12.0)	PS 11, Coal Tar Epoxy PS 15, Chl. Rub.
3D	Chemical exposure, presence of mild solvents. Intermittent contact with aliphatic hydrocarbons (mineral spirits, lower alcohols, glycols, etc.)	PS 13, Epoxy
3E	Chemical exposure, severe. Includes oxidizing chemicals, strong solvents, extreme pHs, or combinations of these with high temperatures.	Use specific exposure data.

(1) Painting systems for minimum protection are listed. More durable systems may, of course, be used for each zone.

Applicability of GPUN Coating Standards and Specifications

The following GPUN documents were reviewed for possible applicability.

GPUN Technical Functions Engineering Standard ES-005, Indoor Coatings Standard: The Coating Selection Guide in this standard requires that uncoated and coated steel surfaces within Radiologically Controlled Areas (RCA) be repair coated with either acrylic epoxy (GPUN Coating System CS-21) or epoxy/epoxy (GPUN Coating System CS-22). Product information for these systems is listed in Appendix B. Acrylic polymers (CS-21) are generally added to epoxies to enhance color and gloss retention. This is not a requirement for the drywell exterior, accordingly CS-21 is not selected as a candidate coating system.

The epoxy/epoxy coating system (CS-22) uses a latex acrylic primer suitable for surfaces prepared per SSPC-SP3 (Power Tool Clean) and a waterborne epoxy topcoat. Waterborne epoxies have some advantages over solvent-borne, high-solids epoxies: specifically, waterborne epoxies usually have an unrestricted recoat window whereas high solids epoxies must be recoated within 48 hours. Waterborne epoxies are recommended for roller or brush application over old paint. Unfortunately, waterborne epoxies are not recommended for surface tolerant applications (Reference 14 and telephone conversation with coating vendor, Keeler and Long). The coating vendor said that if a water-base paint system is needed, (for example, to meet volatile organic compound limits) CS-22 is probably their best for the drywell exterior. However, for better coating performance they recommend a polyamine epoxy (solvent-base) rather than a water-base epoxy for surface tolerant applications such as the rusted, imperfectly cleaned steel. Keeler and Long recommended their Kolormastic II 1800 primer in place of the latex acrylic primer. A number of other polyamine epoxies have been identified as candidate coatings (for example, the Carboline 801, aluminum pigmented epoxy appears similar to the 1800 primer), accordingly, the 1800 is not selected. The water-base CS-22 paints are selected as candidates to provide an option with unlimited recoating time and no solvents.

GPUN Coating System CS-13 used on the torus exterior is a surface tolerant epoxy primer topped with a general purpose, surface tolerant epoxy paint. Based on the GPUN's favorable experience with this system as used on the torus exterior, this system is selected as a candidate for the drywell exterior. The brushability of the epoxy topcoat should be checked; the coating vendor's literature recommends application by airless spray and does not state that this particular epoxy can be brush or roller applied.

GPUN Standard ES-005 also requires that compatibility of these coatings with any existing coatings be verified by in-situ tests for adhesion of the new coating to the existing coated surface. Further, ES-005 states that the coating manufacturer is to be contacted to ensure compatibility of the new coating system with the existing coating.

GPUN Specification No. 9000-06-003, Details for the Application and Repair of Protective Coatings to Service Level II and BOP Areas:

This specification recommends the same coating materials as ES-005, but provides more detailed product information. This specification also describes cleaning methods for removing grease, oil, rust, and old paint. It also covers safety precautions and site procedures. This specification is applicable to cleaning and coating the drywell exterior.

Results of CALTRANS Coating Tests

In the mid-1980's, the California Department of Transportation (CALTRANS) evaluated coatings designed for application to rusted, hand-cleaned steel. This work is reported in Reference 2 and summarized below and in Table 3-5.

The steel samples included:

- Clean, abrasive blasted test plates,
- "Artificially" rusted, hand-cleaned (wire brushed) test panels, and
- Previously painted, field-rusted, hand-cleaned (wire brushed) test panels.

The coatings tested fell into the following categories:

- Pretreatments (phosphoric acid solutions)
- Rust Converters
- Surface-Tolerant Latex Paints
- Nonhardening Waxy Coatings
- Epoxy
- Urethane
- Solvent-borne, Air Drying Paints

Testing was restricted to coatings having low volatile organic compound (VOC) content. Low VOC coatings were materials containing no more than 250 to 275 grams of VOC per liter of material as applied, excluding water and any solvents determined to be exempt by the California Air Resources Board.

The testing performed included accelerated laboratory tests and extended field tests (i.e., two years exposure beneath the Golden Gate Bridge). The CALTRANS test report (Reference 2) provides the following conclusions:

Surface preparation: For all types of coatings, rusted steel prepared by abrasive blasting had better rust resistance than steel that was hand-cleaned with wire brushes.

Phosphate pretreatments increase the adhesion of the paint coating to the metal surface and, with some primers, increase the corrosion protection for the metal. The phosphate pretreatments, by themselves, do not possess film forming properties and do not provide appreciable protection for the underlying metal surface.

Phosphate pretreatments are applied to smaller parts by dipping the parts into vats of phosphoric acid. Following the phosphating bath, a clean water rinse is required to remove insoluble salts and unreacted phosphating material. Failure to remove water soluble chemical residues by rinsing in clear water will result in early failure of the paint coating by blistering, flaking, and rapid spread of corrosion products when the metal surface is scratched. For large structures, phosphate pretreatment can be brush applied as a wash. Some phosphate washes call for fresh water rinsing and some do not.

In the CALTRANS study, phosphate pretreatment washes (phosphoric acid solutions) provided mixed results. Pretreatments were tested alone and with solvent-borne, air drying primer topcoats. Pretreatments improved the performance of some primers and degraded the performance of others.

Rust Converters generally contain tannin and/or phosphoric acid. These materials convert some rust compounds to ferric tannate and ferric phosphate (Reference 10).

In the CALTRANS tests, rust converters were grossly detrimental to the performance of a primer when applied to 100% rusted steel which was wire brushed, treated with a rust converter, topcoated with primer, and then exposed in the field.

Surface-tolerant latex paints were not tolerant of poor surface preparation; performance over rust was poor.

Nonhardening waxy paints performed poorly in both accelerated and outdoor exposure testing on all surfaces.

Epoxy coatings generally performed well on the test panels. Among the seven epoxy coating systems tested, the top three performers were:

- Porter Paint Company's Magna-Mastic Maintenance Primer
- Carboline's Carbomastic 15, and
- International Paint Company's Interplus 770.

In contacting International Paint Company, we learned that Porter Paint and International Paint have merged. The resulting company continues to supply equivalent products to those listed above. The Magna-Mastic is now called Magna-Mastic Product 7900. Carboline's Carbomastic 15 is an epoxy-coal tar coating intended as a heavy duty tank lining.

Urethane paints performed well under accelerated laboratory testing but poorly in field testing.

Solvent-borne, air drying paints gave performance equal to or better than the best of any other coating evaluated over rusty steel. Additionally, coating application was simpler than with epoxies; these air drying paints had longer pot lives and, for brush application, were more consistent in yielding film thicknesses equal to and above those specified. CALTRANS tested a formula they designate PB193; they now use a very similar, updated formula designated PB201.

Based on the CALTRANS testing, we conclude that the following types of coatings should not be considered for use as the base coat (or treatment) on the drywell exterior:

- Pretreatments (phosphoric acid solutions)
- Rust converters
- Surface-tolerant latex paints
- Urethane

The following types of coatings should be considered:

- Epoxy
- Solvent-borne, air drying paints

The top performing epoxy coatings and the specific solvent-borne, air drying paint tested by CALTRANS should be candidates for possible use on the drywell. However, the solvent-borne, air drying paint formula includes a cobalt drier; cobalt in the coating would become activated by neutrons. We contacted CALTRANS and a supplier of this paint; they indicated the cobalt can be eliminated; this will result in a slight elongation of drying time.

Nonhardening waxy coatings should not be considered for application to the drywell if manways are cut in the shield wall and the drywell surface is accessible for cleaning. However, these coating should be considered as an alternative for application to uncleaned steel in the event manways are not cut.

Table 3-5

SUMMARY OF TEST RESULTS
FROM CALTRANS COATING EVALUATION

Coating System Designation	Coating Manufacturer	Prime Coat		Finish Coat		Test Results (Rust Rating)[1] for Rusted, Wire Brushed Plates		Test Results (Rust Rating)[1] for Previously Painted, Rusted, Wire Brushed Plates	
		Product Name	DFT (mils)	Product Name	DFT (mils)	1000 Hour Salt Spray	25 Month Bridge Exposure	1000 Hour Salt Spray	25 Month Bridge Exposure
P24 (epoxy)	International Paint Co. Inc.	Interplus 770	1.5-2.0	Interplus 770	3.5-4.5 Total DFT 5.5-6.5	8	8	-	7
P26 (epoxy)	Porter Paint Company	Magna-Mastic Maintenance Primer	5-6	None	-	5	4	5	5
	Porter Paint Company	Magna-Mastic Maintenance Primer	5-6	Magna-Mastic Maintenance Primer	5-6 Total DFT 7-12	-	9	-	9
P34 (epoxy)	Koppers Company, Inc.	Koppers Aluminum Epoxy Mastic	?	None	-	-	4	-	6
		Koppers Aluminum Epoxy Mastic	?	Koppers Aluminum Epoxy Mastic	?	-	7 Second Coat Delaminated During Test	-	6

Table 3-5

SUMMARY OF TEST RESULTS
FROM CALTRANS COATING EVALUATION

Coating System Designation	Coating Manufacturer	Prime Coat		Finish Coat		Test Results (Rust Rating)[1] for Rusted, Wire Brushed Plates		Test Results (Rust Rating)[1] for Previously Painted, Rusted, Wire Brushed Plates	
		Product Name	DFT (mils)	Product Name	DFT (mils)	1000 Hour Salt Spray	25 Month Bridge Exposure	1000 Hour Salt Spray	25 Month Bridge Exposure
P35 (epoxy)	Devoe Prufcoat Co.	Chemfast 547 (now called Bar-Rust 235) Epoxy High Build Coating, unthinned	?	None	-	8	2		-
					Total DFT 10 to 15		7		5
		Chemfast 547 Epoxy High Build Coating, Unthinned	?	Chemfast 547 Epoxy, High Build Coating, Unthinned			7		4
		Chemfast 547 Epoxy High Build Coating, Thinned 20%	?	Chemfast 547 Epoxy High Build Coating, Unthinned	?				
P36 (epoxy)	Devoe Prufcoat Co.	Pre-Prime Rust Penetrating Sealer (now called Pre-prime 167)	?	None	-	7	-	-	-
P36/P35 (epoxy)	Devoe Prufcoat Co.	Pre-Prime Rust Penetrating Sealer	?	Chemfast 547 High Build Coating	Total DFT 5 to 8		7		6
P37 (epoxy coal-tar)	Carboline Co.	Carbomastic 15	?	None	-	3	5	-	-
		Carbomastic 15	?	Carbomastic 15	?	-	9	-	8
		Carbomastic 15, Thinned	?	Carbomastic 15	?	-	7	-	8

Table 3-5

SUMMARY OF TEST RESULTS
FROM CALTRANS COATING EVALUATION

Coating System Designation	Coating Manufacturer	Prime Coat		Finish Coat		Test Results (Rust Rating)[1] for Rusted, Wire Brushed Plates		Test Results (Rust Rating)[1] for Previously Painted, Rusted, Wire Brushed Plates	
		Product Name	DFT (mils)	Product Name	DFT (mils)	1000 Hour Salt Spray	25 Month Bridge Exposure	1000 Hour Salt Spray	25 Month Bridge Exposure
PB193 (Solvent-borne, air drying paint)	Nonproprietary formula for high solids, phenolic resin/ tung oil primer	CALTRANS Specification PB193	2	CALTRANS Specification PB193	2	9	8	9	8
P10 (non-hardening waxy)	Cortek, Inc.	M-652 Anti-Corrosion Compound	?		?	1 at 300 hrs. 0 at 1000 hrs.	-	-	-
P12 (non-hardening waxy)	Witco Chemical Corp.	RP-78 High Solids Corrosion Preventive Concentrate	?		?	7 at 300 hrs. 0 at 1000 hrs.	-	-	-
P13 (non-hardening waxy)	Witco Chemical Corp.	RP-93 High Solids Corrosion Preventive Concentrate	?		?	4 at 300 hrs. 0 at 1000 hrs.	-	-	-

Note: 1. Rust Rating is defined in ASTM D610 and is a measure of the percentage of surface area with visible rust. The zero to 10 scale is illustrated and described on Figure 4 (see next page).

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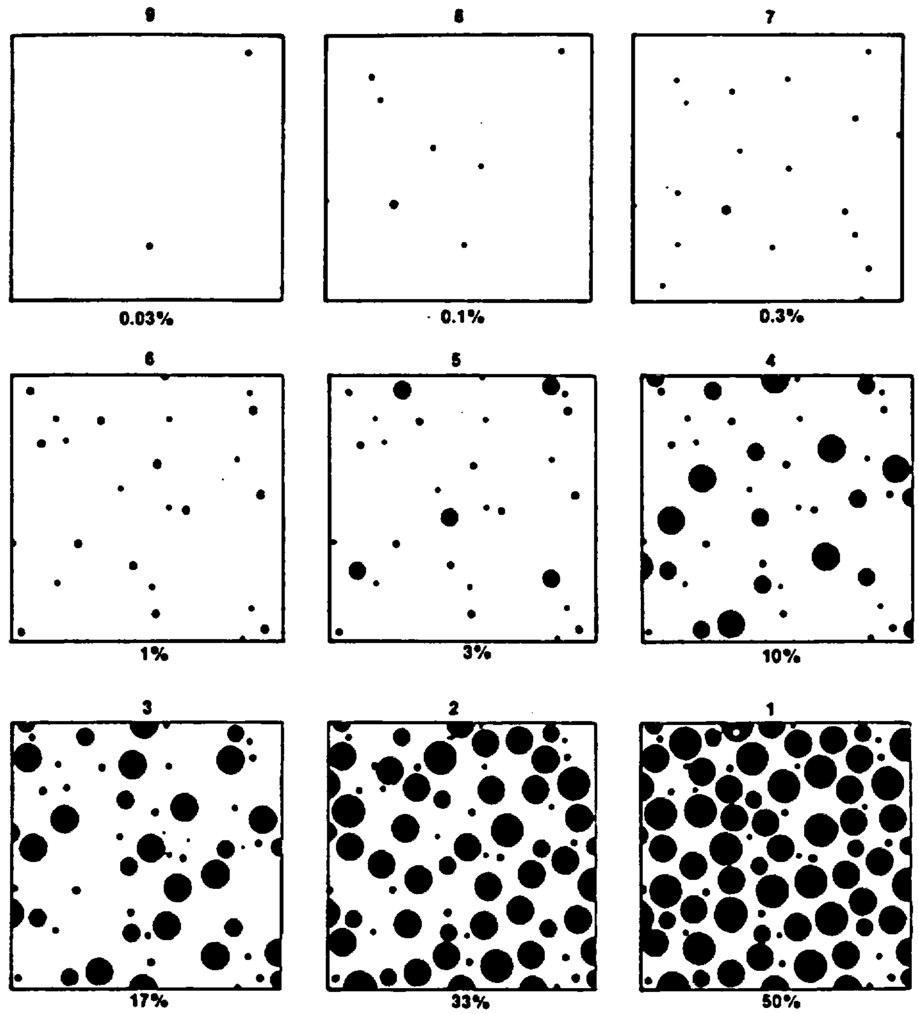
From ASTM D610



EXAMPLES OF AREA PERCENTAGES

Rust Grades	Description
10	no rusting or less than 0.01% of surface rusted
9	minute rusting, less than 0.03% of surface rusted
8	few isolated rust spots, less than 0.1% of surface rusted
7	less than 0.3% of surface rusted
6	extensive rust spots but less than 1 % of surface rusted
5	rusting to the extent of 3% of surface rusted
4	rusting to the extent of 10% of surface rusted
3	approximately one sixth of the surface rusted
2	approximately one third of the surface rusted
1	approximately one half of the surface rusted
0	approximately 100% of surface rusted

DESCRIPTION OF RUST GRADES PER ASTM D610

FIGURE 4

Coating Vendor Survey

As part of an earlier feasibility study, we prepared a Technical Requirements document describing the drywell coating problem and sent it to eight coating vendors for their recommendations. In that study, it was assumed that the coatings would be applied while the plant was operating and the drywell steel was at 130°F.

The vendors recommended the following types of coatings:

- Epoxy
- Polyurethane primer with coal tar extended urethane top coat
- Epoxy-red lead primer with polyurethane top coat
- Modified alkyd with corrosion inhibitors (soft coating with oils, wax, and 70% solids)

The vendor recommendations are evaluated in the discussion below and summarized in Tables 3-6 and 3-7. Vendor correspondence and product literature is provided in Appendix B.

The Carboline 801 aluminum filled epoxy is usable on rusted, hand tool (or power tool) cleaned steel, but not on old red lead primer. This coating is attractive for the drywell exterior because it has no limitations on maximum recoat time; the second coat may be applied one hour or more after the first coat. This coating should be a candidate for selective application over rusted, hand-tool cleaned portions of the drywell exterior.

The Devoe Bar-Rust 235 epoxy is advertised as usable on rusted, power tool cleaned steel and may be compatible with the existing layer of red lead primer. CALTRANS tested this paint by brush application over previously painted, rusted, wire-brushed steel and over rusted, wire-brushed steel. Test results are summarized in Table 3-5: coating system P35 is Chemfast 547, which is now called Bar-Rust 235. Among the epoxy coatings tested, Bar-Rust 235 provided the least rust protection. In spite of that result, this coating should be considered for possible application to the drywell exterior. Its performance when applied over the specific paint (red lead-linseed oil) on the drywell should be checked.

The Martek Duromar 1025 two-part epoxy has a pot life of only 45 minutes at 70°F and a maximum recoat or tie-in time of 24 hours. These time constraints make this coating undesirable for the drywell exterior due to the difficult access to the work areas and the added logistical challenges of applying the coating within the required times. Accordingly, this coating should not be a candidate for possible use on the drywell exterior.

The Martek One-Part Heat Cure Epoxy eliminates concerns over timing of coating applications. The coating would be applied and adjoining bays "tied-in" (coating overlapped) without any time limits. After all surfaces were coated, the air space in the sand bed would be heated to 180-220°F to initiate curing of the epoxy. There would be a considerable amount of effort involved in sealing the sand bed for controlled addition/venting of heated air. Also, the drywell steel and the shield wall concrete would act as heat sinks and could make it difficult or impractical to get the coating to reach 180-220°F. Accordingly, this coating system is not selected for possible use on the drywell exterior.

The 3E Group's recommended coating system detailed in Table 3-6 creates a large volume of waste material (8,000 gallons of potentially contaminated trisodium phosphate) and therefore, is not selected.

The PRAXIS Prax-ten nonhardening waxy coating is based on a group of rust preventive concentrates supplied by Witco's Sonneborn division. The California Department of Transportation (CALTRANS) tested two Witco Chemical Corporation Corrosion Preventive Concentrates applied over rusted, hand-cleaned steel plates (Reference 2). In accelerated laboratory tests (salt spray), these plates become rusted over 100 percent of their surface after 1000 hours of testing. By comparison, two-coat epoxy samples showed less than 0.3 percent surface area rusted after 1,000 hours. Although nonhardening waxy coatings do not last as long as epoxy coatings, they have some potential advantages in that they might be spray or mist applied by simple long-handled tools through existing openings in the drywell shield wall if manways were not bored through the shield wall. Accordingly, this coating system should be tested by spray application to heavily rusted, uncleaned steel to determine if it results in lower corrosion rates than no coating at all.

The Specialties Engineering Corporation (SEC) recommended a primer coat of a Specialties Engineering SPECOAT product designated SEC-EPRI (Epoxy Primer Rust Inhibitor) followed by polyurethane top coats. SEC does not manufacture the polyurethane coating and a separate supplier of the polyurethane top coat would have to be identified. Specialty Engineering literature suggests that this red-lead epoxy primer be used on "non-critical" equipment exposed to marine-sea water, brine, and fresh water. This coating system is not selected due to the vendor's caution that this coating be used on "non-critical" equipment.

Table 3-6

Comparison of Vendor Recommended Coating Systems for Application to 130°F Drywell Steel During Plant Operation

	CARBOLINE	DEVOE	DUPONT	MARTEK	3E GROUP	PARAGON	PRAXIS	SPECIALTIES ENG.
Recommended Surface Preparation and Coatings	Preliminary <u>Recommendations</u>: (see Note below) 1. Remove oil or grease from surface using thinner and rages per SSPC-SP1. 2. Power tool or hand tool clean per SSPC-SP3 or SP2 to produce a rust scale free surface. 3. Apply two or three coats of Carboline 801 aluminum (epoxy) to achieve a minimum of 10 mils. DFT. Additional coats may be applied after one hour. There is no maximum recoat time.	1. Prepare surface by removing water, salt, dirt, oil, loose rust, and <u>all rust scale</u> to a minimum standard of SSPC-SP3: grit blasting is not required. 2. Spray, brush, or roll on two coats of two-part epoxy coating, Bar-Rust 235. Care should be taken that proper and uniform film thickness is obtained. 3. Apply two additional coats (5 to 8 mils per coat) to sharp edges and welds. <u>Note</u>: Pot life is 5 hours at 77°F.	Declined to recommend coating system	<u>Option 1</u>: Epoxy without Heat Cure a. Water or sand blast steel. b. Spray 100 percent solid epoxy coating "HPL1025" onto steel. This epoxy has been success-fully applied by roller to a 130±F tank. <u>Note</u>: "Overcoat window" of 6 to 24 hours. <u>Option 2</u>: Epoxy with heat cure a. Water or sand blast steel b. Spray heat curable epoxy onto steel c. Cure with heated air (180-220°F)	1. Surfaces must be free of dirt, loose debris, oils, greases, or other substances that will interfere with bond. The surface should be as dry as possible. 2. Mist spray 20% acetic acid -- leave for 3 hours. 3. Flood with 0.5% tri-sodium phosphate -- leave for 15 minutes and drain. 5. Apply polaprime 21 6. Air dry 24 hours	Recommendation cannot be published due to proprietary agreement.	1. Remove loose scale, dirt and debris using high pressure water or sand blast. 2. Spray on modified alkyd, with corrosion inhibitors. This is a soft coating with oils and waxes, and about 70 percent solids. <u>Note</u>: Repair and touch up requires no blasting - just spray on additional coating.	Preliminary <u>Recommendations</u>: 1. Remove loose rust 2. Apply two or three coats of red-lead epoxy primer to create 5-8 mil layer. 3. Apply two parts polyuethane top coat.

Table 3-6

Comparison of Vendor Recommended Coating Systems for Application to 130°F Drywell Steel During Plant Operation

	CARBOLINE	DEVOE	DUPONT	MARTEK	3E GROUP	PARAGON	PRAXIS	SPECIALTIES ENG.
	Note: After detailed review, Carboline concluded that their 801 epoxy is not compatible with the existing red lead/linseed oil paint on the steel; the epoxy would pull on the red lead when it dries causing delamination of the red lead. Carboline recommends SP6 blast cleaning to remove the old paint.				7. Apply Encapsol paint (coal tar extended urethane, with variable viscosity). 8. Allow to dry 48 hours			
Projected Life	Twenty years with inspections and touch up every five years						Five to ten years: plan to inspect and maintain at four-to five-year intervals.	Unknown: plan to inspect and maintain at seven-to ten-year intervals.
Material Cost	$673.05 (15 gallons at $44.87/gallon)	(10 gallons)		$4,125 (33 gallons at $125/gallon)				

Table 3-7
COMPARISON OF COATING APPLICATION PROPERTIES FOR
VENDOR RECOMMENDED COATING SYSTEMS

PROPERTY / COATING	CARBOLINE 801	DEVOE BAR-RUST 235	MARTEK DUROMAR 1025	MARTEK	3-E GROUP POLAPRIME 21	3-E GROUP ENCAPSOL	PRAXIS PRAX-TEN
Description	Two-part epoxy, aluminum filled	Two-part Epoxy	Two-part Epoxy	One-part Heat Cure Epoxy	Single component polyethylene primer	Coal tar extended urethane	Single component modified alkyd with corrosion inhibitors
Number of Coats	2 or 3	2	2 or 3				
Recommended Total DFT	14 to 20 mils	10 to 16 mils	20 to 60 mils			30 mils WFT	
Minimum DFT	10 mils		40 mils				
Maximum DFT			60 mils				
Maximum surface temperature during application	135°F	160°F					
Minimum time before next coat	1 hour		6 hours				
Maximum time before next coat	No maximum		24 hours				
Maximum time before tie-in of adjacent areas	10 minutes for best results		24 hours				
Pot Life	4 hours at 75°F	5 hours at 77°F	45 minutes at 70°F				
Compatible with existing red lead paint?	No	Unknown	Unknown				
Repair method	Hand-tool clean per SSPC-SP2 and recoat.	Clean with Devprep 88 and recoat without abrading old coating.					Spray on additional coating.
Cost	$673.05 (15 gallons at $44.87/gallon)	(10 gallons)					

Recent Coating Selection Guidelines

A recent article in Materials Performance Magazine provided a thorough summary of generic coating systems and estimated service lives before initial maintenance for those systems applied to new steel (Reference 4). The generic coating systems and their service life estimates are based on information from coating suppliers and their laboratories; National Association of Corrosion Engineers (NACE); and Steel Structures Painting Council (SSPC) work groups, major users, and industry coating authorities. From that article, we extracted Table 3-8 which lists the coating systems rated for use with the lowest level of surface preparation (SSPC-SP2 or SP3, which is degreasing followed by hand tool or power tool cleaning to remove all loose rust scale). In this comparison, the "service life" is the time until initial breakdown of the topcoat occurs. Maintenance painting would be required at that time to prevent initiation of rust. The estimated service life is for "seacoast marine" environments which are defined as locations within five miles of coastal/salt water with no industrial plants or fumes present. The service life of these coatings on the drywell exterior will be less than listed in the table since those values are for new steel; the old drywell surface will contain contaminants and surface imperfections that will shorten the service life of the coating system.

As indicated in Table 3-8, high-build, surface-tolerant epoxies with urethane top coats for a total of three coats (system numbers 22 and 24) provide the longest expected service lives at 9 to 10 years. The systems using only high-build, surface-tolerant epoxies (generic systems 16 and 18), have an estimated service life before initial repair of 4 years for one coat and 7 for two coats. Service life increases with the coating film thickness; the film thickness increases service life by decreasing diffusion of moisture and oxygen to the steel surface.

Table 3-8

COMPARISON OF ESTIMATED SERVICE LIVES OF
COATING SYSTEMS ON NEW STEEL SURFACES PREPARED PER SSPC-SP2/SP3

SYSTEM NUMBER	NUMBER OF COATS	COATING SYSTEM	MINIMUM DFT	SERVICE LIFE (YEARS)	DRY HEAT RESISTANCE (°F)
1	2	Acrylic water-borne prime/top	4.0	3.5	175-200
4	2	Alkyd prime/top	4.0	1	150-200
6	3	Alkyd prime/top/top	6.0	2	150-200
8	2	Latex prime/top	4.0	2	200-250
10	3	Latex prime/top/top	6.0	3	200-250
12	2	Universal prime/HB epoxy	6.0	4	250-300
14	3	Universal prime/HB epoxy/acrylic urethane	7.5	5	300
16	1	HB surface-tolerant epoxy	5.0	4	250-300
18	2	HB surface-tolerant epoxy	10.0	7	300
20	2	HB surface-tolerant epoxy/acrylic urethane	9.0	5	300
22	3	HB surface-tolerant epoxy/HB acrylic urethane/acrylic urethane	11.0	9	300
24	3	HB surface-tolerant/HB acrylic urethane/polyester urethane	11.0	10	300
26	2	2-pack aromatic urethane prime/HB acrylic urethane	7.0	4	300
28	2	Moisture cure urethane aluminum/HB acrylic urethane	6.5	3	300
32	2	Epoxy primer/HB epoxy	6.0	4	150-300

Note: This table is based on the article, "Selecting Cost-Effective Protective Coating Systems," G.H. Brevoort, and A.H. Roebuck, Materials Performance Magazine, February 1991. The "Service Life" listed applies to new steel cleaned per SSPC-SP2 or SP3 in a "marine seacoast" service condition, which is defined as within five miles of coastal/salt water and no industrial plants or fumes present. The service life is the time until initial breakdown of the topcoat occurs, but active rusting of the substrate has not occurred; maintenance painting would be required at that time to prevent initiation of rusting.

Miscellaneous Coating System Suggestions

Several coating systems were identified for consideration by various sources; these coating systems are evaluated below.

Brookhaven National Laboratory has developed an "Improved Zinc Phosphate Coating System for the Corrosion Protection of Steel." This pretreatment is intended for new steel parts that can be dipped into a vat of pretreatment solution at 176°F. Accordingly, this specific process is not considered practical for use on the drywell exterior. Alternative, room temperature phosphate pretreatments are discussed in the section titled "Review of CALTRANS Coating Tests."

Ameron Protecting Coating Division suggested two coatings: Dimetcote 21-5 and Amercoat 3151. Dimetcote 21-5 is a water-base inorganic-zinc silicate with no volatile organic compounds (VOC). The SSPC painting system guide for this type of coating system indicates it is suitable for use in Environmental Zones 2A (frequently wet by fresh water) and 2C (fresh water immersion). Accordingly, this coating might be acceptable. However, both the manufacturer's literature and the SSPC painting guide say that this coating requires abrasive blast cleaning to at least near-white metal condition for good results; this paint is not designed for poorly prepared surfaces or for application over existing paint. The manufacturer's literature specifies the highest quality surface preparation, SSPC-SP5, White-Metal finish, for previously painted, pitted surfaces such as the drywell. Completely clean steel is required since zinc-rich coating are intended to act as a sacrificial anode and must be electrically contiguous with the steel to work at all. It is likely that the drywell steel will be cleaned to a lesser degree: coatings intended for application to hand and power tool cleaned surface in accordance with SSPC-SP2/3 are preferred. Accordingly, this coating is not selected as a candidate for the drywell exterior.

Amercoat 3151 is a 100% solids by volume epoxy with no volatile organic compounds. The manufacturer's literature calls for surface preparation by abrasive blasting to achieve a near-white metal finish (SSPC-SP10). As discussed above, it is not likely that this level of surface finish will be achieved. Also, this coating is to be applied by airless spray: the manufacturer's literature does not state that it can be roller or brush applied. Accordingly, this coating is not selected.

Predicted Service Life of Coatings

All of the coating vendors contacted, as well as several articles on coating selection, cautioned that coating inspection and possible touch-up work should be expected three to ten years after the initial application. None of the vendors felt that a coating system could be provided that would definitely last 19 years (balance of plant license) without maintenance. Accordingly, the coating system should be repairable with the existing access limitations.

Coating Repairability

If an epoxy coating is used on the drywell exterior the following general approach would be used for localized repairs. Detailed repair steps are covered in Reference 7.

- Use hand-held power tools to strip the paint and any rust with 3M Company Clean-N-Strip wheels or discs (or other methods). The adjacent sound coating shall be feather-edged and roughened.
- Brush or roll apply compatible epoxy paint over the repair area.

Larger scale maintenance of the coating, which may be required after five to ten years, would involve a large number of localized repairs as described above, followed by complete topcoating. The entire surface of the old epoxy coat would have to be warm water washed, perhaps solvent cleaned and then roughened prior to topcoating. Roughening could be performed using hand-held, power tool driven, wire brushes, or abrasive pads/discs.

If paints other than epoxies are used on the drywell, localized repairs would be the same as for epoxy. Larger scale maintenance recoating might be simpler in that the old paint would not have to be roughened to accept the new paint.

Section 4

REFERENCES

1. Steel Structures Painting Manual, Volume 1, Good Painting Practice, and Volume 2, Systems and Specifications, Steel Structures Painting Council (SSPC), 1989.

2. Structural Steel Coatings and Pretreatments for Use in Lieu of Blast Cleaning, Report No. FHWA/CA/TL-88/04, by the State of California, Department of Transportation, Division of Construction, Office of Transportation Laboratory, June 1988.

3. Coatings for Non-Blast Cleaned Highway Metals, Report No. FHWA/RD-82/125, by the Office of Engineering and Highway Operations R&D, Federal Highway Administration, US Department of Transportation, 1982.

4. Selecting Cost-Effective Protective Coating Systems, G.H. Brevoort and A.H. Roebuck, Materials Performance Magazine, February 1991.

5. Drywell and Sand Bed Region Corrosion Assessment, GPUN TDR No. 854, April 22, 1987.

6. GPUN Standard ES-005, Indoor Coatings Standard.

7. GPUN Specification SP-9000-06-003, Application and Repair of Service Level II and Balance of Plant Coatings.

8. A Review of Recent Developments in Surface Preparation Methods, Janet Rex, Journal of Protective Coatings and Linings, October 1990.

9. Cleaning Pipelines Using High-Pressure Water Jets, Sidney Taylor and Gerald Chapman, Material Performance Magazine, September 1991.

10. Application of Infrared Spectroscopy for Investigation of Rust Phase Component Conversion by Agents Containing Oak Tannin and Phosphoric Acid, J. Gust, Corrosion Magazine, Volume 47, No. 6, June 1991.

11. Evaluation of 20,000 PSI Water Jetting for Surface Preparation of Steel Prior to Coating or Recoating, Dr. Lydia M. Frenzel, Coastal Science Associates, Inc., April 1983.

12. NACE RP-01-72, Recommended Practice, Surface Preparation of Steel and Other Hard Materials by Water Blasting Prior to Coating or Recoating.

13. Effectiveness of Nonabrasive Cleaning Methods for Steel Surfaces, S. Frondistov-Yannas, NACE 0094-1492/86/000884, Paper published in July 1986 Materials Performance Mazagine.

14. The Right Choice-Water or High Solids?, George A. Roy II, Materials Performance Magazine, November 1991.

Appendix A

MANUFACTURER LITERATURE FOR CANDIDATE COATING SYSTEMS

MANUFACTURER	PRODUCT	DISTRIBUTOR
Carboline	Carboline 801 (white color) Carboline 801 (light gray color)	Carboline Company 350 Hanley Industrial Ct. St. Louis, MO 63244-1599 (314) 644-1000 Mr. Jerry Arnold, Nuclear Manager
Devoe	Preprimer 167 (clear) Devran 184 (aluminum gray color) Bar-Rust 235 (buff color) Bar-Rust 235 (haze gray color)	Devoe Coatings Company 800 Ferndale Place Rahway, NJ 07065 Mr. William MacKay, Sales Representative (908) 388-5100 (212) 349-7190
Porter International	Magna-Mastic 7900 (aluminum color) Hythane 4600 Series, white 4610 Hythane Super, 8600 Series, light gray Interplus 770 (off-white color) Interplus 770 (light gray color)	Porter International Glen Burnie, MD (800) 447-1275 (ask for Pauline or Cindy)

Appendix A

MANUFACTURER LITERATURE FOR CANDIDATE COATING SYSTEMS

MANUFACTURER	PRODUCT	DISTRIBUTOR
Keeler and Long	Aqua Kolor Primer, 9400 Series (white color) Hydro-Poxy Enamel, H-Series (gray color)	Keeler and Long, Inc. Box 460 Watertown, CT 06795 (203) 274-6701
Nonproprietary Formula	CALTRANS Specification PB201 modified (delete cobalt drier) High Solids, Phenolic Primer (white color for base coat and light gray for top coat, instead of red per PB201)	Triangle Coatings 1930 Fairway Drive San Leandro, CA 94577 (415) 895-8000
Praxis	Prax-ten Sealer (tan color - unpigmented) Prax-ten Sealer (gray color)	Praxis Technologies 901 Society Place Newtown, PA 18940 (215) 860-5240 Mr. John Sices, Technical Director

carboline
350 Hanley Industrial Ct. • St. Louis, MO 63144-1599
an RPM company • 314-644-1000

NUCLEAR COATING SYSTEM

SYSTEM	PRODUCT	GENERIC TYPE	DRY FILM THICKNESS	VOLUME SOLIDS	COVERAGE
PRIMER/ TOPCOAT	CARBOLINE 801	EPOXY	6 MILS	76%	203 ft²

DESCRIPTION: A single coat, self-priming epoxy designed for maintenance. Carboline 801 can be applied directly to steel or to existing, intact coatings.

FEATURES	BENEFITS
• Surface tolerant primer	• Can be applied to intact rust or over hand and power tool cleaned surfaces. Reduces surface preparation labor and potential airborne contamination.
• High solids	• VOC compliant, less effect on personnel and charcoal filters.
• Available in Rapid Tint System	• Wide selection of colors with no minimum order restrictions; fast delivery.

TEST DATA

TEST	METHOD	CONDITIONS	RESULTS
DESIGN BASIS ACCIDENT (DBA)	ANSI N101.2 - 1972 ASTM D3911-89	300°F/48 PSIG 3 x 10⁸ RADS	ACCEPTABLE
RADIATION TOLERANCE	ANSI N5.12 - 1974 ASTM D4082-83	1.01 x 10⁹ RADS	ACCEPTABLE
DECONTAMINATION	ANSI N5.12 - 1974 ASTM D4256-83	PER TEST METHOD AND ORNL PROCEDURES	99.92%
CHEMICAL RESISTANCE	ANSI N5.12 - 1974 ASTM D3912-80	5 DAY IMMERSION	ACCEPTABLE EXCEPT FOR NITRIC, SODIUM HYDROXIDE & POTASSIUM PERMANGANATE
TABER ABRASION	ANSI N5.12 - 1974 FED STD 141 METHOD 6192	1000 CYCLES 1000g WEIGHT CS-17 WHEEL	124 mg LOST
ELCOMETER ADHESION	ANSI N5.12 - 1974 ASTM D4541-85	PER TEST METHOD	983 PSI
FIRE EVALUATION	ANSI N101.2 - 1972 ASTM E-84	PER TEST METHOD	FLAME SPREAD 5

carboline®

CARBOLINE® 801

VOC PLUS

0987

SELECTION DATA

GENERIC TYPE: Two component, cross-linked epoxy.

GENERAL PROPERTIES: CARBOLINE 801 is a self priming, high build, semi-gloss finish available in a wide variety of colors. Can be applied by spray, brush or roller over hand or power tool cleaned steel and is compatible with most existing coatings and tightly adhered rust. The cured film is tough and abrasion resistant and provides an easily cleanable, esthetic surface. Features include:

- Single coat corrosion protection.
- Good weathering resistance.
- Good flexibility and lower stress upon curing than most epoxy coatings.
- Excellent tolerance of damp (not wet) substrates.
- Can be spray applied up to 8 mils dry in one coat.
- *Has a higher flash point than most epoxy coatings (over 110°F, including recommended Carboline Thinner).*
- Meets the most stringent VOC (Volatile Organic Content) regulations.

RECOMMENDED USES: Recommended as a general, plant wide, maintenance coating for tanks, structural steel or miscellaneous equipment in industrial environments that include Chemical Processing, Pulp and Paper, Water and Waste Water Treatment and Power Generation among others. May be used as a single coat, shop applied system for new structural steel and equipment that will receive mild chemical exposures. Two coats of CARBOLINE 801 are recommended for use in more severe environments. Consult Carboline Technical Service Department for other specific uses.

NOT RECOMMENDED FOR: Immersion service, splash and spillage of very strong solvents or concentrated acids.

TYPICAL CHEMICAL RESISTANCE:

Exposure	Splash and Spillage	Fumes
Acids	Good	Very Good
Alkalies	Good	Excellent
Solvents	Very Good	Excellent
Salt Solutions	Excellent	Excellent
Water	Excellent	Excellent

TEMPERATURE RESISTANCE:
Continuous: 200°F (93°C)
Non-continuous: 250°F (121°C)

SUBSTRATES: Apply over suitably prepared metal, concrete, or other surfaces as recommended.

COMPATIBLE COATINGS: May be used over most generic types of coatings which are tightly adhering and properly prepared. A test patch is recommended for use over existing coatings. May be topcoated to upgrade weathering resistance. Not recommended over chlorinated rubber or latex coatings. Consult Carboline Technical Service Department for specific recommendations.

SPECIFICATION DATA

THEORETICAL SOLIDS CONTENT OF MIXED MATERIAL:*

	By Volume
CARBOLINE 801	76% ± 2%

VOLATILE ORGANIC CONTENT:*
As Supplied: 1.74 lbs./gal.(208 gm/liter — Color White (S800)
Thinned: The following are nominal values utilizing CARBOLINE Thinner #4.

% Thinned	Fluid Ounces/Gal.	Pounds/ Gallon	Grams/ Liter
6%	8	2.08	250
12%	16	2.37	284
25%	32	2.88	345

*Varies with color

RECOMMENDED DRY FILM THICKNESS PER COAT:
4-6 mils (100-150 microns) for use in mild environments.
6-8 mils (150-200 microns) for use over light tight rust. In more severe environments a second coat of 4-6 mils(100-150 microns) is recommended.

THEORETICAL COVERAGE PER MIXED GALLON:
1219 mil sq. ft. (30.4 sq. m/l at 25 microns)
244 sq. ft. at 5 mils(6.0 sq. m/l at 125 microns)
Mixing and application losses will vary and must be taken into consideration when estimating job requirements.

STORAGE CONDITIONS: Store Indoors.
Temperature: 40-95°F (4-35°C)
Humidity: 0-90%

SHELF LIFE: Twenty-four months minimum when stored at 75°F (24°C).

COLORS: Available in Carboline Color Chart Colors. Metallic aluminum colors are available upon special request. Some colors may require two coats for adequate hiding. Consult your local Carboline representative or Carboline Customer Service for availability.

- See notice under DRYING TIMES.

GLOSS: Semi-gloss (Epoxies lose gloss and eventually chalk in sunlight exposure).

ORDER INFORMATION

Prices may be obtained from your Carboline sales representative or Carboline Customer Service Department.

APPROXIMATE SHIPPING WEIGHT:

	2's	10's
CARBOLINE 801	28 lbs. (12 kg)	135 lbs. (61 kg)
CARBOLINE Thinner #4	9 lbs. (4 kg) in 1's	45 lbs. (20 kg) in 5's

FLASHPOINT: (Pensky-Martens Closed Cup)

CARBOLINE 801 Part A	110°F (43°C)
CARBOLINE 801 Part B	115°F (46°C)
CARBOLINE Thinner #4	110°F (43°C)

August 90 Replaces July 87

APPLICATION INSTRUCTIONS
CARBOLINE® 801

These instructions are not intended to show product recommendations for specific service. They are issued as an aid in determining correct surface preparation, mixing instructions and application procedure. It is assumed that the proper product recommendations have been made. These instructions should be followed closely to obtain the maximum service from the materials.

0987

SURFACE PREPARATION: Remove oil or grease from surface to be coated with clean rags soaked in CARBOLINE Thinner #2 or SURFACE CLEANER #3 (Refer to Surface Cleaner #3 instructions) in accordance with SSPC-SP 1.

Steel: For mild environments Power Tool or Hand Tool Clean in accordance with SSPC-SP 3 or SSPC-SP 2, respectively to produce a rust-scale free surface.

For more severe environments, abrasive blast to a Commercial Finish in accordance with SSPC-SP 6 (or NACE #3) to obtain a 1-1/2 — 3 mil (40-75 micron) blast profile.

Concrete: Apply over clean, dry recommended surfacer. Can be applied directly to dry concrete where an uneven surface can be tolerated. Remove laitance by abrasive blasting or other means.

Do not coat concrete treated with hardening solutions unless test patches indicate satisfactory adhesion. Do not apply coating unless concrete has cured at least 28 days at 70°F (21°C) and 50% R.H. or equivalent time.

MIXING: Mix separately, then combine and mix in the following proportions:

	2 Gal. Kit	10 Gal. Kit
CARBOLINE 801 Part A	1 gallon	5 gallons
CARBOLINE 801 Part B	1 gallon	5 gallons

DO NOT MIX PARTIAL KITS.

THINNING: For spray applications, may be thinned up to 12% (16 fl. oz./gal.) by volume with CARBOLINE Thinner #4.

For brush and roller application, may be thinned up to 25% (32 fl. oz./gal.) by volume with CARBOLINE Thinner #4.

Refer to Specification Data for VOC information.

Use of thinners other than those supplied or approved by Carboline may adversely affect product performance and void product warranty, whether express or implied.

POT LIFE: Four hours at 75°F (24°C) and less at higher temperatures. Pot life ends when coating loses body and begins to sag. Thinning rates above 12% will shorten the working time to two hours due to reduced film build.

APPLICATION CONDITIONS:

	Material	Surfaces	Ambient	Humidity
Normal	60-85°F (16-29°C)	60-85°F (16-29°C)	60-85°F (16-29°C)	0-90%
Minimum	50°F (10°C)	50°F (10°C)	50°F (10°C)	0%
Maximum	90°F (32°C)	135°F (57°C)	110°F (43°C)	90%

Do not apply when the surface temperature is less than 5°F (2°C) above the dew point.

Special thinning and application techniques may be required above or below normal conditions.

SPRAY: This is a high solids coating and may require slight adjustments in spray techniques. Wet film thicknesses are easily and quickly achieved. The following spray equipment has been found suitable and is available from manufacturers such as Binks, DeVilbiss and Graco.

Conventional: Pressure pot equipped with dual regulators, 3/8" I.D. minimum material hose, .070" I.D. fluid tip and appropriate air cap.

Airless:
Pump Ratio: 30:1 (min.)*
GPM Output: 3.0 (min.)
Material Hose: 3/8"I.D. (min.)
Tip Size: .017-.021"
Output psi: 1900-2100
Filter Size: 60 mesh

*Teflon packings are recommended and are available from the pump manufacturer.

BRUSH OR ROLLER: Use a medium bristle brush, or good quality short nap roller, avoid excessive rebrushing and rerolling. Two coats may be required to obtain desired appearance and recommended DFT. For best results, tie-in within 10 minutes at 75°F (24°C).

DRYING TIMES: These times are at 4 mils (100 microns) dry film thickness. Higher film thicknesses will lengthen cure times.

Dry to Touch at 75°F (24°C)–3-1/2 hours
Dry to Handle at 75°F (24°C)–6-1/2 hours

	Between Coats	Final Cure
50°F (10°C)	36 hours	3 days
60°F (16°C)	24 hours	2 days
75°F (24°C)	12 hours	24 hours
90°F (32°C)	6 hours	12 hours

May discolor if exposed to rain, condensation or moisture from any source prior to final cure. When this occurs, coating may turn white, particularly noticeable with darker colors.

CLEANUP: Use CARBOLINE Thinner #2.

CAUTION: READ AND FOLLOW ALL CAUTION STATEMENTS ON THIS PRODUCT DATA SHEET AND ON THE MATERIAL SAFETY DATA SHEET FOR THIS PRODUCT.

CAUTION: CONTAINS COMBUSTIBLE SOLVENTS. KEEP AWAY FROM SPARKS AND OPEN FLAMES. IN CONFINED AREAS WORKMEN MUST WEAR FRESH AIRLINE RESPIRATORS. HYPERSENSITIVE PERSONS SHOULD WEAR GLOVES OR USE PROTECTIVE CREAM. ALL ELECTRIC EQUIPMENT AND INSTALLATIONS SHOULD BE MADE AND GROUNDED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE. IN AREAS WHERE EXPLOSION HAZARDS EXIST, WORKMEN SHOULD BE REQUIRED TO USE NONFERROUS TOOLS AND TO WEAR CONDUCTIVE AND NONSPARKING SHOES.

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Since 1754

DEVOE COATINGS

Marine·Industrial·Offshore

Pre-Prime 167

Rust Penetrating Sealer

(Formerly Pre-Prime 467)

Catalog Number 167-K-XXXX

FEATURES

Reinforces Rusty Steel Substrates

Penetrates Through Rusty Surfaces

Cures To A Tough, Water Resistant Coating

100% Volume Solids

- Very low viscosity
- Low film thickness required
- No shrinkage

RECOMMENDED USES

The extraordinary penetrating properties of Pre-Prime 167 Sealer provide a means of reinforcing rusty steel substrates—this in turn insures the adhesion of subsequent coatings.

- Recommended in areas where, due to restrictions or economics, blasting or thorough hand cleaning is not feasible.
- Very effective sealer and/or reinforcement for masonry surfaces.
- Excellent sealer for aged "white rusted" zinc surfaces.

SPECIFICATION DATA

Coating Type	100% Solids epoxy
Color Clear	**Catalog Number** 167-K-0000
Packaging	4 Gallon and 1 Gallon two-component kits
Component Ratio	3 to 1 by volume
Gloss	Medium sheen
Flash Point	100°F (38°C) Setaflash
Thinner	Do not thin
Pot Life	4 hours at 77°F (25°C)
Shelf Life	More than 1 year

Density	8.5 Lbs/Gal (1.02 kg/l)
VOC	0
Temperature Resistance	250°F (121°C) dry
Volume Solids	100%
Theoretical Spreading Rate	1604 Sq. Ft/Gal at 1 mil 39.3 Sq. m/l at 25 microns
Recommended Film Thickness 1.5 wet mils to obtain 1.5 dry mils	
Application Methods	Air spray, brush or roller
Dry Time To recoat	At 77°F (25°C), 50% RH Overnight

Application Guide

Surface Preparation

Pre-Prime 167 Sealer is designed for less than ideal surface preparation. However, performance will be improved as surface preparation improves. All oil/grease contaminants, loose rust, loose scale and unsecured old paint must be removed.

Best performance will be obtained by treating all surfaces with Devprep® 88 Cleaner, followed by a high pressure water wash before applying Pre-Prime 167 Sealer.

Mixing and Thinning

Pre-Prime 167 Sealer is a two component product supplied in 4 Gallon and 1 Gallon kits which contain the proper ratio of ingredients. The entire contents of each container must be mixed together.

Add the convertor portion to the base portion slowly with continued agitation. After the convertor add is complete, continue to mix slowly until homogeneous. **Do not thin this material.**

The pot life of the mixed material is 4 hours at 77°F (25°C). Higher temperatures will reduce working life of the coating; lower temperatures will increase it.

Application

Provide good, thorough ventilation.

Apply Pre-Prime 167 Sealer by conventional air spray, brush or roller. Airless spray is not recommended. To minimize overspray, use low air pressure and pot pressure—5 to 10 PSI.

Pre-Prime 167 Sealer is low in viscosity. It should be applied in one thin, wet coat sufficient to completely cover and penetrate to the steel surface. Do not apply heavy coats. Clean up application equipment with Devoe T-10 Thinner.

Apply one coat of Pre-Prime 167 Sealer at 1-1/2 mils—allow overnight cure. An additional coat of Pre-Prime 167 Sealer may be required for very porous surfaces. After overnight cure, Pre-Prime 167 Sealer may be overcoated if still tacky.

Pre-Prime 167 Sealer is normally topcoated with Bar-Rust™ 235 or Bar-Rust 236 Coating. Consult your Devoe Coatings Representative for alternatives.

Precautions

See the material safety data sheet and product label for complete safety and precaution requirements.

167/July, 1988

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Since 1754

DEVOE COATINGS

Marine·Industrial·Offshore

Devran® 184

100% Solids Epoxy Tank Coating

(Formerly Chemfast® 100)

Catalog Number 184-K-XXXX

FEATURES

100% Solids two-component coating

Can be applied with standard heavy-duty airless spray equipment

Devran 184 Coating has a 2 hour pot life

Excellent chemical, solvent and water immersion resistance

Aromatic solvents including xylene, cumene and aromatic naphthas

All gasolines including the super unleaded grades*

Methyl tertiary butyl ether

Caustic solutions

Can be applied up to 1/2 inch thick on horizontal surfaces

Approvals

EPA—Potable water tank lining

*Super unleaded gasoline containing methanol or ethanol are not suitable.

RECOMMENDED USES

- Repair of tank bottoms, including water tanks, fuel tanks, selected chemical tanks and ballast tanks.
- Complete tank linings
- Repair of pitted steel surfaces
- Potable water tank lining—no odor or taste problems
- Chemical resistant self-leveling coating for concrete floors and waste troughs
- Sewage and waste treatment plants
- Containment areas

SPECIFICATION DATA

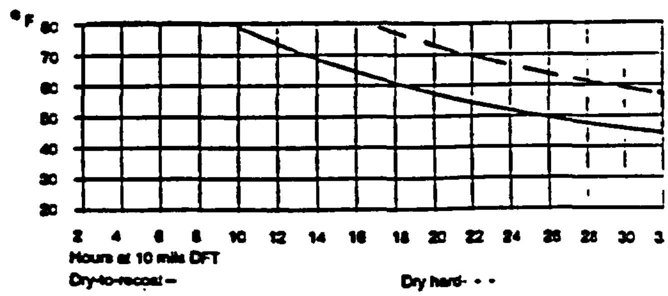
Coating Type	Advanced technology epoxy
Colors	**Catalog Number**
Aluminum Gray	184-K-2000
Oxide Red	184-K-7821
Packaging	4 Gallon two-component kits
Component Ratio	3 to 1 by volume
Gloss	High gloss
Flash Point	200°F (93°C) Setaflash
Thinner	Thinning not recommended
Clean up with Devoe T-10 Thinner	
Pot Life	2 hours at 77°F (25°C)
Shelf Life	More than 1 year
Density	14.8 Lbs/Gal (1.77 kg/l)
VOC	0
Temperature Resistance	250°F (121°C) dry
Volume Solids	100%

Theoretical Spreading Rate
1604 Sq. Ft/Gal at 1 mil
39.3 Sq. m/l at 25 microns

Recommended Film Thickness
8—10 wet mils to obtain 8—10 dry mils
Two coats for tank coatings, plus two stripe coats
Thicker coatings can be applied to horizontal surfaces.

Application	Airless spray

Time—Temperature Drying Curve



The above curve is intended only as a general guideline. Ventilation, film thickness, humidity, thinning and other factors can influence the rate of dry (ASTM D1640).

Application Guide

Surface Preparation

All surfaces must be free of oil, grease salt and moisture before abrasive blasting to near white metal equivalent to Steel Structures Painting Council SP10 or Swedish Standard Sa 2-1/2. The minimum steel profile after blasting should be 2 mils (50 microns) in depth and be of a jagged nature as opposed to a peen pattern. Surfaces must be free of grit dust.

The first coat of the system should be applied to cleaned surfaces as soon as possible to prevent rerusting or contamination.

Ventilation

Although Devran 184 Coating is solventless, good ventilation with dry air is required for the protection of the applicator, to prevent condensation and to obtain proper coating performance. Ventilation should be maintained throughout the cure period. Be sure the air in the lowest areas is constantly replaced with fresh, dry air.

Mixing and Thinning

Devran 184 Coating is a two component product supplied in 4 Gallon kits which contain the proper ratio of ingredients. The entire contents of each container must be mixed together.

Mix the base portion slowly for several minutes. After mixing the base portion, add the convertor slowly with continued agitation. After the convertor add is complete, continue to mix slowly until the system is homogeneous.

Thinning is not normally required. At lower temperatures, efforts should be made to bring the coating to 77°F.

The pot life of the mixed material is 2 hours at 77°F (25°C). Higher temperatures will reduce working life of the coating; lower temperatures will increase it.

Application

Airless spray is recommended. Where airless equipment is used, a 45 to 1 pump and .023" to .029" tip size will provide a good spray pattern. Ideally, fluid hoses should not be less than 3/8" ID and not longer than 50 feet to obtain optimum results.

Devran 184 Coating can also be applied to floors or decks with a spreader or squeegee.

A minimum of four days cure with ventilation at temperatures above 77°F (25°C) should be allowed before tank linings are put into cargo service. Longer curing times with ventilation are required if temperatures are lower than 77°F.

Do not allow coating to remain in the application equipment longer than 2 hours. Flush out all application equipment whenever there is a delay in application.

Precautions

See the material safety data sheet and product label for complete safety and precaution requirements.

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Bar-Rust™ 235

Multi-Purpose Epoxy Coating

(Formerly Chemfast® 547)

Catalog Number 235-K-XXXX

FEATURES

Exceptional Corrosion Protection

Salt and fresh water immersion resistance

Corrosive chemical environments

Lowers The Cost Of Surface Preparation

Grit blasting is not a requirement

Excellent adhesion to tight rust

Good adhesion to damp surfaces

Low Temperature Cure

Cures down to 0°F (-18°C)

Recoats in 3 hours at 70°F (21°C)

Application

Self-priming

Approvals

EPA and AWWA—potable water

Lloyd's—grain cargo

DOD-P-23236A(SH)—for ballast tanks

RECOMMENDED USES

Tank Linings And Pipe Coatings

Ballast and potable water tanks

Bilges, wet voids and drainage pipes

Ships, Offshore And Marine Structures

Above and below-water hull areas

Decks and superstructures

Multi-purpose repair coating

Structural Steel, Equipment And Masonry Surfaces

Pulp and paper mills

Chemical and fertilizer plants

Sewage treatment plants

Storage tanks and pipes

Bridges

Fabrication And New Construction

Speeds up production, even at low temperatures

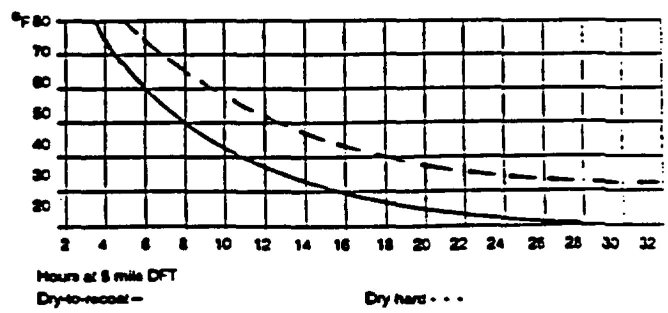
A single multi-purpose, surface-tolerant coating

SPECIFICATION DATA

Coating Type	Advanced technology epoxy
Colors	Catalog Number
Buff	235-K-1642
Haze Gray	235-K-2904
Oxide Red	235-K-7821
Packaging	5 Gallon and 1 Gallon two-component kits
Component Ratio	4 to 1 by volume
Gloss	Semi-gloss
Flash Point	100°F (38°C) Setaflash
Thinner	
For exterior	Devoe T-10 Thinner
For interior	Devoe T-31 Thinner
For potable water	Devoe T-5 Thinner
Pot Life	5 hours at 77°F (25°C)
Induction Time	15 minutes
Shelf Life	More than 2 years
Density (average)	10 Lbs/Gal (1.2 kg/l)
VOC (average)	2.4 Lbs/Gal (287 Grams per liter)

Temperature Resistance	250°F (121°C) dry
Volume Solids	65%
Theoretical Spreading Rate	1043 Sq. Ft/Gal at 1 mil 25.6 Sq. m/l at 25 microns
Recommended Film Thickness	7.7—12.3 wet mils to obtain 5.0—8.0 dry mils
Application	Spray, brush or roller

Time—Temperature Drying Curve



The above curve is intended only as a general guideline. Ventilation, film thickness, humidity, thinning and other factors can influence the rate of dry (ASTM D1640).

Application Guide

Surface Preparation

All direct to metal coatings provide the maximum performance over near white blasted surfaces. There are, however, situations and cost limitations, where grit blasting to near white metal is not possible. Bar-Rust Coatings were designed to provide excellent protection over less than ideal surface preparation.

The surface preparation recommended for Bar-Rust 235 Coating is to include removal of water, salt, dirt, oil, loose rust and all rust scale. The minimum standard for non-immersion service is Steel Structures Painting Council Standard SSPC-SP-2 or Swedish Standard DSt2; for immersion service, the minimum standard is SSPC-SP-3 or Swedish Standard DSt3. Where very rusty surfaces still remain after cleaning for non-immersion service, use Pre-Prime 167 Sealer before application of Bar-Rust 235 Coating.

Mixing and Thinning

Bar-Rust 235 Coating is a two component product supplied in 5 Gallon and 1 Gallon kits which contain the proper ratio of ingredients. The entire contents of each container must be mixed together. Power mix the base portion first to obtain a smooth, homogeneous condition. After mixing the base portion, add the convertor slowly with continued agitation. After the convertor add is complete, continue to mix slowly. Bar-Rust 235 Coating requires a 15 minute induction time.

Thinning is not normally required or desired; however, at lower temperatures, small amounts (10% or less) of the solvents on the reverse page can be added depending on local VOC and air quality regulations. When using Bar-Rust 235 Coating for potable water, use Devoe T-5 Thinner. Any solvent addition should be made after the two components are thoroughly mixed.

The pot life of the mixed material is 5 hours at 77°F (25°C). Higher temperatures will reduce working life of the coating; lower temperatures will increase it.

Ventilation

It is very important for the safety of the applicator and the proper performance of the Bar-Rust 235 Coating that good ventilation be provided to all portions of the enclosed area. It is equally important to bring into the enclosed area dry, fresh air to remove all solvent vapors. Since all solvent vapors are heavier than air, ventilation ducts should reach to the lowest portions of the enclosed areas as well as into any structural pockets. Ventilation should be provided throughout the cure period to insure all the solvents are removed from the coating. For potable water tanks, it is essential that full ventilation be maintained for seven days.

Application

Bar-Rust 235 Coating can be applied by both conventional air spray and airless spray equipment.

For air spray application, a fluid tip of .070" to .086" (DeVilbiss E and D tips) and an air cap with good break-up such as DeVilbiss 704 or 765 will give good results. The fluid pressure should be kept low, with just enough air pressure to get good break-up of the coating. Excessive air pressure can cause overspray problems.

Where airless equipment is used, a 30 to 1 pump and .021" to .025" tip size will provide a good spray pattern. Ideally, fluid hoses should not be less than 3/8" ID and not longer than 50 feet to obtain optimum results.

Bar-Rust 235 Coating may also be applied by brush or roller. Care should be taken that proper and uniform film thicknesses are obtained.

Tank Coating System—Two coats of Bar-Rust 235 Coating at 5 to 8 mils per coat, plus two stripe coats over sharp edges, cutouts and welds. Use contrasting colors for each coat and stripe coat.

Antifouling paints should be applied over Bar-Rust 235 Coating before the Bar-Rust 235 Coating has cured hard.

Precautions

See the material safety data sheet and product label for complete safety and precaution requirements.

235/January, 1990

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CONSULT YOUR DEVOE CATALOG FOR COMPLETE LIST OF OFFICES

Product series number | Product name

7900 Magna-Mastic™

Amido-Amine Epoxy

A two component aluminum maintenance coating for use over marginally prepared steel surfaces. Exhibits excellent chemical and abrasion resistance. Offers high build formulation for reduced application costs. Very low VOC.

Service		Industrial, marine and process environments subject to acids, alkalis, solvents and salts. Topcoat is required for severe exposures. *Dry Temperature Resistance 200°F (93°C)*		
Typical Uses		Maintenance coating for use over marginally prepared surfaces in pulp and paper, chemical and food and beverage plants.		
Color/Gloss	Color	Aluminum-7900		
	Sheen	Semi-Gloss		
Physical Constants	Volume Solids	84.0% ± 2% (ASTM-D-2697)		
	VOC	1.01 lbs/gal (121 g/ltr)		
	Flash Point	Part A, 115°F (46.1°C); Part B, 114°F (45.5°C); Mixed, 121°F (49.4°C) (Seta-flash)		
Application	Recommended Thickness	5.0 mils dry, 6.0 mils wet		
	Theoretical Coverage	(5.0 mils DFT) 269 sq ft/gal		
	Method	Brush, roll or spray.		
	Induction/ Sweat-in Time	15 minutes		
	Thinner	T-5		
	Compatibility	Magna-Mastic™ 7900 may be left as a finish coat or topcoated with epoxy or polyurethane coatings.		
	Typical System	7900/8731		
	Drying Time (hours)	50°F (10°C)	75°F (24°C)	90°F (32°C)
	▪ to touch	7	6	5
	▪ to handle	18	8	6
	▪ to recoat	24	24	6
	Pot Life (hours)	5	4	3
Unit Size		2 Gallon Unit (7.6 ltr)	10 Gallon Unit (37.8 ltr)	
	Part A 7900	1 Gallon	5 Gallon	
	Part B 7900	1 Gallon	5 Gallon	
Unit Shipping Weight		23 lbs (10.4 kg)	114 lbs (51 kg)	
Storage	Shelf Life	One year minimum from date of manufacture when maintained in protected storage at 40-100°F (4-38°C) (subject to reinspection thereafter).		
Regulatory Data	**VOC**	**1.01** lbs/gal (**121** g/ltr) as supplied **1.70** lbs/gal (**204** g/ltr) at maximum recommended thinning		
	USDA	Approved for incidental food contact surfaces in federally inspected meat and poultry plants.		

PRODUCT DATA

Application Instructions

Magna-Mastic™ 7900

Consult Porter International Coatings Specialist for system best suited to enviroment.

Limitations:
Apply in good weather when air and surface temperatures are above 50°F (10°C). Surface temperature must be at least 5°F (3°C) above dew point. For optimum application properties, bring material to 70-80°F (21-27°C) temperature range prior to mixing and application. Unmixed material (in closed containers) should be maintained in protected storage between 40 and 100°F (4-38°C). Material not recommended for immersion service.

Surface Preparation:
Paint only clean, dry surfaces. Remove all grease, oil, dirt or other foreign matter by solvent or detergent washing.

Steel:
For optimum performance apply to blasted steel in accordance to Steel Structures Painting Council No. 6 *"Commercial Blast Cleaning"* (SSPC-SP6). For mild corrosive environments clean in accordance with Steel Structures Painting Council No. 2 *"Hand Tool Cleaning"* (SSPC-SP2), No. 3 *"Power Tool Cleaning"* (SSPC-SP3), No. 7 *"Brush off Blast Cleaning"* (SSPC-SP7) or High Pressure Water Blasting. If a coating remains on the substrate, be sure all gloss has been removed. To check compatibility apply coating to representative area of at least 25 square feet and allow to cure and age several weeks. Then inspect for adhesion failure, wrinkling, lifting, blistering and any other sign of incompatibility. Coating work may proceed if no compatibility problems were encountered.

Mixing:
Material is supplied in 2 containers as a unit. Always mix a complete unit in the proportions supplied. (1) Agitate Part A with a power agitator; (2) Agitate Part B with a power agitator; (3) Combine entire contents of Part A and B and mix thoroughly with a power agitator. Allow the material to set for 15 minutes, then add thinner and thoroughly mix with a power agitator.

Thinning:
Material must be thinned for spray application. Thin ½ pint (237 ml) per gallon with Porter International T-5 thinner. Material may be thinned up to 1 pint (473 ml) per gallon. DO NOT THIN BEYOND YOUR STATE'S COMPLIANCY.

Application:
Apply by conventional or airless spray. Application by other methods, brush or roll, may require more than one coat. Apply 7900 at 6.0 mils (150 microns) wet film thickness will give 5.0 mils (125 microns) dry film thickness.

Equipment:
Brush: inexpensive 4" wide commercial brush.
Roller: use the *"All Purpose Roller Cover."*
Conventional Spray: DeVilbiss MBC-510 gun; E tip and 704 air cap; ⅜" ID material hose; double regulated pressure tank with oil and moisture separator.
Airless Spray: minimum 30:1 ratio pump; .017"-.025" (432-635 microns) orifice tip; ⅜" ID Teflon material hose.

Work Stoppages: *(Lunch, Breaks, etc.)*
Do not allow material to remain in hoses. Release pressure from pressure tank and disconnect material hose. Thoroughly flush hose and spray gun with Porter International T-5 Thinner and reconnect to tank. Maintain material in tank under constant low speed agitation, but do not repressurize tank until ready to resume work.

Cleanup:
Clean all equipment immediately after use with Porter International T-5 Thinner or Xylol. Spray equipment requires flushing with either of these solvents. It is good working practice to periodically flush out spray equipment during the course of the working day. Frequency should depend upon amount sprayed, temperature, elapsed time including delay, etc.

Welding:
In the event welding or flame cutting is performed on metal coated with this product, do so in accordance with instructions in ANSI/ASC Z 49.1, *"Safety in Welding and Cutting."* All welded, burned, or otherwise damaged areas should be reprepared to base metal and recoated as specified.

Safety:
Prior to use, consult *"Material Safety Data Sheet"* of this product for detailed information. The following minimum precautions, however, should be observed for any paint:
(1) Take precautions to avoid skin and eye contact (i.e., gloves, face mask, barrier creams, etc.)
(2) Provide adequate ventilation and/or wear appropriate respiratory protection.
(3) If the product comes into contact with the skin, wash thoroughly with lukewarm water and soap or suitable industrial cleaner. If the eyes are contaminated, flush with water (minimum 15 minutes) and obtain medical attention at once.
(4) Observe all precautionary notices on containers.

PI8163 (7/91)

General Offices
400 S. 13th Street
Louisville, KY 40203
502-588-9200

COURTAULDS COATINGS

Product series number Product name

4600 Hythane®

Acrylic Aliphatic Polyurethane

A two component, interior/exterior finish coat for use over properly prepared steel and masonry surfaces. Exhibits excellent abrasion and chemical resistance.

Service

Severe industrial, marine and process environments exposed to acids, alkalis, salts and solvents. Exhibits excellent gloss and color retention in exterior exposures. *Dry Temperature Resistance 200°F (93°C)*

Typical Uses

Gloss topcoat for transportation equipment, handrails, pipe racks, tank exteriors, process vessel exteriors in chemical and petroleum plants, marine environments and pulp and paper mills.

Color/Gloss

Color	White-4610. Black-4602. Also available in Chromascan® II colors. Special colors can be matched to meet customer's specifications. OSHA colors available.
Sheen	Gloss

Physical Constants

Volume Solids	42.9% ±2% (ASTM-D-2697)
VOC	4.09 lbs/gal (490 g/ltr)
Flash Point	Part A, 79°F (26°C); Part B, 93°F (33.9°C); Mixed, 79°F (26°C); (Setaflash)

Application

Recommended Thickness	2.0 mils dry, 4.7 mils wet
Theoretical Coverage	(2.0 mils DFT) 344 sq ft/gal
Method	Brush, roll or spray
Induction/ Sweat-in Time	None
Thinner	5143
Compatibility	Hythane® 4600 is an excellent high gloss finish coat over epoxy primer/intermediate coats.
Typical System	308/4351/4610

Drying Time (hours)	50°F (10°C)	75°F (24°C)	90°F (32°C)
• to touch	2	¾	¼
• to handle	4	2	1
• to recoat	24	12	4
Pot Life (hours)	24	12	4

Unit Size

	1 Gallon Unit (3.8 ltr)	5 Gallon Unit (18.9 ltr)
Part A	1 Gallon (short filled)	5 Gallon Unit (short filled)
Part B 4646	1 Pint (short filled)	½ Gallon

Unit Shipping Weight

1 Gallon Unit	5 Gallon Unit
11 lbs (5 kg)	54 lbs (25 kg)

Storage

Shelf Life: One year minimum from date of manufacture when maintained in protected storage at 40-100°F (4-38°C) (subject to reinspection thereafter).

Regulatory Data

USDA	Approved for incidental food contact surfaces in federally inspected meat and poultry plants.
VOC	4.09 lbs/gal (490 g/ltr) as supplied 4.46 lbs/gal (534 g/ltr) at maximum recommended thinning

Application Instructions

Hythane® 4600

Consult Porter International Coatings Specialist for system best suited to environment.

Limitations:
Apply in good weather when air and surface temperatures are above 35°F (2°C). Surface temperature must be at least 5°F (3°C) above dew point. For optimum application properties, bring material to 70-80°F (21-27°C) temperature range prior to mixing and application. Unmixed material (in closed containers) should be maintained in protected storage between 40 and 100°F (4-38°C).

Surface Preparation:
Paint only clean, dry surfaces. Remove all grease, oil, dirt or other foreign matter by solvent or detergent washing.

Unpainted Surfaces:
Prepare surface and prime, seal, fill or otherwise coat.

Previously Painted Surfaces:
Remove all rust, rust scale, other corrosion products, loose or heavy chalk and loose or scaling paint by *"Hand or Power Tool Cleaning"* (SSPC-SP2 or 3 respectively). Sand or *"Brush Blast"* (SSPC-SP7) any glossy areas until dull. Spot prime bare areas as recommended. To check compatibility apply coating to representative area of at least 25 square feet and allow to cure and age several weeks. Then inspect for adhesion failure, wrinkling, lifting, blistering or any other sign of incompatibility present. Coating work may then proceed.

Tinting:
Consult Chromascan® II Color Card for color availability. Most colors require that containers be slightly short filled to accommodate the addition of colorant. Actual coverage will depend upon amount of colorant added and should be taken into consideration when ordering. Some colors may require more than one coat for complete hiding.

Mixing:
Material is supplied in 2 containers as a unit. Always mix a complete unit in the proportions supplied. (1) Agitate Part A with a power agitator; (2) Combine entire contents of Part A and B and mix thoroughly with a power agitator.

Thinning:
Material is supplied at spray viscosity and normally needs no thinning. If thinning is necessary, thin up to 1 pint (473 ml) per gallon with Porter 5143 thinner. Add thinner under constant agitation. DO NOT THIN BEYOND YOUR STATE'S COMPLIANCY.

Application:
Apply by brush or spray. Apply at 4.7 mils (117.5 microns) which will give 2.0 mils (50 microns) dry film thickness.

Equipment:
Brush: inexpensive 4" wide commercial brush with short hair bristle.
Roller: use the *"All Purpose Roller Cover"*.
Conventional Spray: DeVilbiss MBC-510 gun; E tip 704 air cap; ⅜" ID material hose; double regulated pressure tank with oil and moisture separator.
Airless Spray: minimum 28:1 ratio pump; .013"-.017" orifice tip; ¼" ID Teflon material hose.

Work Stoppages *(Lunch, Breaks, etc):*
Do not allow material to remain in hoses. Release pressure from pressure tank and disconnect material hose. Thoroughly flush hose and spray gun with Porter 5143 thinner and reconnect to tank. Maintain material in tank under constant low speed agitation, but do not repressurize tank until ready to resume work.

Cleanup:
Clean all equipment immediately after use with Porter 5143 Thinner or Ketone solvents. Spray equipment requires flushing with either or these solvents. It is good working practice to periodically flush out spray equipment during the course of the working day. Frequency should depend upon amount sprayed, temperature, elapsed time including delay, etc.

Welding:
In the event welding or flame cutting is performed on metal coated with this product, do so in accordance with instructions in ANSI/ASC Z 49.1, *"Safety in Welding and Cutting."* All welded, burned or otherwise damaged areas should be reprepared to base metal and recoated as specified.

Safety:
Prior to use, consult *"Material Safety Data Sheet"* of this product for detailed information. The following minimum precautions, however, should be observed for any paint:
(1) Take precautions to avoid skin and eye contact (i.e., gloves, face mask, barrier creams, etc.)
(2) Provide adequate ventilation and/or wear appropriate respiratory protection.
(3) If the product comes into contact with the skin, wash thoroughly with lukewarm water and soap or suitable industrial cleaner. If the eyes are contaminated, flush with water (minimum 15 minutes) and obtain medical attention at once.
(4) Since this product contains flammable materials, keep away from heat, sparks and open flames. No smoking should be permitted in the area.
(5) Observe all precautionary notices on containers.

PI8165 (7/91)

General Offices
400 S. 13th Street
Louisville, KY 40203
502-588-9200

COURTAULDS COATINGS

Product series number	Product name
8600	**Hythane® Super**

Aliphatic Polyurethane

A two-component, interior/exterior finish coat for use over properly prepared and primed steel and masonry surfaces. Exhibits excellent abrasion and chemical resistance. Offers high build formulation for reduced application costs. Low VOC.

Service		Severe industrial, marine and process environments exposed to acids, alkalis, salts and solvents. Exhibits excellent gloss and color retention in exterior exposures. *Dry Temperature Resistance 200°F (93°C).*		
Typical Uses		Economical low VOC topcoat for transportation equipment, pipe racks, tank exteriors, process vessel exteriors in chemical and petroleum plants, marine environments and pulp and paper mills.		
Color/Gloss	Color	White-8610. Also available in Chromascan® II colors. Special colors can be matched to meet customer specifications.		
	Sheen	Semi-Gloss		
Physical Constants	Volume Solids	69.9% ±2% (ASTM-D-2697)		
	VOC	2.24 lbs/gal (268 g/ltr)		
	Flash Point	Part A, 97°F (36.1°C); Part B, 90°F (32.2°C); Mixed, 90°F (32.2°C) (Seta-flash)		
Application	Recommended Thickness	4.0 mils dry, 5.7 mils wet.		
	Theoretical Coverage	(4.0 mils DFT) 280 sq ft/gal		
	Method	Brush or spray		
	Induction/ Sweat-in Time	None		
	Thinner	T-24		
	Compatibility	Hythane® Super 8600 is an excellent high build finish coat over epoxy primer/intermediate coats.		
	Typical System	308/7500/8610		
	Drying Time (hours)	50°F (10°C)	75°F (24°C)	90°F (32°C)
	■ to touch	4	2	1
	■ to handle	10	6	4
	■ to recoat	16	12	8
	Pot Life (hours)	16	6	3
Unit Size		1 Gallon Unit (3.8 ltr)	5 Gallon Unit (18.9 ltr)	
	Part A	1 Gallon (short-filled)	5 Gallon (short-filled)	
	Part B 8646B	½ Gallon (short-filled)	2 Gallon (short-filled)	
Unit Shipping Weight		16 lbs (7.2 kg)	77 lbs. (35 kg)	
Storage	Shelf Life	One year minimum from date of manufacture when maintained in protected storage at 40-100°F (4-38°C) (subject to reinspection thereafter).		
Regulatory Data	**VOC**	**2.24** lbs/gal (**268** g/ltr) as supplied **2.87** lbs/gal (**334** g/ltr) at maximum recommended thinning.		
	USDA	Approved for incidental food contact surfaces in federally inspected meat and poultry plants.		

Application Instructions

Hythane®
Super
8600

Consult Porter International Coatings Specialist for system best suited to environment.

Limitations:
Apply in good weather when air and surface temperatures are above 35°F (2°C). Surface temperature must be at least 5°F (3°C) above dew point. For optimum application properties, bring material to 70-80°F (21-27°C) temperature range prior to mixing and application. Unmixed material (in closed containers) should be maintained in protected storage between 40 and 100°F (4-38°C).

Surface Preparation:
Paint only clean, dry surfaces. Remove all grease, oil, dirt or other foreign matter by solvent or detergent washing.

Unpainted Surfaces:
Prepare surface and prime, seal, fill or otherwise coat.

Previously Painted Surfaces:
Remove all rust, rust scale, other corrosion products, loose or heavy chalk and loose or scaling paint by *"Hand or Power Tool Cleaning"* (SSPC-SP2 or 3 respectively). *"Sweep"* or *"Brush Blast"* (SSPC-SP7) any glossy areas until dull. Spot prime bare areas as recommended. To check compatibility apply coating to representative area of at least 25 square feet and allow to cure and age several weeks. Then inspect for adhesion failure, wrinkling, lifting, blistering or any other sign of incompatibility present. Coating work may then proceed.

Tinting:
Consult Chromascan® II Color Card for color availability. Most colors require that containers be slightly short filled to accommodate the addition of colorant. Actual coverage will depend upon amount of colorant added and should be taken into consideration when ordering. Some colors may require more than one coat for complete hiding.

Mixing:
Material is supplied in 2 containers as a unit. Always mix a complete unit in the proportions supplied. (1) Agitate Part A with a power agitator; (2) Combine entire contents of Part A and B and mix thoroughly with a power agitator.

Thinning:
Material should be thinned for airless spray application. Thin ½ pint (237 ml) per gallon. Material may be thinned up to 1 pint (473 ml) per gallon. Use Porter International's T-24 thinner. DO NOT THIN BEYOND YOUR STATE'S COMPLIANCY.

Application:
Apply by spray. Apply at 5.7 mils (145 microns) wet film thickness which will give 4.0 mils (100 microns) dry film thickness.

Equipment:
Brush: good quality 4" wide brush with short hair bristle (touch up only).
Conventional Spray: DeVilbiss MBC-510 gun; E tip and 704 air cap; ⅜" ID material hose; double regulated pressure tank with oil and moisture separator.
Airless Spray: minimum 28:1 ratio pump; .013"-.021" (330-533 microns) orifice tip; ¼" ID Teflon material hose.

Work Stoppages *(Lunch, Breaks, etc):*
Do not allow material to remain in hoses. Release pressure from pressure tank and disconnect material hose. Thoroughly flush hose and spray gun with Porter International's T-24 thinner and reconnect to tank. Maintain material in tank under constant low speed agitation, but do not repressurize tank until ready to resume work.

Cleanup:
Clean all equipment immediately after use with Porter International's T-24 thinner or Ketone solvents. Spray equipment requires flushing with either of these solvents. It is good working practice to periodically flush out spray equipment during the course of the working day. Frequency should depend upon amount sprayed, temperature, elapsed time including delay, etc.

Welding:
In the event welding or flame cutting is performed on metal coated with this product, do so in accordance with instructions in ANSI/ASC Z 49.1, *"Safety in Welding and Cutting."* All welded, burned, or otherwise damaged areas should be reprepared to base metal and recoated as specified.

Safety:
Prior to use, consult *"Material Safety Data Sheet"* of this product for detailed information. The following minimum precautions, however, should be observed for any paint:
(1) Take precautions to avoid skin and eye contact (i.e., gloves, face mask, barrier creams, etc.)
(2) Provide adequate ventilation and/or wear appropriate respiratory protection.
(3) If the product comes into contact with the skin, wash thoroughly with lukewarm water and soap or suitable industrial cleaner. If the eyes are contaminated, flush with water (minimum 15 minutes) and obtain medical attention at once.
(4) Since this product contains flammable materials, keep away from heat, sparks and open flames. No smoking should be permitted in the area.
(5) Observe all precautionary notices on containers.

PI8186 (7/91)

General Offices
400 S. 13th Street
Louisville, KY 40203
502-588-9200

COURTAULDS COATINGS

Product series number | Product name

770 Interplus® 770

Polyamide Epoxy

A two component, surface tolerant, high build polyamide cured epoxy with semi-gloss finish. Exhibits excellent chemical and abrasion resistance. High build. Low VOC. Accepts a variety of topcoats.

Service

Industrial, marine and process environments subject to acids, alkalis, solvents and salts. *Dry Temperature Resistance 225°F (107°C)*

Typical Uses

Single coat* system for application to hand-prepared surfaces and aged coatings. For use on steel surfaces where is not possible to abrasive blast. May be applied to most tightly adhered coatings systems and to hand-prepared steel.

Color/Gloss	Color	Off-white-EPA780. Available in a limited color range.		
	Sheen	Semi-Gloss		
Physical Constants	Volume Solids	73.1% ±2% (ASTM-D-2697)		
	VOC	1.85 lbs/gal (221 g/ltr)		
	Flash Point	Part A, 85°F (29.5°C); Part B, 115°F (46°C); Mixed, 98°F (37°C) (Seta-flash)		
Application	Recommended Thickness	5.0 mils dry, 6.9 mils wet. *See Application section on back.		
	Theoretical Coverage	(5.0 mils dry) 234 sq. ft/gal		
	Method	Brush, roll or spray.		
	Induction/ Sweat-in Time	15 minutes		
	Thinner	T-44		
	Compatibility	Accepts a wide range of topcoats.		
	Typical System	Interplus®/Interthane® PC		
	Drying Time (hours)	50°F (10°C)	75°F (24°C)	90°F (32°C)
	■ to touch	12	8	6
	■ to handle	48	16	12
	■ to recoat	36	16	12
	Pot Life (hours)	6	4	2
Unit Size		1 Gallon Unit (3.8 ltr)	5 Gallon Unit (18.9 ltr)	
	Part A	1 Gallon (short-filled)	5 Gallon (short-filled)	
	Part B EPA100	1 Quart (short-filled)	1 Gallon (short-filled)	
Unit Shipping Weight		15 lbs (6.8 kg)	67 lbs (30.5 kg)	
Storage	Shelf Life	One year minimum from date of manufacture when maintained in protected storage at 40-100°F (4-38°C) (subject to reinspection thereafter).		

Regulatory Data	**VOC**	**1.85** lbs/gal (**221** g/ltr) as supplied **2.46** lbs/gal (**295** g/ltr) at maximum recommend thinning.

Application Instructions

Interplus®
770

Consult Porter International Coatings Specialist for system best suited to environment.

Limitations:
Apply in good weather when air and surface temperatures are above 50°F (10°C). Surface temperature must be at least 5°F (3°C) above dew point. For optimum application properties, bring material to 70-80°F (21-27°C) temperature range prior to mixing and application. Unmixed material (in closed containers) should be maintained in protected storage between 40 and 100°F (4-38°C). Material not recommended for immersion service.

Surface Preparation:
Paint only clean, dry surfaces. Remove all grease, oil, dirt or other foreign matter by solvent or detergent washing (SSPC-SP1).

Steel:
For optimum performance apply to blased steel in accordance to *"Commercial Blast Cleaning"* (SSPC-SP6). For mild corrosive environments clean in accordance with Steel Structures Painting Council No. 2 *"Hand Tool Cleaning"* (SSPC-SP2), No. 3 *"Power Tool Cleaning"* (SSPC-SP3), No. 7 *"Brush-Off Blast Cleaning"* (SSPC-SP7) or High Pressure Water Blasting. If a coating remains on the substrate, be sure all gloss has been removed. To check compatibility apply coating to representative area of at least 25 square feet and allow to cure and age several weeks. Then inspect for adhesion failure, wrinkling, lifting, blistering and any other sign of incompatibility. Coating work may proceed if no compatibility problems were encountered.

Mixing:
Material is supplied in 2 containers as a unit. Always mix a complete unit in the proportions supplied. (1) Agitate Part A with a power agitator; (2) Agitate Part B with a power agitator; (3) Combine entire contents of Part A and B and mix thoroughly with a power agitator. Allow the material to set for 15 minutes, then add thinner and thoroughly mix with a power agitator.

Thinning:
Material must be thinned for spray application. Thin ½ pint (237 ml) per gallon with Porter International's T-44 thinner. Material may be thinned up to 1 pint (473 ml) per gallon. DO NOT THIN BEYOND YOUR STATE'S COMPLIANCY.

Application:
Apply by conventional or airless spray. Application by other methods, brush or roll, may require more than one coat. Apply Interplus® 770 in accordance with the following recommended thickness schedule: apply at 6.9 mils wet/5.0 mils dry when topcoating; apply at 4.0 mils wet/3.0 mils dry as a tie-coat over tightly adhering coatings; or apply at 11.0 mils wet/8.0 mils dry for a single coat application.

Equipment:
Brush: inexpensive 4" wide commercial brush.
Roller: use the *"All Purpose Roller Cover"*.
Conventional Spray: DeVilbiss MBC-510 gun; E tip 704 air cap; ⅜" ID material hose; double regulated pressure tank with oil and moisture separator.
Airless Spray: minimum 30:1 ratio pump; .021"-.027" (533-686 microns) orifice tip; ⅜" ID Teflon material hose.

Work Stoppages: *(Lunch, Breaks, etc.)*
Do not allow material to remain in hoses. Release pressure from pressure tank and disconnect material hose. Thoroughly flush hose and spray gun with Porter International's T-44 thinner and reconnect to tank. Maintain material in tank under constant low speed agitation, but do not repressurize tank until ready to resume work.

Cleanup:
Clean all equipment immediately after use with Porter International's T-44 thinner. Spray equipment requires flushing with either of these solvents. It is good working practice to periodically flush out spray equipment during the course of the working day. Frequency should depend upon amount sprayed, temperature, elapsed time including delay, etc.

Welding:
In the event welding or flame cutting is performed on metal coated with this product, do so in accordance with instructions in ANSI/ASC Z 49.1, *"Safety in Welding and Cutting."* All welded, burned, or otherwise damaged areas should be reprepared to base metal and recoated as specified.

Safety:
Prior to use, consult *"Material Safety Data Sheet"* of this product for detailed information. The following minimum precautions, however, should be observed for any paint:
(1) Take precautions to avoid skin and eye contact (i.e., gloves, face mask, barrier creams, etc.)
(2) Provide adequate ventilation and/or wear appropriate respiratory protection.
(3) If the product comes into contact with the skin, wash thoroughly with lukewarm water and soap or suitable industrial cleaner. If the eyes are contaminated, flush with water (minimum 15 minutes) and obtain medical attention at once.
(4) Since this product contains flammable materials, keep away from heat, sparks and open flames. No smoking should be permitted in the area.
(5) Observe all precautionary notices on containers.

PI8160 (7/91)

General Offices
400 S. 13th Street
Louisville, KY 40203
502-588-9200

COURTAULDS COATINGS

KEELER & LONG INC.

WESTERN OFFICE:
P. O. Box 964
Solana Beach, CA 92075
Tel (619) 481-3777
Fax (619) 481-3236

HEADQUARTERS:
P. O. Box 460
856 Echo Lake Road
Watertown, CT 06795
Tel (203) 274-6701
Fax (203) 274-5857

AQUA-KOLOR PRIMER
No. 9400 SERIES

GENERIC TYPE: LATEX ACRYLIC

PRODUCT DESCRIPTION: A single component, rapid-drying, latex emulsion primer formulated to produce a tough adhering film when applied over properly prepared substrates.

RECOMMENDED USES: As a primer for properly prepared carbon steel, galvanized, or zinc primed surfaces in normal and most chemical environments.

NOT RECOMMENDED FOR: Immersion service; strong acid or alkali environments.

COMPATIBLE TOPCOATS:
Aqua-Kolor Gold Primer
Aqua-Kolor Enamels
Poly-Silicone Enamels
Tri-Polar Silicone Enamels
Kolor-Sil Enamels
Hydro-Sil Enamels

PRODUCT CHARACTERISTICS:

Solids by Volume:	35% ± 3%
Solids by Weight:	51% ± 3%
Recommended Dry Film Thickness:	2.0-3.0 mils
Theoretical Coverage:	280 Sq. Ft./Gallon @ 2.0 mils DFT
Finish:	Flat
Available Colors:	White (9400) and Black (9402)
Drying Time @ 72°F	
To Touch:	30 Minutes
To Handle:	60 Minutes
To Recoat:	60 Minutes
VOC Content:	2.15 Pounds/Gallon 258 Grams/Liter

June, 1990

TECHNICAL BULLETIN

No. 9400 L.130

TECHNICAL DATA

PHYSICAL DATA:	Weight per gallon:	10.8 ± 0.5 (pounds)
	Flash Point (Pensky-Martens):	NA
	Shelf Life:	1 Year
	Temperature Resistance:	250°F
	Viscosity @ 77°F:	100 ± 3 (Krebs Units)
	Gloss (60° meter):	8.7 ± 5
	Storage Temperature:	45 - 90°F
APPLICATION DATA:	Application Procedure Guide:	APG-1
	Wet Film Thickness Range:	5.5 - 8.5 mils
	Dry Film Thickness Range:	2.0 - 3.0 mils
	Temperature Range:	250°F
	Relative Humidity:	85% Maximum
	Substrate Temperature:	Dew Point + 5°F
	Minimum Surface Preparation:	SSPC-SP3,SP6,SP7
	Recommended Solvent:	Water

Application Methods

Air Spray	
Tip Size:	.051"
Pressure:	40 - 60 PSIG
Thin:	0.5 - 1.5 Pts/Gal
Airless Spray	
Tip Size:	.015" - .021"
Pressure:	2000 - 2500 PSIG
Thin:	0.0 - 1.0 Pt/Gal
Brush or Roller	
Thin:	0.5 - 1.5 Pts/Gal

KEELER & LONG INC.
P. O. Box 460, 856 Echo Lake Road
Watertown, CT 06795
Tel: (203) 274-6701 Fax: (203) 274-5857

KOLORS

SSPC SUSTAINING MEMBER

E.350

KEELER & LONG INC.

WESTERN OFFICE:
P. O. Box 964
Solana Beach, CA 92075
Tel (619) 481-3777
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HEADQUARTERS:
P. O. Box 460
856 Echo Lake Road
Watertown, CT 06795
Tel (203) 274-6701
Fax (203) 274-5857

HYDRO-POXY ENAMEL
H-SERIES

GENERIC TYPE: WATER BASED EPOXY

PRODUCT DESCRIPTION: A water miscible, two component polyamide type epoxy enamel displaying many of the desirable properties of solvent type epoxies. It exhibits moderate chemical resistance, and a tough abrasion resistant film with a sharp, glossy appearance.

RECOMMENDED USES: As a topcoat for interior steel or concrete surfaces. May be applied over most other generic types in order to improve the chemical resistance, and/or the abrasion resistance, and/or the decontaminability of the coating system.

NOT RECOMMENDED FOR: Exterior exposures; exposure to splash or spillage of strong acids, alkalies or solvents.

COMPATIBLE UNDERCOATS:

Kolor-Poxy Primers and Enamels
Hydro-Poxy Surfacer
Hydro-Poxy White Primer
Tri-Polar Primers and Enamels
Aqua-Kolor Primers and Enamels

Poly-Silicone Enamels	Kolor-Sil Enamels
Kolor-Nine Primers	Vinyl-Latex

PRODUCT CHARACTERISTICS:

Solids by Volume:	39% ± 3%
Solids by Weight:	51% ± 3%
Recommended Dry Film Thickness:	2.0 - 3.0 mils
Theoretical Coverage:	310 Sq. Ft./Gallon @ 2.0 mils DFT
Finish:	Full Gloss (H-1), Semi-Gloss (H-2)
Available Colors:	Limited
Drying Time @ 72°F	
To Touch:	8 Hours
To Handle:	12 Hours
To Recoat:	24 Hours
VOC Content:	1.5 Pound/Gallon 180 Grams/Liter

April, 1991

TECHNICAL BULLETIN

TECHNICAL DATA

PHYSICAL DATA:

Weight per gallon:	10.5 ± 0.5 (pounds)
Flash Point (Pensky-Martens):	>200°F
Shelf Life:	1 Year
Pot Life @ 72°F:	9 Hours
Temperature Resistance:	300°F
Viscosity @ 77°F:	85 ± 5 (Krebs Units)
Gloss (60° meter):	95 ± 5 (H-1)
Storage Temperature:	55 - 95°F
Mixing Ratio (Approx. by Volume):	4:1

APPLICATION DATA:

Application Procedure Guide:	APG-4
Wet Film Thickness Range:	5.0 - 7.5 mils
Dry Film Thickness Range:	2.0 - 3.0 mils
Temperature Range:	55 - 120°F
Relative Humidity:	85% Maximum
Substrate Temperature:	Dew Point + 5°F
Minimum Surface Preparation:	See APG-4
Induction Time @ 72°F:	None
Recommended Solvent:	No. 0900

Application Methods

Air Spray	
Tip Size:	.055" - .073"
Pressure:	30 - 60 PSIG
Thin:	1.0 - 2.0 Pts/Gal
Airless Spray	
Tip Size:	.011" - .017"
Pressure:	2500 - 3000 PSIG
Thin:	0.0 - 1.0 Pt/Gal
Brush or Roller	
Thin:	1.0 - 2.0 Pts/Gal

KEELER & LONG INC.
P. O. Box 460, 856 Echo Lake Road
Watertown, CT 06795
Tel: (203) 274-6701 Fax: (203) 274-5857

KOLORS

SSPC SUSTAINING MEMBER

Modifications to Formula PB-201

1. Delete Cobalt Drier ASTM D600, Class B.
2. Provide one quart pigmented white.
3. Provide one quart pigmented light gray.

STATE OF CALIFORNIA

Specification

Red Primer, High Solids Phenolic Type
(Formula PB-201)

Description:

This specification covers a red, ready-mixed, air-drying, high solids, corrosion resistant, phenolic resin/tung oil primer. This coating is intended for spray application to blast-cleaned steel surfaces exposed to the air. Limited application can be made by brushing or rolling.

Composition:

			Pounds/100 gallons
PIGMENT			
Magnesium Silicate	(1*)		194
Zinc Phosphate	(2*)		171
Red Iron Oxide	(3*)		190
Silica	(4*)		3
VEHICLE			
Phenolic Resin/Tung Oil Varnish	(5*)		512
Aliphatic Thinner TT-T-291F, Type I			82
Xylene ASTM D846			3
Zirconium Drier ASTM D600, Class A		6%	4.9
Cobalt Drier ASTM D600, Class B		6%	2.5
Calcium Drier ASTM D600, Class B		5%	1.9
Anti-skinning Agent, Oxime Type			4.7

Characteristics:

Weight per gallon, pounds, ASTM D1475	11.6-11.8
Pigment by weight of paint, percent, ASTM D2371	47-49
Nonvolatile content, percent, ASTM D2369, Procedure B	80.0-82.5
Nonvolatile content, volume percent	66.5-68.0
Fineness of grind, Hegman, ASTM D1210	4-5
Consistency, Krebs Units, ASTM D562	76-86
Drying time at 77°F. 50% RH, 3 mil wet film, ASTM D1640	
Set to touch, hours	2.5 max.
Through dry, hours	8 max.

Color to essentially match Color Chip No. 197 on file at the Transportation Laboratory.

(1*) Magnesium Silicate, platey shape, specific gravity 2.7 +/- 0.1, oil absorption 50 +/- 3, pH 8.8 +/- .3, Hegman fineness +6.0, 100% passing 325 mesh screen, CaO content 0.5% max., water soluble matter 1.0% max.

Specification PB-201
Red Primer, High Solids Phenolic Type

(2*) Essentially $Zn_3(PO_4)_2 \cdot 2H_2O$, specific gravity 3.2 +/- .1, *oil absorption 22 +/- 3, average particle size less than 10 microns, water soluble matter 0.2% maximum.

(3*) Synthetic Red Iron Oxide, spheroidal particle shape, Fe_2O_3 98% minimum, *oil absorption 18 +/- 2, specific gravity 5.2 +/- 0.1, 99.9% passing 325 mesh screen, water soluble matter 0.15% maximum.

(4*) Precipitated hydrophobic silica, surface area N_2 B.E.T. 120 +/- 15 m^2/g, mean particle diameter 3 microns, drying loss at 150°C 1-2%, ignition loss (2 hours at 1000°C) 5-6%, SiO_2 content 98% minimum based on substance ignited for two hours at 1000°C.

(5*) Phenolic resin/tung oil varnish shall be a 75% non-volatile solution composed of the following:

	Lbs
Union Carbide CK-2500 Resin	125
Aliphatic Thinner TT-T-291F, Type I	108
Xylene ASTM D846	19
Tung Oil ASTM D12	260

Dissolve CK-2500 in xylene and aliphatic thinner. Add tung oil slowly while stirring.

*Oil absorption values determined according to ASTM D281.

Prax – Ten™

Penetrant – Sealer

"Modified Sulfonate Barrier Coatings For Corroding Metals"

PRODUCT BULLETIN

Description

Prax-Ten™ corrosion preventative coatings employ the same modified-overbased sulfonate technology which has been employed in the automotive industry for the past twenty years. Prax-Ten's unique chemical structure provides a material which forms strong, chemical bonds to metallic surfaces. The resultant coating actually shields the metal from the air and moisture necessary for corrosion to occur.

The base of our coating system is far more polar than water. As a result, Prax-Ten can be applied to wet, metallic surfaces. In fact, it can be applied to rusted surfaces as well, with extremely good adhesion to the substrate. A series of 'scalar like' platelets provide a continuous barrier against water and oxygen penetration, which are mandatory for the corrosion process to occur. These platelets allow for far more moisture vapor transmission resistance than conventional coatings.. and . . . they won't peel or chip.

Another quality inherent in the product line is the ability to remain flexible over time. With the normal expansion and contraction forces that develop with changes in temperature, metals demand a coating that can expand and contract with them. Conventional coatings become brittle and, as they age, they can't keep up with this constant change. These membrane type coatings crack and allow paths for moisture to attack the surface eventually causing blistering & chipping. The Prax-Ten material surpasses all conventional coatings in underpinning tests with less than 10% of the creep experienced by conventional systems.

Maybe you've tried sulfonate coatings before – before Praxis modified, hardened and made them more resilient than ever. Hardness is no longer sacrificed for adhesion to the metallic substrate. Why not have a Praxis representative discuss your corrosion problem today! For more information contact Praxis at 215-860-5240.

Applications

Several of the characteristics of Prax-Ten translate directly into $$$$$$$$$ saved.

- high solids content – 70% by weight on the Sealer 50% by weight on the Penetrant for high build protection with a hard, 'wax-like' finish.

- along with the high solids comes low volatiles. This provides for an environmentally safe, non-toxic application that meets the latest EPA, OSHA, Navy and Caltrans specs for volatility requirements.

- finished surface! . . . . our coatings are not rust converters! The material offers a hard, color pigmented to spec, finish. Any existing surface rust is encapsulated in an inert matrix.

- it's easy to apply. . . . no messy field mixing is required. In fact, our material probably won't even have to be stirred prior to field use. Our plant mixing is generally sufficient for quite some time. And, unlike the epoxies you don't have to waste what you don't use. . . just replace the lid and store. Sprayed or brushed on. . . Prax-Ten offers beautiful finishes with little effort!

- cleanup is easy as well. . . . uncured material breaks down with conventional solvents.

Custom Solutions

At Praxis, we're customer driven. We specialize in customizing our products to meet your particular needs. Of course, we don't have the answer to all of your corrosion problems. If you're using rust converters that just won't perform to your specifications or if you're just plain tired of conventional systems that require too much work for too little performance, then why not give Prax-Ten a try. Let a Praxis representative review your corrosion problems today!

Typical Physical Properties

	Sealer	Penetrant
Non Volatile (by weight)	70%	50%
Flash Point (PMCC)	40.5°C	40.5°C
Brookfield Viscosity, #6 spindle 10RPM, 25°C	10,000 cps	1,000 cps
pH	slightly alkaline	slightly alkaline
Appearance	dispersion	dispersion
Specific Gravity	.983	.975
Color (dries clear–pigmenting available)	tan	tan

Typical Performance Characteristics

	Sealer
• Salt Spray Resistance, ASTMB-117	
@ 3 mil DFT	700+ hours
@ 5 mil DFT	1700+ hours
• Salt Spray Resistance, Scribed @ 3.5 DFT (after 2000 hour exposure)	0-2 mm creep
• Humidity Resistance	
@ 3 mil DFT	1000 hours
@ 5 mil DFT	2000 hours
• Ultra-Violet Resistance (QUV cabinet) (un-pigmented)*	
@ 3 mil DFT	400 hours
@ 5 mil DFT	800 hours

* Color pigmenting greatly increases life of product with respect to the UV characteristics. Full range of colors available.

Safety / Handling

Volatile Components:

Hydro-treated light petroleum distillate, CAS #64742-47-89
(commonly referred to as mineral spirits)

- eye protection should be worn during application
- use in ventilated areas
- skin contact - wash with soap and water
- eye contact – continuously flush for 15 minutes; call physician
- extinguish with commercially available extinguisher

KEELER & LONG INC.

WESTERN OFFICE:
P. O. Box 864
Solana Beach, CA 92075
Tel (619) 481-3777
Fax (619) 481-3236

HEADQUARTERS:
P. O. Box 460
856 Echo Lake Road
Watertown, CT 06795
Tel (203) 274-6701
Fax (203) 274-5857

KOLORMASTIC II
No. 1800

GENERIC TYPE: POLYAMINE EPOXY

PRODUCT DESCRIPTION: A high solids, two component, aluminum pigmented polyamine epoxy coating that is resistant to splash or spillage of alkalies, acids, fresh and salt water, and most solvents.

RECOMMENDED USES: May be used for the painting or repainting of most steel surfaces, such as structural steel, tanks, bridges and piping.

NOT RECOMMENDED FOR: Immersion service in strong acids or alkalies.

COMPATIBLE TOPCOATS:
Kolor-Poxy Hi-Build Enamels
Kolor-Poxy Enamels
Kolorane Enamels
Acrythane Enamels
Anodic Self-Priming Paints
Poly-Silicone Enamels
Acite Hi-Build Enamels

PRODUCT CHARACTERISTICS:

Solids by Volume:	90% ± 3%
Solids by Weight:	94% ± 3%
Recommended Dry Film Thickness:	5.0 - 12.0 mils
Theoretical Coverage:	180 Sq. Ft./Gallon @ 8.0 mils DFT
Finish:	Eggshell
Available Colors:	Metallic Aluminum
Drying Time @ 72°F	
To Touch:	8 Hours
To Handle:	16 Hours
To Recoat:	24 Hours
VOC Content:	.74 Pounds/Gallon 88.4 Grams/Liter

Post-it™ brand fax transmittal memo 7671 | # of pages ▸ 2

To Tom Friderichs	From Curt Hickcox
Co. MPE	Co. Keeler + Long
Dept.	Phone #
Fax # 209-659-0358	Fax # 203-274-5857

December, 1990

TECHNICAL BULLETIN

TECHNICAL DATA

PHYSICAL DATA:

Weight per gallon:	13.3 ± 0.5 (pounds)
Flash Point (Pensky-Martens):	103°F ± 3°
Shelf Life:	2 Years
Pot Life @ 72°F:	4 Hours
Temperature Resistance:	200°F
Viscosity @ 77°F:	118 ± 5 (Krebs Units)
Gloss (60° meter):	20 ± 5
Storage Temperature:	50 - 85°F
Mixing Ratio (Approx. by Volume):	4:1

APPLICATION DATA:

Application Procedure Guide:	APG-8
Wet Film Thickness Range:	5.6 - 13.5 mils
Dry Film Thickness Range:	5.0 - 12.0 mils
Temperature Range:	50 - 95°F (see APG-8)
Relative Humidity:	80% Maximum
Substrate Temperature:	Dew Point + 5°F
Minimum Surface Preparation:	SSPC-SP2,SP3,SP6,SP7
Induction Time @ 72°F:	None
Recommended Solvent	
@ 50 - 85°F:	No. 3700
@ 86 - 95°F:	No. 2200

Application Methods

Air Spray	
Tip Size:	.073" - .086"
Pressure:	30 - 60 PSIG
Thin:	1.0 Qt/Gal (Maximum)
Airless Spray	
Tip Size:	.021" - .031"
Pressure:	2500 - 4000 PSIG
Thin:	1.0 Qt/Gal (Maximum)
Brush or Roller	
Thin:	1.0 Qt/Gal (Maximum)

KEELER & LONG INC.
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Kolors

SSPC
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Appendix B

COATING VENDOR CORRESPONDENCE FROM 1990 FEASIBILITY STUDY

The following letters and technical literature were received from coating vendors in response to a coating specification issued by MPR in late 1990. That specification called for coatings that could be spray applied to the drywell surface during plant operation. The drywell surface temperature was taken to be 130°F as an upper bound. Correspondence was received from the following vendors.

1. Carboline
2. Devoe
3. Martek
4. Three-E Group
5. Praxis
6. Specialties Engineering Corporation

RPM CARBOLINE COMPANY

January 21, 1991

Tom Fridericks
MPR Associates, Inc.
1050 Connecticut Ave. N.W.
Washington, D.C. 20036

Dear Tom:

In regards to your recent request for coating system recommendations for the Oyster Creek Drywell application, I am proposing Carboline's 801 epoxy (Preferably 801 aluminum). Carboline 801 will be compatible with intact rust and coating residue that might be present on the drywell surface after surface preparation steps are completed; the coating can be applied to the anticipated 135°F surface and can handle the exposure to the expected continuous operating temperatures; and it is appropriate for the potential chemical conditions outlined in Table 3-1.

Since the desired mode of application is by remote spray equipment and subsequent video inspection, I recommend a minimum of two coats (three coats would provide better assurance) to achieve a minimum of 10 mils. At the expected operating surface temperatures, an intercoat cure time of 1 hour will be required.

A performance life of twenty years is reasonable considering periodic inspection and maintenance at five year intervals.

Enclosed is a Carboline Nuclear Binder which outlines Carboline products for the nuclear industry. Inside the front cover, I have included a nuclear coating test data outline for 801, a product data sheet, and a material safety data sheet.

Also attached to this letter is a response to Section 6, "Documentation Requirements for Coating Vendors".

Tom, if you have any questions or if I can assist you in any way please don't hesitate to contact me.

Sincerely,

Jerry Arnold

Jerry Arnold
Nuclear Manager

enclosure
cc: Earl Bowery, John Montle, Tony Franchetti, Stan Drexler
JA/sj

carboline

350 Hanley Industrial Ct. • St. Louis, MO 63144-1599
an RPM company • 314-644-1000

FACSIMILE TRANSMISSION
~~314-644-4617~~
504-734-9120

- ☐ ALPHA
- ☐ HAYWARD
- ☐ ST. LOUIS
- ☐ XENIA
- ☐ IMPERIAL
- ☐ LAKE CHARLES
- ☐ OTHER

Phone # ________

TO: Tom FRIDERICKS

FROM: JERRY ARNOLD

NUMBER OF PAGES: 1

DATE/TIME WRITTEN: 9:30 Am

DOCUMENT NUMBER: ______

DATE/TIME SENT: 2-1-91

Tom,

I have discussed the composition of the TTP-86-C coating on the Oyster Creek drywell with Carboline chemists and it is their opinion that the Carboline 801 would not be compatible over a film of this product. The existing coating should be removed to conform to SSPC-SP-6, "commercial blast", prior to the application of the Carboline 801

Jerry Arnold
Nuclear Mgr
(504-733-3791)

10586

April 15, 1991

TELECON MEMORANDUM

Date:	2/4/91	Project:	Drywell Gap 3 83-144
Person Making Call:	Mr. Mike Heffernan, MPR		
Person Called:	Jerry Arnold, Carbine (handwritten insertion: "ol") (504) 733-3791		
Reason:	Inquire about message left on 2/1 by J. Arnold. "Present coating TCP 86C is not compatible with an epoxy."		

Mr. Arnold explained that the present drywell coating, linseed oil - red lead primer (TCP-86C), is not compatible with a two-part epoxy. That is, if the red lead is not removed, the epoxy would pull on the red lead when it dries, causing delamination of the red lead. He recommends that SP-6 Commercial Blasting be done.

DOCUMENTATION REQUIREMENTS per SECTION 6

	REQUIREMENT	RESPONSE/COMMENTS
1.	Surface Preparation	Minimum SSPC-SP-2. Refer to Product Data Sheet.
2.	Application Requirements	Refer to Product Data Sheet
3.	Temperature Limits	Max. surface temperature of 135°F. Refer to P.D.S.
4.	Relative Humidity	Max. 90%. Refer to Product Data Sheet.
5.	Surface Profile	Not required. Refer to Product Data Sheet.
6.	Ventilation	See attached ventilation recommendations.
7.	Cure Times & Temperatures	Minimum 1 hour at 110°F. Refer to P.D.S.
8.	Repair Methods	Same as initial application.
9.	Inspection Requirements	Check for film thickness and holidays.
10.	Cost	Carboline 890 Aluminum $44.87/gallon
11.	Case Histories	See attached. References provided upon request.
12.	Expected Useful Life	Twenty years with five year inspection & maintenance.
13.	Test Data	Refer to enclosed Test Data summary
14.	Material Safety Data	Refer to enclosed MSDS for 801.

CARBOLINE 801

CASE HISTORIES

1.	Placid Refinery Baton Rouge, LA.	Compressor Station	Freeze-thaw, exterior exposure (4 years)
2.	Big 3 Industries Norco, LA.	Structural Steel	Sweating, exterior exposure - (6 years)
3.	ARMCO Steel [a] Middletown, Ohio	Structural Steel	Acid environment, cooling tower - (3 years)
4.	Champion Paper [b]	Equipment	Chemical exposure (5 years)

NOTES: References

a) Keith Kennedy 513-425-3030

b) Rudy Rutherford 513-868-5549

RECOMMENDED VENTILATION FOR

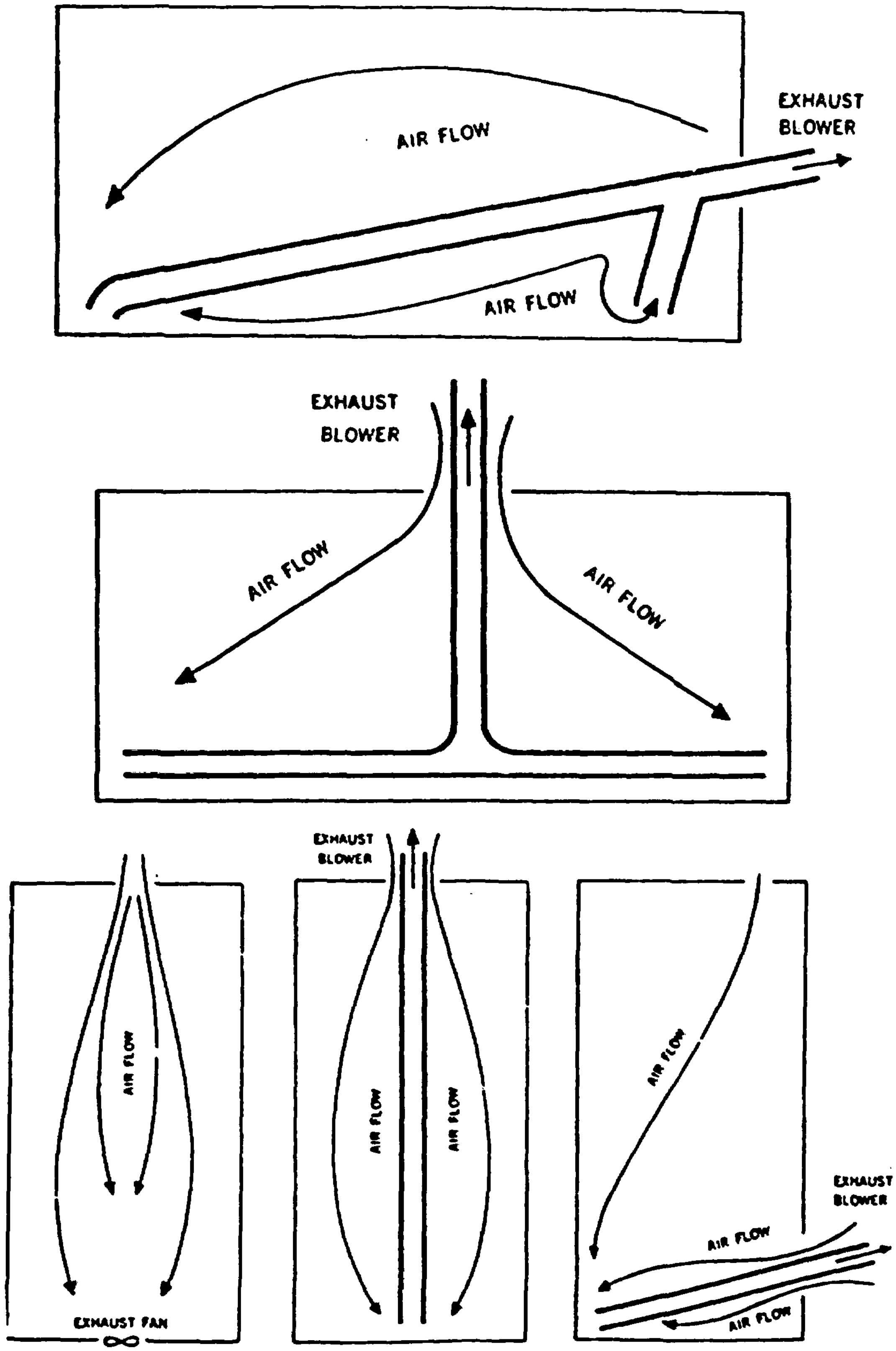
VARIOUS SIZED TANKS

SIZE OF TANK	VOLUME IN CUBIC FEET	CUBIC FEET OF SOLVENT VAPOR TO MAKE 1% BY VOLUME	GALS COATING USED TO MAKE 1% BY VOLUME OF SOLVENT VAPOR IN AIR	AIR CHANGES PER HOUR NEEDED TO KEEP SOLVENT TO 1% BY VOLUME	GALLONS OF COATING SPRAYED IN ONE HOUR	MINUTES REQUIRED TO CHANGE AIR TO KEEP SOLVENT TO 1% BY VOLUME[1]	RECOMMENDED SUCTION FAN TO KEEP THE AIR FAR BELOW ANY EXPLOSIVE LIMIT (CU FT PER MINUTE)	RECOMMENDED CHANGES OF AIR IN MINUTES TO KEEP SOLVENT FUMES FAR BELOW EXPLOSIVE LIMIT
5,000 gals	668	6.7	.26	19.30	5	3	1,000	40 seconds
10,000 gals	1,336	13.4	.52	9.60	5	6	2,000	40 seconds
25,000 gals	3,342	33.4	1.30	3.80	10	8	2,000	1.7 seconds
50,000 gals	6,684	66.8	2.60	3.80	10	16	3,000	2.2 minutes
100,000 gals	13,378	133.6	5.20	1.90	10	31	5,000	2.7 minutes
250,000 gals	33,420	334.2	13.00	0.77	20	40	10,000	3.3 minutes
400,000 gals	53,500	535.0	20.80	0.48	20	62	10,000	5.4 minutes
13,500 bbls	75,800	758.0	29.40	0.34	50	35	25,000	3.0 minutes
27,000 bbls	151,600	1516.0	58.80	0.26	50	70	35,000	4.3 minutes
50,000 bbls	280,000	2800.0	108.30	0.14	50	130	50,000	5.6 minutes

[1] This data is based on a specific coating. To obtain the gallons required of any coating to make 1% by volume of solvent vapor in air: (a) Multiply the percent solvents by volume by the cubic ft. of solvent vapor per gallon. If there is more than 1 solvent multiply the percentage of each by the cubic ft. of vapor per gallon and add them. This will give the cubic ft. of solvent vapor per gallon of coating (b) Divide the cubic ft. of solvent vapor to make 1% by volume by the cubic ft. of solvent vapor per gallon of coating. This will give the gallons of coating required to make 1% by volume of solvent vapor in air.

HOW TO VENTILATE TANKS

Various arrangements of ventilating fan designed to ensure proper circulation of air and removal of combustible or toxic gases.



carboline

350 Hanley Industrial Ct • St. Louis, MO 63144-1599
an RPM company • 314-644-1000

NUCLEAR COATING SYSTEM

SYSTEM	PRODUCT	GENERIC TYPE	DRY FILM THICKNESS	VOLUME SOLIDS	COVERAGE
PRIMER/ TOPCOAT	CARBOLINE 801	EPOXY	6 MILS	76%	203 ft²

<u>DESCRIPTION:</u> A single coat, self-priming epoxy designed for maintenance. Carboline 801 can be applied directly to steel or to existing, intact coatings.

<u>FEATURES</u>	<u>BENEFITS</u>
• Surface tolerant primer	• Can be applied to intact rust or over hand and power tool cleaned surfaces. Reduces surface preparation labor and potential airborne contamination.
• High solids	• VOC compliant, less effect on personnel and charcoal filters.
• Available in Rapid Tint System	• Wide selection of colors with no minimum order restrictions; fast delivery.

TEST DATA

TEST	METHOD	CONDITIONS	RESULTS
DESIGN BASIS ACCIDENT (DBA)	ANSI N101.2 - 1972 ASTM D3911-89	300°F/48 PSIG 3×10^9 RADS	ACCEPTABLE
RADIATION TOLERANCE	ANSI N5.12 - 1974 ASTM D4082-83	1.01×10^9 RADS	ACCEPTABLE
DECONTAMINATION	ANSI N5.12 - 1974 ASTM D4256-83	PER TEST METHOD AND ORNL PROCEDURES	99.92%
CHEMICAL RESISTANCE	ANSI N5.12 - 1974 ASTM D3912-80	5 DAY IMMERSION	ACCEPTABLE EXCEPT FOR NITRIC, SODIUM HYDROXIDE & POTASSIUM PERMANGANATE
TABER ABRASION	ANSI N5.12 - 1974 FED STD 141 METHOD 6192	1000 CYCLES 1000g WEIGHT CS-17 WHEEL	124 mg LOST
ELCOMETER ADHESION	ANSI N5.12 - 1974 ASTM D4541-85	PER TEST METHOD	983 PSI
FIRE EVALUATION	ANSI N101.2 - 1972 ASTM E-84	PER TEST METHOD	FLAME SPREAD 5

carboline

CARBOLINE® 801

VOC PLUS

SELECTION DATA

GENERIC TYPE: Two component, cross-linked epoxy.

GENERAL PROPERTIES: CARBOLINE 801 is a self priming, high build, semi-gloss finish available in a wide variety of colors. Can be applied by spray, brush or roller over hand or power tool cleaned steel and is compatible with most existing coatings and tightly adhered rust. The cured film is tough and abrasion resistant and provides an easily cleanable, esthetic surface. Features include:

- Single coat corrosion protection.
- Good weathering resistance.
- Good flexibility and lower stress upon curing than most epoxy coatings.
- Excellent tolerance of damp (not wet) substrates.
- Can be spray applied up to 8 mils dry in one coat.
- Has a higher flash point than most epoxy coatings (over 110°F, including recommended Carboline Thinner).
- Meets the most stringent VOC (Volatile Organic Content) regulations.

RECOMMENDED USES: Recommended as a general, plant wide, maintenance coating for tanks, structural steel or miscellaneous equipment in industrial environments that include Chemical Processing, Pulp and Paper, Water and Waste Water Treatment and Power Generation among others. May be used as a single coat, shop applied system for new structural steel and equipment that will receive mild chemical exposures. Two coats of CARBOLINE 801 are recommended for use in more severe environments. Consult Carboline Technical Service Department for other specific uses.

NOT RECOMMENDED FOR: Immersion service, splash and spillage of very strong solvents or concentrated acids.

TYPICAL CHEMICAL RESISTANCE:

Exposure	Splash and Spillage	Fumes
Acids	Good	Very Good
Alkalies	Good	Excellent
Solvents	Very Good	Excellent
Salt Solutions	Excellent	Excellent
Water	Excellent	Excellent

TEMPERATURE RESISTANCE:
Continuous: 200°F (93°C)
Non-continuous: 250°F (121°C)

SUBSTRATES: Apply over suitably prepared metal, concrete, or other surfaces as recommended.

COMPATIBLE COATINGS: May be used over most generic types of coatings which are tightly adhering and properly prepared. A test patch is recommended for use over existing coatings. May be topcoated to upgrade weathering resistance. Not recommended over chlorinated rubber or latex coatings. Consult Carboline Technical Service Department for specific recommendations.

SPECIFICATION DATA

THEORETICAL SOLIDS CONTENT OF MIXED MATERIAL:*

	By Volume
CARBOLINE 801	76% ± 2%

VOLATILE ORGANIC CONTENT:*
As Supplied: 1.74 lbs./gal.(208 gm/liter — Color White (S800)
Thinned: The following are nominal values utilizing CARBOLINE Thinner #4.

% Thinned	Fluid Ounces/Gal.	Pounds/ Gallon	Grams/ Liter
6%	8	2.08	250
12%	16	2.37	284
25%	32	2.88	345

*Varies with color

RECOMMENDED DRY FILM THICKNESS PER COAT:
4-6 mils (100-150 microns) for use in mild environments.
6-8 mils (150-200 microns) for use over light tight rust. In more severe environments a second coat of 4-6 mils(100-150 microns) is recommended.

THEORETICAL COVERAGE PER MIXED GALLON:
1219 mil sq. ft. (30.4 sq. m/l at 25 microns)
244 sq. ft. at 5 mils(6.0 sq. m/l at 125 microns)
Mixing and application losses will vary and must be taken into consideration when estimating job requirements.

STORAGE CONDITIONS: Store Indoors.
Temperature: 40-95°F (4-35°C)
Humidity: 0-90%

SHELF LIFE: Twenty-four months minimum when stored at 75°F (24°C).

COLORS: Available in Carboline Color Chart Colors. Metallic aluminum colors are available upon special request. Some colors may require two coats for adequate hiding. Consult your local Carboline representative or Carboline Customer Service for availability.

* See notice under DRYING TIMES.

GLOSS: Semi-gloss (Epoxies lose gloss and eventually chalk in sunlight exposure).

ORDER INFORMATION

Prices may be obtained from your Carboline sales representative or Carboline Customer Service Department.

APPROXIMATE SHIPPING WEIGHT:

	2's	10's
CARBOLINE 801	28 lbs. (12 kg)	135 lbs. (61 kg)
CARBOLINE Thinner #4	9 lbs. (4 kg) in 1's	45 lbs. (20 kg) in 5's

FLASHPOINT: (Pensky-Martens Closed Cup)

CARBOLINE 801 Part A	110°F (43°C)
CARBOLINE 801 Part B	115°F (46°C)
CARBOLINE Thinner #4	110°F (43°C)

August 90 Replaces July 87

APPLICATION INSTRUCTIONS
CARBOLINE® 801

These instructions are not intended to show product recommendations for specific service. They are issued as an aid in determining correct surface preparation, mixing instructions and application procedure. It is assumed that the proper product recommendations have been made. These instructions should be followed closely to obtain the maximum service from the materials.

0987

SURFACE PREPARATION: Remove oil or grease from surface to be coated with clean rags soaked in CARBOLINE Thinner #2 or SURFACE CLEANER #3 (Refer to Surface Cleaner #3 instructions) in accordance with SSPC-SP 1.

Steel: For mild environments Power Tool or Hand Tool Clean in accordance with SSPC-SP 3 or SSPC-SP 2, respectively to produce a rust-scale free surface.

For more severe environments, abrasive blast to a Commercial Finish in accordance with SSPC-SP 6 (or NACE #3) to obtain a 1-1/2 — 3 mil (40-75 micron) blast profile.

Concrete: Apply over clean, dry recommended surfacer. Can be applied directly to dry concrete where an uneven surface can be tolerated. Remove laitance by abrasive blasting or other means.

Do not coat concrete treated with hardening solutions unless test patches indicate satisfactory adhesion. Do not apply coating unless concrete has cured at least 28 days at 70°F (21°C) and 50% R.H. or equivalent time.

MIXING: Mix separately, then combine and mix in the following proportions:

	2 Gal. Kit	10 Gal. Kit
CARBOLINE 801 Part A	1 gallon	5 gallons
CARBOLINE 801 Part B	1 gallon	5 gallons

DO NOT MIX PARTIAL KITS.

THINNING: For spray applications, may be thinned up to 12% (16 fl. oz./gal.) by volume with CARBOLINE Thinner #4.

For brush and roller application, may be thinned up to 25% (32 fl. oz./gal.) by volume with CARBOLINE Thinner #4.

Refer to Specification Data for VOC information.

Use of thinners other than those supplied or approved by Carboline may adversely affect product performance and void product warranty, whether express or implied.

POT LIFE: Four hours at 75°F (24°C) and less at higher temperatures. Pot life ends when coating loses body and begins to sag. Thinning rates above 12% will shorten the working time to two hours due to reduced film build.

APPLICATION CONDITIONS:

	Material	Surfaces	Ambient	Humidity
Normal	60-85°F (16-29°C)	60-85°F (16-29°C)	60-85°F (16-29°C)	0-90%
Minimum	50°F (10°C)	50°F (10°C)	50°F (10°C)	0%
Maximum	90°F (32°C)	135°F (57°C)	110°F (43°C)	90%

Do not apply when the surface temperature is less than 5°F (2°C) above the dew point.

Special thinning and application techniques may be required above or below normal conditions.

SPRAY: This is a high solids coating and may require slight adjustments in spray techniques. Wet film thicknesses are easily and quickly achieved. The following spray equipment has been found suitable and is available from manufacturers such as Binks, DeVilbiss and Graco.

Conventional: Pressure pot equipped with dual regulators, 3/8" I.D. minimum material hose, .070" I.D. fluid tip and appropriate air cap.

Airless:
Pump Ratio: 30:1 (min.)*
GPM Output: 3.0 (min.)
Material Hose: 3/8" I.D. (min.)
Tip Size: .017-.021"
Output psi: 1900-2100
Filter Size: 60 mesh

*Teflon packings are recommended and are available from the pump manufacturer.

BRUSH OR ROLLER: Use a medium bristle brush, or good quality short nap roller, avoid excessive rebrushing and rerolling. Two coats may be required to obtain desired appearance and recommended DFT. For best results, tie-in within 10 minutes at 75°F (24°C).

DRYING TIMES: These times are at 4 mils (100 microns) dry film thickness. Higher film thicknesses will lengthen cure times.

Dry to Touch at 75°F (24°C)–3-1/2 hours
Dry to Handle at 75°F (24°C)–6-1/2 hours

	Between Coats	Final Cure
50°F (10°C)	36 hours	3 days
60°F (16°C)	24 hours	2 days
75°F (24°C)	12 hours	24 hours
90°F (32°C)	6 hours	12 hours

May discolor if exposed to rain, condensation or moisture from any source prior to final cure. When this occurs, coating may turn white, particularly noticeable with darker colors.

CLEANUP: Use CARBOLINE Thinner #2.

CAUTION: READ AND FOLLOW ALL CAUTION STATEMENTS ON THIS PRODUCT DATA SHEET AND ON THE MATERIAL SAFETY DATA SHEET FOR THIS PRODUCT.

CAUTION: CONTAINS COMBUSTIBLE SOLVENTS. KEEP AWAY FROM SPARKS AND OPEN FLAMES. IN CONFINED AREAS WORKMEN MUST WEAR FRESH AIRLINE RESPIRATORS. HYPERSENSITIVE PERSONS SHOULD WEAR GLOVES OR USE PROTECTIVE CREAM. ALL ELECTRIC EQUIPMENT AND INSTALLATIONS SHOULD BE MADE AND GROUNDED IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE. IN AREAS WHERE EXPLOSION HAZARDS EXIST, WORKMEN SHOULD BE REQUIRED TO USE NONFERROUS TOOLS AND TO WEAR CONDUCTIVE AND NONSPARKING SHOES.

carboline

350 Hanley Industrial Ct. • St. Louis, MO 63144-1599
an RPM company • 314-644-1000

PRODUCT: CARBOLINE 801 PART A

MATERIAL SAFETY DATA SHEET CHEMTREC EMERGENCY PHONE NO.: 800-424-9300

SECTION I - PRODUCT CARBOLINE 801 PART A (0987A1NL) DATE: 04/19/89 Replaces 12/08/88 - VLF

SECTION II - HAZARDOUS INGREDIENTS EXPOSURE LIMITS

CHEMICAL NAME	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
COLOR PIGMENT	MIXTURE	35%	3.5mg/m3	NE	0.0	NO	NO	NO	
EPOXY RESIN	25068-38-6	25%	NE	NE	0.0	NO	NO	NO	1,2
SILICA	14808-60-7	10%	0.1mg/m3	NE	0.0	YES	NO	NO	
PM SOLVENT	107-98-2	10%	100 ppm	150 ppm	8.0	NO	NO	NO	1,2,3
AROMATIC SOLVENT	64742-95-6	5%	50 ppm	NE	5.0	NO	NO	NO	1,2,3
EP GLYCOL ETHER	2807-30-9	5%	25 ppm	NE	1.3	NO	NO	NO	1,2,3

TABLE (A)CAS NUMBER (B) LESS THAN WT (C) TLV-TWA (D)PEL (E) VAPOR PRESSURE (F) CARCINOGEN (G) SARA 302 (H) SARA 313 (I) SARA 311/312 CATEGORIES

NE = not established, NR = not required, NO = no. Color Pigment Mixture may contain Iron Oxides, Titanium Dioxide, Carbon Black, and other particulates not otherwise regulated in varying amounts depending on color of product. WARNING: This product contains a chemical known to the State of California to cause cancer and/or birth defects or other reproductive harm.

SECTION III - PHYSICAL DATA: BOILING RANGE: 248-348 F VAPOR DENSITY: Heavier than air. EVAPORATION RATE: Slower than ether. VOLATILE BY WEIGHT: 11 % VOLATILE BY VOLUME: 18 % PRODUCT WT/GAL : 12.3 LBS./GAL.(U.S.)

SECTION IV - FIRE AND EXPLOSION HAZARD DATA: FLAMMABILITY CLASSIFICATION: FLASH POINT: 110 F (Pensky-Martens\Closed Cup) LEL: 0.9% UEL: 15.8%. OSHA-COMBUSTIBLE LIQUID-CLASS II DOT-PAINT COMBUSTIBLE LIQUID UN1263
EXTINGUISHING MEDIA: Dry Chemical,Foam,Carbon Dioxide,Water Fog ***
UNUSUAL FIRE AND EXPLOSION HAZARDS: Vapors are heavier than air and will accumulate. Vapors will form explosive concentrations with air. Vapors travel long distances and will flashback. SPECIAL FIRE FIGHTING PROCEDURES: Evacuate hazard area of unprotected personnel. Use a NIOSH approved self-contained breathing unit and complete body protection. Cool surrounding containers with water in case of fire.

SECTION V - HEALTH HAZARD DATA: INHALATION: Harmful if inhaled. May affect the brain or nervous system, causing dizziness, headache or nausea. May cause nose and throat irritation. CONTACT: May cause eye and skin irritation. Contains a skin sensitizer. Avoid all eye and skin contact. NOTE: Reports have associated repeated and prolonged occupational overexposure to solvents with permanent brain and nervous system damage. Contains SILICA which can cause cancer. Risk of cancer depends on duration and level of exposure. SILICA, MICA and TALC present limited potential of exposure due to the physical form of the mixture. MEDICAL CONDITIONS PRONE TO AGGRAVATION BY EXPOSURE: If sensitized to amines, epoxies or other chemicals do not use. See a physician if a medical condition exists. PRIMARY ROUTE(S) OF ENTRY: Inhalation, Dermal, Ingestion.
EMERGENCY AND FIRST AID PROCEDURES: When exposed always get medical attention. EYE CONTACT: Flush with water for 15 minutes SKIN CONTACT: Wash with soap and water. Remove contaminated clothing and clean before reuse. INHALATION: Remove to fresh air. Provide oxygen if breathing is difficult. Use artificial respiration if not breathing. Get medical attention. IF SWALLOWED, DO NOT INDUCE VOMITING!! Always get medical attention.

SECTION VI - REACTIVITY DATA: STABILITY: This product is stable under normal storage conditions. HAZARDOUS POLYMERIZATION: Will not occur under normal conditions. HAZARDOUS DECOMPOSITION PRODUCTS: Carbon monoxide and unidentified organic compounds. CONDITIONS TO AVOID: Heat,sparks,and open flames. INCOMPATIBILITY: Avoid contact with strong oxidizing agents.

SECTION VII - SPILL OR LEAK PROCEDURES: STEPS TO BE TAKEN IN CASE OF SPILL: Eliminate all ignition sources. Handling equipment must be grounded to prevent sparking. Evacuate the area of unprotected personnel. Contain and soak up residual with an absorbent (clay or sand). Take up absorbent material and seal tightly for proper disposal. Dispose of in accordance with local, state and federal regulations.

SECTION VIII - SAFE HANDLING AND USE INFORMATION: RESPIRATORY PROTECTION: Use only with ventilation to keep levels below exposure guidelines. (Section II). Use (OSHA)approved air-purifying respirator when necessary. VENTILATION: Use explosion-proof ventilation as required. SKIN AND EYE PROTECTION: Recommend impervious gloves, clothing and safety glasses with side shields or chemical goggles to avoid skin and eye contact. HYGIENIC PRACTICES:Wash with soap and water before eating,drinking,or using toilet facilities. Launder contaminated clothing before reuse.

SECTION IX - SPECIAL PRECAUTIONS: PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE: Keep away from heat,sparks,open flame,and strong oxidizing agents. Keep containers closed. Store in cool,dry place with adequate ventilation. If pouring or transferring materials ground all containers and tools. OTHER PRECAUTIONS: Do not weld,heat or drill on full or empty containers.

The information contained herein is,to the best of our knowledge and belief accurate. However,since the conditions of handling and use are beyond our control,we make no guarantee of results,and assume no liability for damages incurred by use of this material. It is the responsibility of the user to comply with all applicable federal,state,local laws and regulations.

MATERIAL SAFETY DATA SHEET CHEMTREC EMERGENCY PHONE NO.: 800-424-9300

SECTION I - PRODUCT CARBOLINE 801 PART B (0987B1NL) DATE: 09/08/89 Replaces 12/08/88 - VLF

SECTION II - HAZARDOUS INGREDIENTS EXPOSURE LIMITS

CHEMICAL NAME	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)
SILICA	14808-60-7	65%	0.1mg/m3	NE	0.0	YES	NO	NO	
AROMATIC SOLVENT	64742-95-6	10%	50 ppm	NE	5.0	NO	NO	NO	1,2,3
ALIPHATIC AMINE	100-51-6	10%	NE	NE	0.0	NO	NO	NO	1,2
BARIUM METABORATE	7440-39-3	5%	0.5 mg/m3	NE	0.0	NO	NO	NO	
EP GLYCOL ETHER	2807-30-9	5%	25 ppm	NE	1.3	NO	NO	NO	1,2,3
PM SOLVENT	107-98-2	5%	100 ppm	150 ppm	8.0	NO	NO	NO	1,2,3
QUATERNARY AMMONIUM	NE	5%	NE	NE	0.0	NO	NO	NO	

TABLE (A)CAS NUMBER (B) LESS THAN WT (C) TLV-TWA (D)PEL (E) VAPOR PRESSURE (F) CARCINOGEN (G) SARA 302 (H) SARA 313 (I) SARA 311/312 CATEGORIES

NE = not established, NR = not required, NO = no. Color Pigment Mixture may contain Iron Oxides, Titanium Dioxide, Carbon Black, and other particulates not otherwise regulated in varying amounts depending on color of product. WARNING: This product contains a chemical known to the State of California to cause cancer and/or birth defects or other reproductive harm.

SECTION III - PHYSICAL DATA: BOILING RANGE: 248-348 F VAPOR DENSITY: Heavier than air EVAPORATION RATE: Slower than ether. VOLATILE BY WEIGHT: 15 % VOLATILE BY VOLUME: 29 % PRODUCT WT/GAL : 13.7 LBS./GAL.(U.S.)

SECTION IV - FIRE AND EXPLOSION HAZARD DATA: FLAMMABILITY CLASSIFICATION: FLASH POINT: 115 F (Pensky-Martens\Closed Cup) LEL: 0.9% UEL: 15.8%. OSHA-COMBUSTIBLE LIQUID-CLASS II DOT-NOT REGULATED

EXTINGUISHING MEDIA: Dry Chemical,Foam,Carbon Dioxide,Water Fog ***

UNUSUAL FIRE AND EXPLOSION HAZARDS: Vapors are heavier than air and will accumulate. Vapors will form explosive concentrations with air. Vapors travel long distances and will flashback. SPECIAL FIRE FIGHTING PROCEDURES: Evacuate hazard area of unprotected personnel. Use a NIOSH approved self-contained breathing unit and complete body protection. Cool surrounding containers with water in case of fire.

SECTION V - HEALTH HAZARD DATA: INHALATION: Harmful if inhaled. May affect the brain or nervous system, causing dizziness, headache or nausea. May cause nose and throat irritation. CONTACT: May cause eye and skin burns. Contains a skin sensitizer. Avoid all eye and skin contact. NOTE: Reports have associated repeated and prolonged occupational overexposure to solvents with permanent brain and nervous system damage. Contains SILICA which can cause cancer. Risk of cancer depends on duration and level of exposure. MEDICAL CONDITIONS PRONE TO AGGRAVATION BY EXPOSURE: If sensitized to amines, epoxies or other chemicals do not use. See a physician if a medical condition exists. PRIMARY ROUTE(S) OF ENTRY: Inhalation, Dermal, Ingestion.

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The information contained herein is,to the best of our knowledge and belief accurate. However,since the conditions of handling and use are beyond our control,we make no guarantee of results,and assume no liability for damages incurred by use of this material. It is the responsibility of the user to comply with all applicable federal,state,local laws and regulations.

SINCE 1754
DEVOE
COATINGS
Marine·Industrial·Offshore

Devoe Coatings Company

800 Ferndale Place
Rahway, New Jersey 07065

Division of Grow Group, Inc

April 1, 1991

M P R Associates
1050 Connecticut Ave., N.W., Suite 400
Washington, D. C. 20036

Attention: Mr. Tom Fredericks

Dear Mr. Fredericks:

During our recent conversation you had indicated that G.P.U.'s Nuclear Oyster Creek containment coating project was to be done with the reactor "on line". While this precludes the use of our 100% solids coatings as originally recommended, our laboratory has assured us that with adequate ventilation, our Bar-Rust 235 coating will apply at up to 160°F without embrittlement or application problems.

A two coat system is recommended to eliminate "holidays" or pin holes which can lead to further corrosion. The first coat should be approximately 2-3 mils D.F.T.; the second coat should be 3-5 mils D.F.T. This should provide adequate coverage at a reasonable cost.

As you will note, our Bar-Rust 235 is a surface preparation tolerant coating so that surface preparation can be kept to a minimum. The pot life of Bar-Rust 235 is 5 hours at 77°F. This can easily be extended by keeping the paint pot at a lower temperature. The flash point of Bar-Rust 235's solvent is 100°F (setaflash). Adequate ventilation, coupled with this high flash point render 235 an ideal coating for this project. Bar-Rust 235 will also displace moisture on the substrate being coated. Bar-Rust 235 has unlimited recoatability when cleaned with Devprep 88 so that any maintenance can be accomplished without sandblasting or mechanical abrading of the coating.

As indicated in our previous correspondence, our company is quite anxious and capable of assisting in developing a coating application specification for this project.

If we can be of any further assistance, please do not hesitate to call.

Very truly yours,

William Mackay

WM:lz

Since 1754

DEVOE COATINGS

Marine·Industrial·Offshore

Bar-Rust™ 235

Multi-Purpose Epoxy Coating

(Formerly Chemfast® 547)

Catalog Number 235-K-XXXX

FEATURES

Exceptional Corrosion Protection

- Salt and fresh water immersion resistance
- Corrosive chemical environments

Lowers The Cost Of Surface Preparation

- Grit blasting is not a requirement
- Excellent adhesion to tight rust
- Good adhesion to damp surfaces

Low Temperature Cure

- Cures down to 0°F (-18°C)
- Recoats in 3 hours at 70°F (21°C)

Application

- Self-priming

Approvals

- EPA and AWWA—potable water
- Lloyd's—grain cargo
- DOD-P-23236A(SH)—for ballast tanks

RECOMMENDED USES

Tank Linings And Pipe Coatings

- Ballast and potable water tanks
- Bilges, wet voids and drainage pipes

Ships, Offshore And Marine Structures

- Above and below-water hull areas
- Decks and superstructures
- Multi-purpose repair coating

Structural Steel, Equipment And Masonry Surfaces

- Pulp and paper mills
- Chemical and fertilizer plants
- Sewage treatment plants
- Storage tanks and pipes
- Bridges

Fabrication And New Construction

- Speeds up production, even at low temperatures
- A single multi-purpose, surface-tolerant coating

SPECIFICATION DATA

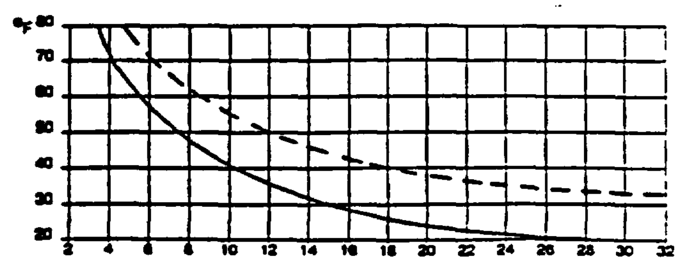
Coating Type	Advanced technology epoxy
Colors	**Catalog Number**
Buff	235-K-1642
Haze Gray	235-K-2904
Oxide Red	235-K-7821
Packaging	5 Gallon and 1 Gallon two-component kits
Component Ratio	4 to 1 by volume
Gloss	Semi-gloss
Flash Point	100°F (38°C) Setaflash
Thinner	
For exterior	Devoe T-10 Thinner
For interior	Devoe T-31 Thinner
Pot Life	5 hours at 77°F (25°C)
Induction Time	15 minutes
Shelf Life	More than 2 years
Density (average)	10 Lbs/Gal (1.2 kg/l)
VOC (average)	2.4 Lbs/Gal (287 Grams per liter)

Temperature Resistance	250°F (121°C) dry
Volume Solids	65%
Theoretical Spreading Rate	1043 Sq. Ft/Gal at 1 mil 25.6 Sq. m/l at 25 microns

Recommended Film Thickness
7.7—12.3 wet mils to obtain 5.0—8.0 dry mils

Application Spray, brush or roller

Time—Temperature Drying Curve



Hours at 5 mils DFT

Dry-to-recoat — Dry hard - - -

The above curve is intended only as a general guideline. Ventilation, film thickness, humidity, thinning and other factors can influence the rate of dry (ASTM D1640).

Application Guide

Surface Preparation

All direct to metal coatings provide the maximum performance over near white blasted surfaces. There are, however, situations and cost limitations, where grit blasting to near white metal is not possible. Bar-Rust Coatings were designed to provide excellent protection over less than ideal surface preparation.

The surface preparation recommended for Bar-Rust 235 Coating is to include removal of water, salt, dirt, oil, loose rust and all rust scale. The minimum standard for non-immersion service is Steel Structures Painting Council Standard SSPC-SP-2 or Swedish Standard DSt2; for immersion service, the minimum standard is SSPC-SP-3 or Swedish Standard DSt3. Where very rusty surfaces still remain after cleaning for non-immersion service, use Pre-Prime 167 Sealer before application of Bar-Rust 235 Coating.

Mixing and Thinning

Bar-Rust 235 Coating is a two component product supplied in 5 Gallon and 1 Gallon kits which contain the proper ratio of ingredients. The entire contents of each container must be mixed together. Power mix the base portion first to obtain a smooth, homogeneous condition. After mixing the base portion, add the convertor slowly with continued agitation. After the convertor add is complete, continue to mix slowly. Bar-Rust 235 Coating requires a 15 minute induction time.

Thinning is not normally required or desired; however, at lower temperatures, small amounts (10% or less) of the solvents on the reverse page can be added depending on local VOC and air quality regulations. Any solvent addition should be made after the two components are thoroughly mixed.

The pot life of the mixed material is 5 hours at 77°F (25°C). Higher temperatures will reduce working life of the coating; lower temperatures will increase it.

Ventilation

It is very important for the safety of the applicator and the proper performance of the Bar-Rust 235 Coating that good ventilation be provided to all portions of the enclosed area. It is equally important to bring into the enclosed area dry, fresh air to remove all solvent vapors. Since all solvent vapors are heavier than air, ventilation ducts should reach to the lowest portions of the enclosed areas as well as into any structural pockets. Ventilation should be provided throughout the cure period to insure all the solvents are removed from the coating. For potable water tanks, it is essential that full ventilation be maintained for seven days.

Application

Bar-Rust 235 Coating can be applied by both conventional air spray and airless spray equipment.

For air spray application, a fluid tip of .070" to .086" (DeVilbiss E and D tips) and an air cap with good break-up such as DeVilbiss 704 or 765 will give good results. The fluid pressure should be kept low, with just enough air pressure to get good break-up of the coating. Excessive air pressure can cause overspray problems.

Where airless equipment is used, a 30 to 1 pump and .021" to .025" tip size will provide a good spray pattern. Ideally, fluid hoses should not be less than 3/8" ID and not longer than 50 feet to obtain optimum results.

Bar-Rust 235 Coating may also be applied by brush or roller. Care should be taken that proper and uniform film thicknesses are obtained.

Tank Coating System—Two coats of Bar-Rust 235 Coating at 5 to 8 mils per coat, plus two stripe coats over sharp edges, cutouts and welds. Use contrasting colors for each coat and stripe coat.

Antifouling paints should be applied over Bar-Rust 235 Coating before the Bar-Rust 235 Coating has cured hard.

Precautions

See the material safety data sheet and product label for complete safety and precaution requirements.

235/July, 1988

DEVOE COATINGS COMPANY
Division of GROW GROUP, INC.

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(65) 2641772

CONSULT YOUR DEVOE CATALOG FOR COMPLETE LIST OF OFFICES

PRODUCT DATA SHEET

MARTEK
p. 1 of 2

DUROMAR 1025

rev 1

General

Duromar 1025 is a lightly filled, 100% solids lining with excellent chemical resistance. It is excellent product for tank linings because of its good all around chemical resistance and ease of workablility. It can be applied with conventional airless spray equipment or by brush or roller.

Chemical Description

Multi-functional epoxy, with a uniquely modified amido-amine hardner.

Typical Properties

Components	2
Visual Appearance	High Gloss
Specific Gravity	1.5
Solids by weight	100%

Physical Data

Temp Limit Dry(F)	375
Temp Limit Wet(F)	220
Tensile Strength(psi)	12,500
Bending Strength(psi)	14,000
Impact Resist(in-lb)	65
Tensile Bond Str.(psi)	1800

Application Information

Pot Life @70 F	45min
Equipment	airless,brush, roller
Number of Coats	2-3
Theoretical Coverage	40ft^2/gal/40mils
Film Thickness/coat	10mils min 20mils nom 30mils max
Max Film Thickness	60mils
Overcoat Window @ 70F	6 hr min 24 hr max
Min Application Temp	60 F
Cure Time @ 70F	7 days
Mixing Ratio by Wt.	2.3
Tack Free	8 hrs

Storage

This product has a minimum shelf life of one year when stored at 70 F in the original sealed container.

MARTEK
p. 2 of 2

Handling/Safety

Warning! Eye and skin irritant. May cause dermatitis and sensitization.
Avoid contact with eyes, skin or clothing.
Avoid breathing vapor, mist or spray.
Use with good ventilation

First Aid

In case of contact
Eyes: Immediately flush with water for at least 15 minutes.
Skin: Immediately remove from skin with dry cloth followed by thorough washing with soap and water.
Inhalation: Remove to fresh air. If breathing is difficult, give oxygen.
Ingestion: Give large quantity of milk or water, induce vomiting. Contact a physician immediately.

April 15, 1991

TELECON MEMORANDUM

Date: 1/11/91 Project: 83-144

Person Making Call: Mr. Art Schmidt, Three-E Group

Person Called: Tom Friderichs, MPR

Subject: Coatings for Oyster Creek Drywell Exterior

Mr. Schmidt called to provide a specific recommendation for a coating system to meet the technical requirements document MPR provided.

Neil Shearer, one of the principals at Three-E, provided the detailed recommendation below. Mr. Schmidt encouraged me to call Mr. Shearer with any detailed questions [phone - (609) 866-7600, FAX (609) 866-7603].

After the sand has been removed, N. Shearer recommends the following process.

1. Air dry the sand bed area.

2. Mist spray a 20 percent acetic acid solution onto the steel. The drains in the sand pocket should be left open to permit the excess solution to drain out. Allow the solution to remain in place for 3 hours.

3. Close the drains and flood the sand bed area with a solution of 0.5% Trisodium phosphate. Let it sit for 15 minutes, then drain the cavity.

4. Fill the cavity with deionized water, let it sit for 15 minutes, then drain.

5. Dry with forced air for 8 hours.

6. Mist spray "Polaprime 21" onto the steel. This coating provides a coverage of about 200 ft^2/gallon.

7. Allow 24 hours drying time.

8. Mist spray with "Encapsol." This is a coal tar extended urethane. The viscosity can be varied from water-like to mud-like.

9. Dry for 48 hours.

POLAPRIME SERIES

Which primer to use and where. . .

	POLAPRIME No. 2	No. 3	No. 7	No. 8	No. 21
Porous Materials (brick, stucco, block)	●	►	►		
Concrete (medium, light density)	●	►	►		►
Concrete, Stone (high density)	►	●			►
Wood	●	●	►		
Epoxy, Alkyd, Polyester		●			
Lead, Brass, Copper, Tin		►		●	
Iron, Mild Steel (New, Bare)	►		►		●
Aluminum, Zinc (solid)		●		►	►
Oxidized Steel					●
Rubber, EPDM		●			
Polyurethane Foam (PUF)	►	●			
Painted Surfaces, Galvanized, Galvalume		●	►		
Coal Tars or Asphaltic Bitumens	●	►			

● Best ► Alternate (trial recommended)

POLAPRIME 2 is an aquaborne, single component multi purpose acrylic primer designed for masonry surfaces, coal tar or asphaltic bitumens, wood, and some bare metal surfaces.

POLAPRIME 3 is an alcohol based, single component, vinyl terpene copolymer primer which is effective over a wide variety of substrates including aluminum, wood, dense masonry, synthetic rubber, and painted surfaces.

POLAPRIME 7 is a naphtha based, single component urethane obliteration primer suitable for masonry, steel, and wood. Its high hiding power makes it effective in preventing read-through of stains and graffiti.

POLAPRIME 8 is a solvent based, two component polyvinyl etch primer especially designed for bright metal (lead, brass, copper, tin) priming.

POLAPRIME 21 is a solvent based, single component polyurethane primer that is highly effective over oxidized steel as well as new mild steel.

Plastics & Resins, Inc.
850 Glen Avenue, PO Box 392, Moorestown, NJ 08057-0392 • USA Tel 609-866-7600 • Fax 609-866-7603

POLAPRIME SERIES

FEATURES

- complies with existing VOC legislation
- use the best available technology
- has rheology adjusted for optimum coverage and penetration

BENEFITS

- can be used where VOC legislation is in effect
- gives maximum bond performance between substrate and top coat
- is highly cost effective and performance designed

APPLICATION

PLEASE READ ENTIRE DATA SHEET BEFORE CONTINUING.
Surfaces must be free of dirt, loose debris, oils, greases, or other substances that will interfere with bond. It is advisable to have the surface as dry as possible. All repairs of damage or defects must be made prior to coating.

Apply by spray, roller, or brush. Roller and brush techniques provide best penetration and performance results. For roller application, use a medium or short nap roller. For brush application, use a soft bristle brush. Apply enough Polaprime only to cover the surface. It is not advisable to pour Polaprime straight onto the surface.

LIMITATIONS

Do not apply Polaprime 2 if the temperature is predicted to drop below 35°F within four hours of completion of application. Do not apply any of the Polaprime series to saturated surfaces or substrates that have ice crystals entrapped. Do not apply if rain is forecast within four hours of completion of application. With the exception of Polaprime 2, use EP rated spray equipment.

Polaprime 3 is flammable. Keep away from open sparks and flames.

Polaprime 7, 8 and 21 are combustible. Keep away from open sparks and flames.

MAINTENANCE

If an area becomes damaged, remove loose substrate and coating and clean the damaged area. Repair the substrate and re-prime with the appropriate Polaprime product. Finally, top coat with a finish coating to match the surrounding area.

COVERAGE

Polaprime	Approximate Coverage
2	150 sq. ft. / gallon
3	200 sq. ft. / gallon
7	100 sq. ft. / gallon
8	250 sq. ft. / gallon
21	175 sq. ft. / gallon

Coverages will vary depending upon substrate porosity and application technique.

PRECAUTIONS

Polaprime 2
Polaprime 2 is an alkaline water based product. Avoid contact with skin and eyes. In case of contact, immediately flush with clear water. For eyes, get medical attention in addition to flushing. Avoid inhalation of spray mist. If spray mist is inhaled, seek immediate medical attention. In case of ingestion, immediately contact a physician. Wear rubber gloves, coveralls, and safety goggles when applying Polaprime 2.

Polaprimes 3, 7, 8, and 21
The above primers are solvent based products. Avoid contact with skin and eyes. In case of contact with skin, wash with soap and water for 15 minutes. In case of contact with eyes, immediately flush with clean water for 15 minutes and get medical attention in addition to flushing. Do not ingest. In case of ingestion, do not induce vomiting; immediately contact a physician. Avoid inhalation of fumes; if aerosol mist is inhaled, immediately seek medical attention. Wear safety goggles, rubber gloves, coveralls and filter mask when applying these primers.

For additional application information, please contact our Technical Department.

TECHNICAL DATA

Polaprime	*Solids	Viscosity (cps)	Solvent	lbs / gal	**Flashpoint
2	35%	500	water	9.0	>200°F
3	51%	50	alcohol	6.2	53°F
7	80%	3500	naphtha	7.5	105°F
8	35%	200	naphtha	8.5	105°F
21	51%	100	naphtha	7.3	105°F

*by weight **Seta

MATERIAL SAFETY DATA SHEET
U.S. Department of Labor
Occupational Safety and Health Administration

SECTION I - Identifiers

Manufacturer: Plastics & Resins, Inc.
Address: 850 Glen Avenue, Moorestown, NJ 08057
Telephone: (609) 866-7600; emergency 800-424-9300 (Chemtrec)
Trade Name: Polaprime 21
Chemical Family: Metal Oxide Extended Urethane Prepolymer

SECTION II - Composition

COMPONENT	CAS #	APPROX. %	TLV
Lampblack/Titanium Dioxide or Iron Oxide	13463-67-7	11.2	
Naptha light aromatic solvent	64742-95-6	42.3	
Polyester Prepolymer Resin Solution N.O.S.	(ITASCA File)	39.9	
Acrylic Resin	(ITASCA File)	6.6	

KNOWN CARCINOGENS OR MUTAGENS - TYPE & DEFINITION

None

SECTION III - Physical Data

Boiling Point (F)	312	Specific Gravity (H2O=1)	0.98
Vapor Pressure (mm Hg)	10	Percent, Volatile by Volume	42.3
Vapor Density (Air=1)	4.8	Evaporation Rate (n.b.a.=1)	0.25
Solubility in Water	Insoluble	pH (5% slurry)	7

Appearance & Odor
Gray or red liquid with perfume-like odor.

SECTION IV - Fire & Explosion Hazard Data

Flash Point (Method Used) 105 degrees F. Closed Cup (ASTM D50)
Flammable Limits Lel 0.9, Uel 6.0
Extinguishing Media Carbon dioxide, dry chemical, foam

Special Fire Fighting Procedures If excessive fumes or smoke is encountered, wear self-contained respiratory equipment and full protective clothing.
Unusual Fire & Explosion Hazards Sealed containers may build up pressure if exposed to heat (fire). Water may be used to cool the exterior of the containers.
Hazardous Decomposition Products Oxides of carbon, nitrogen and iron, possible HCN and polyurethane combustion compounds.

SECTION V - Health Hazard Data

Effects of Overexposure

SKIN: May irritate skin.

EYES: Contact may cause severe damage. Vapor may irritate.

BREATHING: Inhalation may cause headache, dizziness, nausea and irritation.
SWALLOWING: Harmful or fatal if swallowed.

First Aid Procedures

SKIN: Clean thoroughly with pumice-based hand cleaner, followed by soap and water.
EYES: Flush with clear water for 15 minutes and seek medical attention immediately.
BREATHING: Move victim to fresh air. If asthmatic conditions occur, call a physician.
SWALLOWING: Do not induce vomiting. Seek medical attention immediately.

SECTION VI - Reactivity Data

Stability: Stable

Incompatability (Materials to Avoid) Water (moisture), alcohols, amines, strong acids and bases.
Hazardous Decomposition Products: Oxides of carbon and nitrogen.

Hazardous Polymerization: Will Not Occur

Conditions to Avoid: Excessive heat and/or wet conditions. Will react with water to produce CO2 and exotherm.

SECTION VII - Spill or Leak Procedures

Steps to be taken in case material is released or spilled:
Cover with a layer of sand or other suitable absorbent. Use protective measures as outlined under Section VIII below. Avoid contact with eyes, skin or clothing.
Waste Disposal Method: Dispose of in accordance with local, state and federal regulations. Absorb with sand.

SECTION VIII - Special Protection Information

RESPIRATORY PROTECTION (Specify Type): In confined spaces, use fresh air hood or NIOSH certified organic vapor canister unit.
EYE PROTECTION: Safety goggles or face shield.

SKIN PROTECTION: Nitrile rubber gloves.

OTHER PROTECTIVE EQUIPMENT: Coveralls and/or rubber apron, rubber shoes or boots.
Personal Hygiene: Wash thoroughly after applying this material.

SECTION IX - Special Precautions

Precautions to be taken in handling and storage:
Avoid prolonged or repeated contact with skin. Avoid contact with moisture. Do not use in confined areas without adequate ventilation.

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This information accumulated herein is believed to be accurate but is not warranted to be, whether originating with the company or not. Recipients are advised to confirm, in advance of need, that the information is current, applicable and suitable to their circumstances.

Date Issued: November 1990

ANDEK CHEMICAL CORPORATION

World Leader in Advanced Waterproofing Technology

P.O. Box 392
850 Glen Avenue
Moorestown, NJ 08057
(609) 866-7600

ENCAPSALL

DESCRIPTION

ENCAPSALL is a coal tar extended urethane, especially designed as a waterproof corrosion inhibiting membrane for all kinds of industrial applications. The coating can be applied by brush, airless spray or roller in one coat, and after drying will cure to a tough, black rubber-like finish with exceptional elasticity. It protects and waterproofs whatever surface to which application has been made. Laboratory tests show no significant deterioration after the equivalent of 20 years' exposure to ultraviolet radiation.

Application is simple, and a priming coat is necessary only for porous substrates and certain bituminous surfaces. ENCAPSALL can be applied to both horizontal and vertical surfaces and will cure within 24 hours, dependent upon local conditions. The cured membrane is very elastic and will accommodate all normal degrees of expansion, contraction or minor cracking of the surface to which it has been applied.

USES

Among the surfaces to which ENCAPSALL may be applied are the following:

Concrete gulleys	Steel tanks	Structural steelwork
Reinforcing bars	Dip tanks	Stone Pipes
Asbestos cement	Asphalt	Plywood
Cast Iron	Pipelines	Aluminum fabrications
Brickwork	Bridge decks	Below grade waterproofing
Barges	Vehicles	Industrial roofing
Railcars	Marine Equipment	

PREPARATION

All surfaces to be treated must be clean and dry. Surface debris and excessive dust should be removed along with any patches of oil or similar contaminant that could impair adhesion. A careful inspection of the surface should be made to detect any signs of damage or defects, and all repairs should be completed before application of ENCAPSALL may proceed.

APPLICATION

Once preparation is completed, a uniform coating of ENCAPSALL straight from the can is applied by either brush, roller or airless spray equipment onto a smooth surface at a rate of 50 square feet per gallon, achieving a wet thickness of 30 mils.

To achieve a 30-mil wet thickness over rough surfaces, the coverage rate may need to be increased from 2 gallons to 2½ or 3 gallons per 100 square feet. Application thickness may be readily checked and controlled by first measuring off a known area and ascertaining thickness by simple calculation.

Black surfaces, by their nature, tend to absorb heat, which is then transmitted through the structure. To prevent this heat build-up, we recommend the application of ENCAPSALL SILVER FILM over the ENCAPSALL at a rate of 1 gallon per 350 square feet. ENCAPSALL SILVER FILM, applied by brush, roller or spray, dries to form a solar reflective finish that may be installed overall, including areas where ponding occurs.

STORAGE

Protect ENCAPSALL drums from direct sunlight. The product is a moisture-curing urethane and is packaged in specially sealed and air excluded drums. If damaged, air and moisture vapor may enter and cause premature curing. For this reason also, care should be taken to avoid creating part-full drums.

PHYSICAL TEST DATA

'oisture vapor transmission	8.4gms/M^2/24 hrs = 0.715 perms	ASTM E 96
Tensile strength after 24 hours cure	265 lbs/square inch	ASTM D-412
Tensile strength after simulated ageing	585 lbs/square inch	ASTM D-412
Elongation after 24 hours cure	400%	ASTM D-412
Elongation after simulated ageing	340%	ASTM D-412
Impact resistance 4mm indentation	No cracking or loss of adhesion	B.S.3900 Part E3
Total solids content (B.W.)	80%	ASTM D-1044
Flexibility at low temperatures	180° bend @ 20°F	ASTM C-711
Flashpoint	Above 100°F	FTMS 141A (M4293)
Shore 'A' hardness after 24 hrs cure	48°	ASTM D-2240
Shore 'A' hardness after simulated ageing	55°	ASTM D-2240
Weatherometer exposure	No significant effect after 3,000 hours (equivalent to 18 years natural weathering)	B.S.3900 Part F3

HEALTH & SAFETY

Contains solvent and reactive isocyanate groups. Do not get in eyes or on skin or clothing. Wear chemical splash goggles and rubber gloves. Inhalation should be avoided. Persons with known respiratory allergies should avoid exposure to this product. If inhaled, swallowed, or in the event of eye contact, call a physician immediately. Flush skin and eyes with large amounts of water for at least 15 minutes.

CLEANING

Tools can be cleaned after use in any aromatic solvent. A special cleaning solvent may be supplied if necessary. Hands should be protected with a barrier cream and cleaned with a proprietry hand cleaner. Gloves may also be worn to minimize soiling.

PACKING

ENCAPSALL is supplied in 5-gallon containers. Other pack sizes are available on request.

INFORMATION

Further information of a specific or technical nature or advice and recommendations regarding individual applications may be obtained by contacting our Technical Department.

MATERIAL SAFETY DATA SHEET

U.S. Department of Labor
Occupational Safety and Health Administration

SECTION I - Identifiers

Manufacturer: Andek Chemical Corporation
Address: 850 Glen Avenue, Moorestown, NJ 08057
Telephone: (609) 866-7600 or emergency 800-424-9300 (Chemtrec)
Trade Name: Encapsall
Chemical Family: Coal Tar Extended Polyurethane

SECTION II - Composition

COMPONENT	CAS #	APPROX. %	TLV
Refined Coal Tar	65996-90-9	43.3	
Naptha, light aromatic solvent	64742-95-6	14.5	
Methylene Bisphenyl Isocyanate	101-68-8	1.5	
Aluminum Silicate		0.4	
Ethyl Ortho Formate	122-51-0	0.3	
Polyether prepolymer (Isocyanate solution N.O.S., boiling point <300 degrees C, flashpoint >23 degrees C)		40.0	

KNOWN CARCINOGENS OR MUTAGENS - TYPE & DEFINITION

Refined coal tar contains compounds that are considered to be carcinogenic to skin, lungs, kidneys and bladder. Risk depends upon level of exposure.

SECTION III - Physical Data

Boiling Point (F)	312	Specific Gravity (H2O=1)	1.11
Vapor Pressure (mm Hg)	10	Percent, Volatile by Volume	20%
Vapor Density (Air=1)	4.8	Evaporation Rate (n.b.a.=1)	0.2
Solubility in Water	Insoluble	pH (5% slurry)	Neutral

Appearance & Odor:
Black liquid with coal tar odor

SECTION IV - Fire & Explosion Hazard Data

Flash Point (Method Used): 108 degrees F. Closed Cup (ASTM D50)
Flammable Limits: Lel 0.9, Uel 6.0
Extinguishing Media: Carbon Dioxide, foam, dry chemical

Special Fire Fighting Procedures: If excessive fumes or smoke is encountered, wear self-contained respiratory equipment and full protective equipment.
Unusual Fire & Explosion Hazards: Sealed containers may build up pressure if exposed to heat (fire). Water can be used to cool the exterior of the containers.
Decomposition Products: Oxides of carbon and nitrogen, possible HCN and polyurethane combustion compounds.

SECTION V - Health Hazard Data

Effects of Overexposure

SKIN: Liquid can cause skin irritation and dermatitis, including acne. Coal tar is a phototoxic substance which, in the presence of ultra-violet light (sunlight), can cause a skin reaction similar to an exaggerated sunburn, frequently causing blisters.
EYES: Contact may cause severe damage. Vapor may irritate.

BREATHING: Inhalation may cause headache, dizziness, nausea and irritation of respiratory tract.
SWALLOWING: Can cause severe gastrointestinal irritation, nausea and vomiting if swallowed; fatal in large amounts.
First Aid Procedures

SKIN: Clean thoroughly with waterless hand cleaner, then follow with soap and water.
EYES: Flush with water for 15 minutes and seek immediate medical attention.
BREATHING: Move victim to fresh air. If asthamatic conditions occur, call a physician.
SWALLOWING: DO NOT induce vomiting. Seek medical attention immediately.

SECTION VI - Reactivity Data

Stability: Stable

Incompatability (Materials to Avoid): Water (moisture), alcohols, amines, strong acids and bases.
Hazardous Decomposition Products: Oxides of carbon and nitrogen.

Hazardous Polymerization: Will Not Occur

Conditions to Avoid: Contamination with water will evolve CO_2.

SECTION VII - Spill or Leak Procedures

Steps to be taken in case material is released or spilled:
Cover with a layer of sand or other suitable absorbent. Use protective measures as outlined under Section VIII below. Avoid contact with eyes, skin or clothing.
Waste Disposal Method: Dispose of in accordance with local, state and federal regulations.

SECTION VIII - Special Protection Information

RESPIRATORY PROTECTION (Specify Type): In confined spaces use fresh air hood or NIOSH certified organic vapor canister unit. If used indoors, ventilate well using a general or local exhaust ventilation.
EYE PROTECTION: Wear chemical splash goggles or face shield. Do not wear contact lenses while working with this material.
SKIN PROTECTION: Wear nitrile rubber gloves and apply a solvent-resistant barrier cream to areas of skin that may come in contact with material.
OTHER PROTECTIVE EQUIPMENT: Eye wash station or fresh running water should be readily available.
Personal Hygiene: Wash hands thoroughly with soap and water after handling and especially before eating or smoking. Shower at the end of the work shift. Wash contaminated clothing before reuse.

SECTION IX - Special Precautions

Precautions to be taken in handling and storage:
Avoid contact with moisture. Isocyanates react with water and generate CO_2 which may rupture sealed containers. Store between 40 and 80 degrees F.

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This information accumulated herein is believed to be accurate but is not warranted to be, whether originating with the company or not. Recipients are advised to confirm, in advance of need, that the information is current, applicable and suitable to their circumstances.

Date Issued: December 1990

JAN-29-1991 10:20 FROM KATCHEN NYC WALL ST TO ...

Praxis Technologies Inc.
901 Society Place
Newtown, PA 18940
(215) 860-5240

January 29,1991

Mr. Tom Friderichs
M P R Associates
1050 Connecticut Ave., NW
Washington, DC 20036

Dear Mr. Friderichs:

Thank you for the opportunity to participate in the coating rehabilitation project on the exterior of the Drywell at the Oyster Creek Nuclear Power Generation facility.

After careful review of the Technical Requirements Document and from our conversations last week, I am confident that our Prax-Ten, Sealant has proven reliability in many of the areas that you address. Your situation closely parallels problems associated with crevice corrosion where Prax-Ten has excelled in exhaustive tests at the SSPC and the Port Authority of NY/NJ.

Let me begin by covering the requirements stated in Section 6 of the "Technical Requirements" dated January 8, 1991. Our Prax-Ten Sealant is a technologically advanced coating system, comprised of an organic/inorganic complex, specifically designed to prevent corrosion. This formulation can be applied over minimally prepared surfaces and exhibits excellent metal wetting properties. Our Sealant also demonstrates outstanding adhesion and anti-corrosive properties.

Prax-Ten Sealant can be applied using any standard application method, over a wide range of environmental conditions and temperatures. Removal of loose scale, dirt and debris utilizing a high pressure hose is more than sufficient with regard to surface preparation. Any of the systems employed in the high pressure wash will be more than adequate for the application of our Sealant thus eliminating the need to provide for two separate systems for cleaning and application.

Prax-Ten is a single component system that does not require field mixing or dilution and is applicable as purchased. Clean up is done using standard paint cleaners and thinners. The material is sticky in it's uncured state; however, it will not clog the guns. The oil components of the formulation will even provide lubricity to the rollers and jointed couplings if they are necessary for the application equipment. It cures to a flexible finish that is able to expand and contract with the structure as well as resist underpinning, cracking and peeling.

The material contains approx. 20% Mineral Spirits with a flash point of 105 F. There is no danger of applying the material while the plant is in operation; however, we would caution not to apply when open flames are present. Additionally, our material will cure more rapidly at elevated temperatures (12 - 24 hrs.) vs. (24 - 36 hrs.) at normal ambient temperatures.

We at Praxis are of the opinion that no coating will last "forever". Considering the nature of this application we would recommend a maintenance type inspection at 7-10 yr. intervals. We think that this makes good engineering sense regardless of the coating selected. If our product were found to have any abrasions, touch up application is all that would be required. No additional surface prep or washing would be necessary.

As this application is truly unique,it is our opinion that our material will last for a minimum of 10 years at which time minimal touch ups may be required. It could very well exceed the expected life of the vessel with no additional maintenance. We are willing to offer the associated warranties to demonstrate our commitment to product reliability.

Attached, please find the MSDS's which you required. We have also included a copy of a recent reprint from the October issue of 'Modern Paint & Coatings'. There is a data sheet provided as well. Should you require any references we would be happy to do so.

Thanks again for the opportunity to work on this project with you. I hope your presentation went well last Friday and we are sorry we couldn't get this to you on time.

If you have any questions regarding this submittal, please feel free to contact us at any time.

Kindest regards,

John Sices (cg)

John Sices, Technical Director
Praxis Technologies Inc.

JS/cg

Attachements

XC: Albert H. Kurz - President
Praxis Technologies Inc.

Prax – Ten™

Penetrant – Sealer

"Modified Sulfonate Barrier Coatings For Corroding Metals"

PRODUCT BULLETIN

Description

Prax-Ten™ corrosion preventative coatings employ the same modified-overbased sulfonate technology which has been employed in the automotive industry for the past twenty years. Prax-Ten's unique chemical structure provides a material which forms strong, chemical bonds to metallic surfaces. The resultant coating actually shields the metal from the air and moisture necessary for corrosion to occur.

The base of our coating system is far more polar than water. As a result, Prax-Ten can be applied to wet, metallic surfaces. In fact, it can be applied to rusted surfaces as well, with extremely good adhesion to the substrate. A series of 'scalar like' platelets provide a continuous barrier against water and oxygen penetration, which are mandatory for the corrosion process to occur. These platelets allow for far more moisture vapor transmission resistance than conventional coatings.. and ... they won't peel or chip.

Another quality inherent in the product line is the ability to remain flexible over time. With the normal expansion and contraction forces that develop with changes in temperature, metals demand a coating that can expand and contract with them. Conventional coatings become brittle and, as they age, they can't keep up with this constant change. These membrane type coatings crack and allow paths for moisture to attack the surface eventually causing blistering & chipping. The Prax-Ten material surpasses all conventional coatings in underpinning tests with less than 10% of the creep experienced by conventional systems.

Maybe you've tried sulfonate coatings before – before Praxis modified, hardened and made them more resilient than ever. Hardness is no longer sacrificed for adhesion to the metallic substrate. Why not have a Praxis representative discuss your corrosion problem today! For more information contact Praxis at 215-860-5240.

Applications

Several of the characteristics of Prax-Ten translate directly into $$$$$$$$$ saved.

• high solids content – 70% by weight on the Sealer 50% by weight on the Penetrant for high build protection with a hard, 'wax-like' finish.

• along with the high solids comes low volatiles. This provides for an environmentally safe, non-toxic application that meets the latest EPA, OSHA, Navy and Caltrans specs for volatility requirements.

• finished surface! .... our coatings are not rust converters! The material offers a hard, color pigmented to spec, finish. Any existing surface rust is encapsulated in an inert matrix.

• it's easy to apply. . . . no messy field mixing is required. In fact, our material probably won't even have to be stirred prior to field use. Our plant mixing is generally sufficient for quite some time. And, unlike the epoxies you don't have to waste what you don't use. . . just replace the lid and store. Sprayed or brushed on. . . Prax-Ten offers beautiful finishes with little effort!

• cleanup is easy as well. . . . uncured material breaks down with conventional solvents.

Custom Solutions

At Praxis, we're customer driven. We specialize in customizing our products to meet your particular needs. Of course, we don't have the answer to all of your corrosion problems. If you're using rust converters that just won't perform to your specifications or if you're just plain tired of conventional systems that require too much work for too little performance, then why not give Prax-Ten a try. Let a Praxis representative review your corrosion problems today!

Typical Physical Properties

	Sealer	Penetrant
Non Volatile (by weight)	70%	50%
Flash Point (PMCC)	40.5°C	40.5°C
Brookfield Viscosity, #6 spindle 10RPM, 25°C	10,000 cps	1,000 cps
pH	slightly alkaline	slightly alkaline
Appearance	dispersion	dispersion
Specific Gravity	.983	.975
Color (dries clear–pigmenting available)	tan	tan

Typical Performance Characteristics

	Sealer
• Salt Spray Resistance, ASTMB-117	
@ 3 mil DFT	700+ hours
@ 5 mil DFT	1700+ hours
• Salt Spray Resistance, Scribed @ 3.5 DFT (after 2000 hour exposure)	0-2 mm creep
• Humidity Resistance	
@ 3 mil DFT	1000 hours
@ 5 mil DFT	2000 hours
• Ultra-Violet Resistance (QUV cabinet) (un-pigmented)*	
@ 3 mil DFT	400 hours
@ 5 mil DFT	800 hours

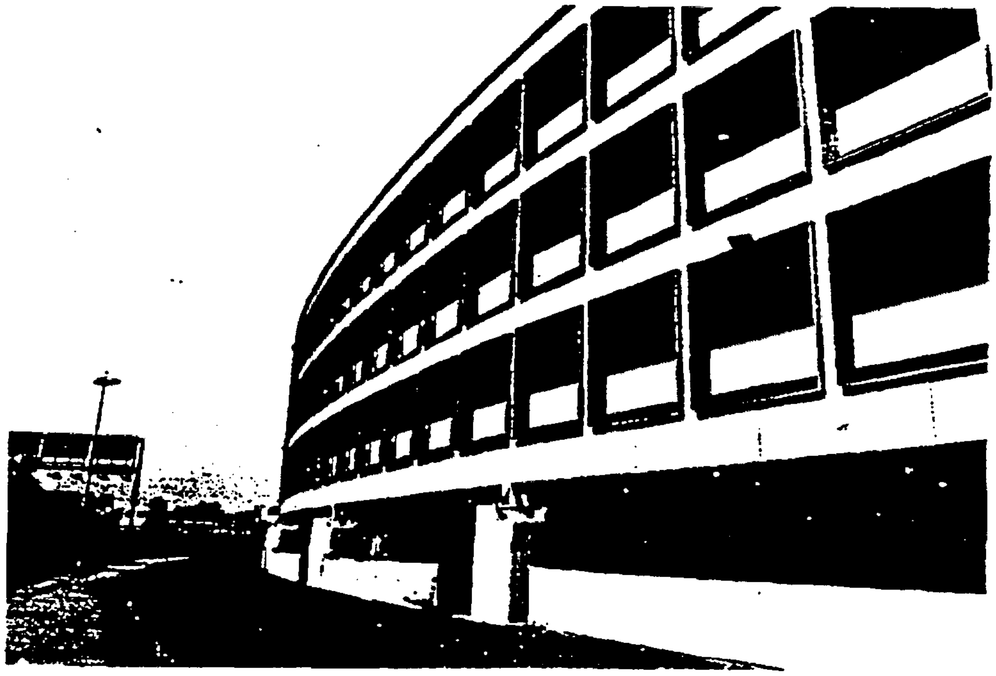
* Color pigmenting greatly increases life of product with respect to the UV characteristics. Full range of colors available.

Safety / Handling

Volatile Components:
Hydro-treated light petroleum distillate, CAS #64742-47-89
(commonly referred to as mineral spirits)

- eye protection should be worn during application
- use in ventilated areas
- skin contact - wash with soap and water
- eye contact – continuously flush for 15 minutes; call physician
- extinguish with commercially available extinguisher

Reprinted from Modern Paint and Coatings OCTOBER 1990



LaGuardia Airport parking garage uses a sulfonate corrosion-inhibiting coating to halt accumulation of rust byproducts at joints of interior structural beams.

Sulfonate Coating Systems In Rust Prevention Applications

Originally used in the automotive industry, high-performance sulfonate technology is being adapted to maintenance uses. Benefits include adhesion to rusted substrates.

A MANUFACTURER OF specialty corrosion-inhibiting coatings, Praxis Technologies Inc., Newtown, Pa., reports the existence of a growing market for its sulfonate-based barrier coatings to protect corroding steel in applications that require unusual performance or present difficult application conditions.

The company says that its Prax-Ten sulfonate coatings are being used or evaluated in public transportation, bridge and highway, water/wastewater treatment, and pulp and paper installations where a number of different corrosive environments exist. The coatings are based on SACI modified sulfonate technology, developed by Witco Corp. and used widely in the manufacture of rust-preventive coatings for the automobile industry.

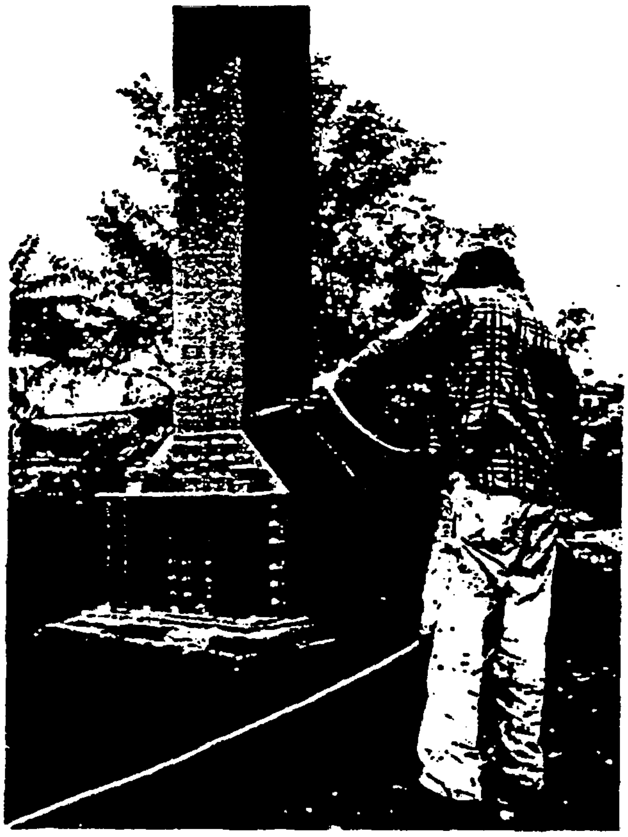
A recent project described by Praxis was the treatment of weathering steel joints at the LaGuardia Airport, New York, parking garage complex to halt the accumulation of rust byproducts. The accumulations were creating additional tensile forces that in the future might loosen or "pop" bolts in the flange connections. To correct this condition by unbolting the connections and sandblasting and recoating them would have required extraordinary amounts of manpower and time.

Instead, the airport maintenance department sprayed each side of the flange connections with Prax-Ten primer which penetrated the entire thickness to halt the corrosive action. The treatment required a minimum of surface preparation and no sandblasting.

Next, it applied a sealer version of the coating to bridge the gaps between the connection plates. Later, it put down a finish coat consisting of an oil alkyd primer and a silicone alkyd topcoat over the sulfonate-based barrier system.

The airport is now conducting another trial with the sulfonate coating system on the structural steel beams in the splash-zone on the underside of its runway extending out into the adjoining bay. The application consisted of a primer and a topcoat designed to provide weathering protection with a minimum of surface preparation.

For a similar type of application, the modified sulfonate coating system was evaluated in a recent study of materials being considered for protecting steel utility towers. The study, conducted by the Steel Structures Painting Council for nine utilities, judged the modified sulfonate system, applied as both a primer and a topcoat, to be one of the most promising candidates out of a field of 130 products to deal with the problem of rust accumulation in utility tower



A sulfonate-based barrier coating is sprayed on a steel catinary structure supporting electrical feed lines for a suburban railroad line.

crevices and bolted connections.

The study described the sulfonate primer as one needing no field mixing and suited to easy application with a minimum of dripping when applied at very low film thickness. The topcoat, it said, also needed no mixing and was easily applied by brush with a minimum of dripping and running. It also indicated that the coating had excellent prospects for providing moderate-to-long-term field durability of 5 to 10 years.

Praxis Technologies reports that its sulfonate barrier coatings are also being considered for various other types of applications. One is to protect reinforced steel plates (holding suburban railroad tracks in cast-in-place concrete) from stray electrical currents that pass from the tracks. Another is to provide existing galvanized sign structures and lighting standards of a large eastern city with long-term corrosion protection.

For a military jet-engine testing installation, the coating system is being evaluated for 42-in.-diameter exhaust lines needing a product that can be applied to damp surfaces. Previous materials have failed because the surfaces could not be kept dry during the painting process.

One characteristic that distinguishes the Prax-Ten sulfonate coatings from other systems is their excellent adhesion to rusted substrates. The adhesion and penetration properties of the sulfonate-type coatings allow application to take place over surfaces after only minimal preparation. In contrast, "Most coatings need a well-prepared surface in order to achieve good adhesion," says Albert H. Kurz, Praxis president.

The sulfonate base is highly polar in nature and effectively displaces water while forming strong bonds with metal. If the coating is damaged, corrosion is localized to that spot and there is high resistance to undercutting and blistering in surrounding surface areas.

Another notable property of the coating system is its flexibility. Whereas many conventional coatings become brittle over time, the Prax-Ten coatings may shear under force but tend to reform when the force is removed, providing self-healing characteristics. The penetrant version of the coating is specifically recommended for surfaces that are impractical or difficult to access. Typical performance characteristics of the Prax-Ten barrier coatings are given in Table I.

These coatings systems can be custom-formulated and pigmented to meet performance and color requirements. They can be used as a complete paint system or as a primer for other compatible topcoat systems. Prax-Ten coatings also meet most existing VOC requirements.

The Prax-Ten coatings are based on one of a group of SACI rust preventive concentrates supplied by Witco's Sonneborn division. The concentrates are dispersions of modified overbased calcium sulfonates said to possess an unusual ability to restrict the passage of moisture, thus providing a high-performance barrier to rust and corrosion in finished coatings.

The concentrate technology, originally adapted for protective coatings used in the automotive industry, has evolved to other systems of firmer films and higher solvent resistance suited as low-cost alternatives to paints for maintenance coatings. The concentrates cure and crosslink to permanent and flexible films that are durable and suitable for pigmentation. □

Table I. Typical Performance Characteristics* Of Prax-Ten Modified Sulfonate Barrier Coatings

	Concentrate
• Salt Spray Resistance, ASTM B-117	
@ 1 mil DFT	700+ hours
@ 2 mils DFT	1700+ hours
• Salt Spray Resistance, Scribed 3.5 mil DFT (after 2000 hr. exposure)	0-2mm creep
• Humidity Resistance	
@ 1 mil DFT	800+ hours
@ 2 mils DFT	2000+ hours
• Ultra-Violet Resistance (QUV cabinet)	
@ 1 mil DFT	400+ hours
@ 2 mil DFT	750+ hours

* Typical performance data based on clear product applied in thin films. Actual field installations provide for thicker applications as well as a build-up of coats under normal conditions. Pigmenting also greatly enhances the life of material that is exposed to UV light.

Distributed through the courtesy of

Praxis Technologies Inc.
901 Society Place
Newtown, PA 18940
(215) 860-5240

Praxis Technologies Inc.
901 Society Place
Newtown, PA 18940
(215) 860-5240

NFPA HAZARD RATING	Fire	2
4 – EXTREME	Toxicity	1
3 – HIGH	Reactive	0
2 – MODERATE	Special	0
1 – SLIGHT		
0 – INSIGNIFICANT		

MATERIAL SAFETY DATA SHEET
FOR COATINGS, RESINS AND RELATED MATERIALS

(Approved by U.S. Department of Labor "Essentially Similar" to Form OSHA-20)

PRODUCT: PRAX-TEN™ Sealer – Clear Material

Emergency Telephone Number
215 - 860 - 5240
(Manufacturer)

Section I

1) manufacturer: Praxis Technologies Inc.
2) complete address: 901 Society Place, Newtown, PA 18940
3) chemical name or family: Modified Metal Alkyl Sulfonates
4) formula: N/A

Section II – HAZARDOUS INGREDIENTS

1) ingredient: Hydrotreated light petroleum distillate, CAS#64742-47-8 (referred to as 'Mineral Spirits)
   % by weight: 70%
   threshold limit value: 500 ppm – 2950 mg/M*3
   permissible exposure limit: 360
   lower explosive limit: .9
   vapor pressure (mm Hg @ 20°C): < 2 mm
   vapor density (air = 1): >1
2) ingredient: N/A
   % by weight:
   threshold limit value:
   permissible exposure limit:
   lower explosive limit:
   vapor pressure (mm @ 20°C):
   vapor density (air = 1):

Section III – PHYSICAL PROPERTIES

1) hazardous decomposition products: When burning – CO, CO2 and oxides of sulfur may be generated
2) incompatibility (keep away from): keep away from sparks, flames and strong oxidizers
3) form: thixotropic liquid
4) odor: slight, kerosene – like
5) appearance: dispersion
6) color: tan
7) color: tan
8) specific gravity(H20=1): 0.891
9) boiling point (IBP): >149°C >300°F
10) melting point: N/A
11) solubility in water: at all °C
12) evaporation rate (ether = 1): >than ether
13) pH: mildly alkaline
14) viscosity (SUS @ 100°F): 100 or >

Section IV – FIRE AND EXPLOSION DATA

1) special fire fighting procedures: the use of self contained breathing apparatus is recommended for firefighters
2) unusual fire and explosion hazards: none
3) flashpoint (method used): P.M.C.C. 40.5°C or 105°F
4) flammable limits: Lower 0.8 Upper ??
5) extinguishing agents: drychemical, CO2, waterspray, foam, waterfog, sand/earth

Praxis Technologies Inc.
901 Society Place
Newtown, PA 18940
(215) 860-5240

HAZARD RATING	
4 – EXTREME	Fire: 2
3 – HIGH	Reactivity: 0
2 – MODERATE	Toxicity: 1
1 – SLIGHT	Special: 0
0 – INSIGNIFICANT	

MATERIAL SAFETY DATA SHEET
FOR COATINGS, RESINS AND RELATED MATERIALS

(Approved by U.S. Department of Labor "Essentially Similar" to Form OSHA-20)

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threshold limit value: 500 ppm - 2950 mg/M*3
permissible exposure limit: 360
lower explosive limit: .9
vapor pressure (mm Hg @ 20°C): < 2 mm
vapor density (air = 1): >1

2) ingredient: N/A
% by weight:
threshold limit value:
permissible exposure limit:
lower explosive limit:
vapor pressure (mm @ 20°C):
vapor density (air = 1):

Section III - PHYSICAL PROPERTIES

1) hazardous decomposition products: When burning - CO, CO2 and oxides of sulfur may be generated
2) incompatibility (keep away from): keep away from sparks, flames and strong oxidizers
3) form: thixotropic liquid
4) odor: slight, kerosene - like
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1) special fire fighting procedures: the use of self contained breathing apparatus is recommended for firefighters
2) unusual fire and explosion hazards: none
3) flashpoint (method used): P.M.C.C. 40.5°C or 105°F
4) flammable limits: Lower 0.8 Upper 7?
5) extinguishing agents: drychemical, CO2, waterspray, foam, waterfog, sand/earth

April 15, 1991

TELECON MEMORANDUM

Date: 1/21/91 Project: 83-144

Person Making Call: Mr. Jack Mundy, SPECOTE
(619) 276-3333

Person Called: Tom Friderichs, MPR

Subject: Coatings for Oyster Creek Drywell Exterior

Mr. Mundy said that SPECOTE would be interested in supplying coating material for this project, but could not do the paint application.

Mr. Mundy had read the technical requirements document quickly and thought that a coating system used by Union Oil for underground piping would be appropriate. The system used an epoxy red-lead primer and a 2 part polyethylene top coat. The company that manufactured the polyethylene coating is now out of business, and a substitute would have to be identified.

Mr. Mundy indicated he would try to find the test report covering the 10-year long test performed by Union Oil and provide MPR a copy.

Note: As of April 1991, SPECOTE has been unable to find the test report.

SPECO

SPECIALTIES ENGINEERING CORPORATION

1364 MORENA BLVD. SAN DIEGO, CALIFORNIA 92110 (619) 276-3333

SPECOAT PRODUCTS

Protective Coatings to meet Specifications

FORMULATORS and APPLICATORS

TO COMBAT

Corrosion
Electrolysis
Cavitation
Galvanic Action
Tuberculation

IN MOST

Chemicals
Sea Water
Water
All Conditions

ON

Valves, Hydrants
Pumps, Impellers
Pipes, Tanks
Condensors
Tube Sheets
Tube Repairs

FOR

Public Utilities
Water Works
Desalination
Power
Steam
Hydro
Nuclear
Sanitation Equip.
Oil Refineries
Construction
Waterproofing
Marine, All Areas
Air Conditioning
Equip. Heads
Tube Sheets
Evaporators

TECHNICAL BULLETIN # 16
RED LEAD EPOXY, SEC-EPRI
EPOXY PRIMER RUST INHIBITOR

FOR: Marine-sea water, brine and fresh water installations on non-critical equipment, needing protection against environmental and corrosive conditions. Difficult locations, enclosures and direct or indirect exposures.

SCOPE: To cover non-critical areas with a primer or an undercoat for our SEC-AS aluminum cover coat or polyurethane coatings having a fine coverage and ability to resist salt spray exposure when used as a companion to SEC-EPRI.

APPLICATION:

1. Sand blast or clean surface, remove scale, oil, grease and moisture as much as possible.
2. Apply, either with brush, roller or spray, 5-8 mils in either two or three coat applications. (Only a few minutes of waiting between coats necessary.)
3. Use only recommended solvent as a thinner supplied by the formulators.
4. Take necessary precautions for fire prevention and ventilation.
5. In most cases, no other coating is needed over this for added protection.
6. For brush or roller application, work the material into the metal surface.

PROPORTIONS & PROPERTIES:

1. Use 100 parts of base to 9 parts of reactor, by weight, (exclusive of thinner).
2. May be thinned down with recommended solvents, up to 200% if need be.
3. Pot life, 8 to 48 hours, according to temperatures, solvents & kept closed.
4. Tack free within few minutes, next coat may be placed anytime thereafter.
5. Do not cover with other materials that may keep solvents sealed, until cured.
6. Able to withstand corrosion of sea water, salt brine, fresh water, or exposure to corrosive atmosphere.
7. Excellent chemical corrosion resistance.
8. May be dipped or poured into non-accessable areas.
9. Excellent coverage, over 200 sq. ft. per gal. at 5 mils.
10. Do not add the solvent until you have added the reactor and mixed.
11. Shelf life, over a year, but recommend to order as needed, keep in cool place.
12. Full cure, 7 days at room temperature or accelerated, 250°F for 1-hour.

SPECIAL PROPERTIES:

Red Lead is of value, only when it is in a "free floating" formulation, such as is in this SPECOAT SEC-EPRI formulation. This free floating allows the red lead to counteract against the oxide of the ferrous metals when exposed to corrosion. That is why the present day red lead enamels do not meet the needs of the industry, because their red lead is not free floating. In one test that was run in comparison with governmental approved formulations, our SEC-EPRI withstood a year and a half of extreme corrosion exposure, whereas the enamel red lead, lasted only a few weeks. We have had excellent results in sea water and exposure to salt air.

USES: On all non-critical sea water installations, power plants, marine applications and etc. where general protection is needed.

service above profit

SEC

SPECIALTIES ENGINEERING CORPORATION
4600 WORTH ST. LOS ANGELES, CALIFORNIA 90063 (213) 263-4151

TECHNICAL BULLETIN No. 60 1/1

PROTECTIVE COATING OF GALVANIZED IRON SURFACES, NEW OR USED.

SCOPE: To provide a protective coating on Galvanized Iron either new or used, for submerged or atmostpheric installations.

1. Those preparations for used surfaces shall consist of cleaning the contaminating deposts, prior to the other requirements. Sand blasting may have to be resorted to, but the galvanizing should not be removed.

2. For new metal, application and prepartion shall be done after the assembly and installation whenever necessary.
   2.1. Clean any grease or oil, with solvents, prior to other operations.
   2.2. Clean the galvanized surface with 10% Muriatic Acid, exercising the proper protective steps by wearing goggles and hand gloves.
   2.3. Rinse the surface with clear water after the acid washing.
   2.4. Allow to dry or use forced heat of any kind to have a dry surface.
   2.5. Keep clean for the application process. (and dry)

3. SPRAY, BRUSH OR ROLLER, two coats of SPECOAT SEC-EPRI (Epoxy-Primer-Rust-Inhibitor) Red Lead Epoxy formuation. This is a two part system, having a reactor of 9 parts per 100 parts of base. The reactor is packaged separately for each gallon of base. Mix only that which is to be used.. There is plenty of pot life time, 8 hours to 24 hours, according to temperatures and sealing of the containers. (shelf life is many years)

4. Apply a thick coat, of approx 3 mils thick, allow to dry, tack free which would be several hours. Try to apply both coats in one day. (the EPRI)

5. Solvents: After the reactor has been mixed into the base and throughly mixed, add the required amount of SEC-EPRI solvent, upto 50% of the total. To the consistency required for the application. Mix well. The greater amount of solvents used the less will be the dry film thickness.

6. Finish coat, SEC-PSN (Polyurathane Sprayable Natural(clear)) This "Polyu" is a two part system of equal parts, marked A and B. Mix well, only that which you can use properly, long pot life, unless at very warm climatic conditions. SPRAY, BRUSH OR ROLL. Apply two coats, waiting until the first coat has become tack free and both coats in onw day. The longer the waiting period between coats in the one day, the better the job. Application should be done on a dry surface, and if the primer Red Lead Epoxy coating has become dirty, clean off, before the application of the "Polyu".

7. Do not damage the coated surfaces with sharp objects or nailed shoes.

8. Thickness of the Polyu cover coats shall be 2 mils each coat., or a total of 10 mils for the four coats of work.

9. For those applications that are in atmostpheric areas, Than use the SPECOAT SEC-ASA (Aluminum Silicone Alkyd) ase the cover coats.

SPECIALTIES ENGINEERING CORPORATION
4600 WORTH ST. LOS ANGELES, CALIFORNIA 90063 (213) 263-4151

TECHNICAL BULLETIN No. 81 8/4

CONDUCTIVE AND NON-CONDUCTIVE COATING SYSTEMS.

QUESTIONS TO BE ANSWERED: One usually doesnot think of coatings in this manner of conductive or non-conductive systems, however, the sooner one does, the better results he will have with either system. Here are some of the questions to ask, in making the decisions.

1. What is a stake, can the equipment be replaced? Or is it a permanent piece of equipment that cannot be replaced.
2. Will the usage be for atmospheric exposure or submerged?
3. Will the use of either, conductive or non-conductive make a differance, and therefore the choice does not matter?
4. Can harm come form a wrong choice?
5. What happens when a conductive coating is covered with a non-conductive coating system?
6. Should costs be considered?

CONDUCTIVE COATING SYSTEMS: Conductive coatings are usually considered as undercoatings or primers. They can be either Sacrificial or Chemical Conversion systems. It is not only the ingredients that make it conductive, such as the inorganic zincs or metallic powders, but also the vehicles used. You can put any amount of zinc, metal powders or red leads into our SPECOAT epoxy formulations and they will still be NON-conductive, as they will be bound in with the material and not allowed to leach or come in contact with the outside. Whereas with the use of these compounds, in a special formulation, they will remain active to the outside and be effective. A good case in point, the common red lead enamel primers, will only last a couple of weeks in sea water, whereas in our special epoxy vehicle, it lasts over ten years, as we have known Therefore the conductive primers or coatings have to be active to their surroundings, depositing a thin film of converted inter-metallic compound at the point where electrolytic or chemical corrosion occures, thus inhibiting further degradation.

COVER COATS, OVER CONDUCTIVE COATING SYSTEMS: When you place a non-conductive coating over a conductive primer coating, you negate the value of the conductive coating to a great extent! Therefore:

1. You should use a conductive coating basically for atmospheric usages.
2. You should cover a conductive coating with a conductive cover coat, such as some aluminum coatings.
3. When you use a conductive coating in a submerged usage, you cannot totally depend upon it.
4. You can cover an atmospheric conductive coating with a non-conductive coating of any kind as no damage can occur.with the combination.
5. No testing for pin holes are required in this system as it has no value.

NON-CONDUCTIVE COATING SYSTEM, IN SUBMERGED USAGE: Regardless of the price or quality, most coatings are NON-conductive, and therefore the freedom from pin holes are of vital importançe, because: (1) you isolate the entire field and concentrate all of the corrosion and galvanic action to the pin hole conductive points! (2) the careful attention necessary by knowledgable personne of the details of design, requiring expertize developed over the years. (3) pin holes developed from (a) too thin a coating in relation to the surface irrigularities (b) poor preperation & workmanship (c) solvent evaporation leaving a dry film thickness with voids or pin holes (d) additives in the formulation that are not able to withstand the corrosive elements while in use.

SEC

SPECIALTIES ENGINEERING CORPORATION
4600 WORTH ST. LOS ANGELES, CALIFORNIA 90063 (213) 263-4151

"SPECOAT" PRODUCTS
Protective Coatings to meet Specifications
*
FORMULATORS and APPLICATORS
TO COMBAT
Corrosion
Electrolysis
Cavitation
Galvanic Action
Tuberculation
IN MOST
Chemicals
Sea Water
Water
All Conditions
ON
Valves, Hydrants
Pumps, Impellers
Pipes, Tanks
Condensors
Tube Sheets
Tube Repairs
FOR
Public Utilities
Water Works
Desalination
Power
Steam
Hydro
Sanitation Equip.
Oil Refineries
Construction
Waterproofing
Marine, All Areas
Air Conditioning
Equip. Heads
Tube Sheets
Evaporators

TECHNICAL BULLETIN No. 81 Sheet No. 2 8/4

NON-CONDUCTIVE COATINGS, CONTINUED: (4) Too much pigmentation in the formulation, most of them are opaque at about 2 or 3 mils, thereby loosing the ability of detecting thickness while applicating. All coatings should be pigmented to be opaque at the dry film thickness desired for a proper job on the objects being coated, and this pigmentation should not be a conductive additive, unless it is a sacrificial or a chemical conversion additive. (5) Failures also occur due to the penetration of the membrane by the invironment, and this means that the least membrane permeability the better for the coating. If the coating depends upon a primer coat, than you will have to consider them combined. When a coating membrane is penetrated, the membrane expands and you have blisters. (6) Inspection: There can be no let down in the quality control of inspection. If you use only a few volts, you will not break through small bubbles and imperfections. We recommend a 1000 volts per mil thickness of the coating, and when you get through you are positive there are NO PIN HOLES. We use a high frequency spark tester, going upto 50,000 volts. One problem when testing a solvent type of a coating, especially when several coats are applied, the solvents are trapped in the sub-layers of the coating and therefore take weeks and months to come out, after the pin hole testing has taken place, which means that you can be sure of pin holes at a latter date. A fair test of a coating is to observe it about a year latter, when you can see if it has blistered, or has rust stains, meaning pin holes. You need not test it at that time, as it's condition will be written on the surface. When a coat-fails, don't ask it to be replaced or done over again, as it will fail again. What you need is to have it replaced with an other coating which the company will guarantee again. Take a look at our guarantee outlines that we give, this will give you an idea as to what to expect and demand.

SPECOAT: Specoat is our trade name, derived from: specifications & coatings. We formulate it and have not changed it's formulation since we started some 20 years ago. It did take us many years to learn about the application problem and the job conditions that accompany corrosion. It contains no solvents, and is formulated from the heaviest molecular epoxies. It is almost 96% resins, a a few percent of inert additives. A very fast life coating, as we have found that slower reactors, fall short in their chemical values. There is practicall no membrane penitration of SPECOAT.

SPECOAT IN LIEU OF METALURGY: SPECIFY SPECOAT, ONLY IF YOU HAVE SEVERE USAGE, AND YOU WANT MANY YEARS OFCONTINUED LIFE, WITHOUT MANTENANCE PROBLEMS EACH YEAR. Yes you may have to touch up a damage, due to unforseen action, but not to blistering, chemical failures, or deterioration. SPECOAT costs more than other coatings, because it is hand applied, not sprayed. It comes like honey in the standard form of SEC-ETP, and like butter for the SEC-ETCL. It is applied with knives, and special brushes. The standard thickness on most appliactions, is about 30 to 35 mils. You should consider it in lieu of stainless steel on very important valves, pumps, impellers, tanks, circulating water systems, water boxes, tube sheets, etc.

GUARANTEE: In most cases, we will give an UNCONDITIONAL GUARANTEE with the work that we apply. If this means anything to you, knowing that there will be no failures, and that the equipment will last the many years of design that is required of it, than SPECIFY SPECOAT!

Call us if you have any questions, thanks.

service above profit

06/11/06 09:36:16

130692

MPR-TP-83161-001

OTHER

TEST PLAN FOR

QUALIFYING THE PAINTING PROCESS FOR THE EXTERIOR SURFACE OF THE DRYWELL

OYSTER CREEK

NUCLEAR GENERATING STATION

PREPARATION Dawn Jacobs DATE 6/19/92

ENGINEERING APPROVAL [signature] DATE 6/19/92

REV. 2

	DOCUMENT NO. MPR-TP-83161-001 Page 2 of 16

TITLE Test Plan for Qualifying the Painting Process for the Exterior Surface of the Drywell

REV	SUMMARY OF CHANGE	APPROVAL	DATE
0	Original Issue		
1	Para. 3.1, 4.1.1, 4.2: revised to allow "at least three people" to participate in test instead of "three people." Para. 4.1.2: added two dry film thickness measurement spots (one in a pit and one in a high spot on the rusted surface). Changed "in the same location" to "in the same approximate location." Para. 4.2: added humidity range requirements and dew point requirement. Revised temperature range from 70-90°F to 60-80°F. Para. 4.2: specified that holiday detection (sponge test) shall be done with test panel horizontal with painted side up. Data Sheet 1: added surface temperature and dew point. Data Sheet 2: added dry film thickness measurements in a pit and at a high spot. Data Sheet 2: added Visual Inspections.		
2	Changed document number from OC-TP-402950-001 to MPR-TP-83161-001		

TABLE OF CONTENTS

Article 1

INTRODUCTION

1.1 PURPOSE

The purpose of this document is to provide a test plan for determining the range of coating thicknesses that can be expected on the exterior surface of the drywell in the sandbed area if DEVOE Pre-Prime 167 and Devran 184 paints are applied using brushes and rollers.

This document provides a test plan and evaluation methods to determine:

- Whether or not the recommended wet and dry film thicknesses can be obtained using brushes and rollers and whether any specific precautions or application techniques are needed,
- Whether or not the wet film thickness can be measured using commercially available film thickness gages on the rough drywell surface,
- An estimate of the range of coating thicknesses that will be obtained in the drywell sandbed area with a specified confidence level (statistical analysis), and
- Whether or not holidays or pinholes exist in the coating.

1.2 BACKGROUND

Portions of the drywell exterior surface at Oyster Creek Nuclear Station are corroded due to occasional water leakage from various sources. The 1000 square feet which are potentially corroded will be inspected and, based on the inspection results, will be cleaned and coated to minimize future corrosion.

The drywell is a welded carbon steel pressure vessel made of ASTM A-212-61T, Grade B plate. Plates were welded from both sides; the welds are not ground flush on the exterior surface (Reference 2.1).

The drywell steel will be cleaned using various mechanical methods in accordance with Steel Structures Painting Council Surface Preparation Specifications (References 2.2 and 2.3). DEVOE Pre-Prime 167 and Devran 184 epoxy coatings will be applied in accordance with manufacturer's recommendations.

1.3 SCOPE

1.3.1 Establish Painting Process

These initial tests are to be performed outside the sand bed mock-up with adequate lighting and space to allow for a "best possible" paint application. Personnel performing the tests are not required to wear anti-contamination clothing.

Personnel will apply DEVOE Pre-Prime 167 and Devran 184 epoxy coatings to test panel surfaces using brushes and rollers in any combination which works well on the test panel surfaces. During application, the wet film thickness will be measured periodically and adjustments will be made to obtain the recommended dry film thickness. Non-destructive dry film thickness measurements will be taken for each coat. Destructive dry film thickness measurements will be taken after all coats are applied as a check of the non-destructive measurements.

Upon completion of this testing, a process for achieving the desired film thicknesses without using any gages (wet or dry film thickness gages) will have been identified. In addition, personnel will know how to use the wet film thickness gages on the rough drywell exterior (in case these tests indicate that it is necessary to measure wet film thicknesses during painting).

1.3.2 Qualify Painting Process

These tests are to be performed inside the sand bed mock-up with lighting conditions and space constraints similar to those expected in the actual sand bed. Personnel performing the tests are required to wear anti-contamination clothing, respirators, and any other equipment expected to be used in the actual sand bed.

DEVOE Pre-Prime 167 and Devran 184 will be applied to test panel surfaces using brushes and rollers with the painting techniques developed during the previous testing. Wet film thickness measurements will not be performed. The dry film thickness will be measured after each coat. Following testing, the confidence level with which the manufacturer's recommended coating thicknesses can be obtained on the drywell exterior surface will be calculated. Tests will also be performed to determine if holidays or pinholes are present in the coating.

Article 2

CODES, STANDARDS, AND REFERENCES

2.1 Chicago Bridge and Iron Drawing 9-0971, Pressure Suppression Containment Vessels

2.2 Steel Structures Painting Council, Surface Preparation Specification No. 2, "Hand Tool Cleaning."

2.3 Steel Structures Painting Council, Surface Preparation Specification No. 3, "Power Tool Cleaning."

2.4 Steel Structures Painting Council, Paint Application Specification
No. 2, "Measurement of Dry Paint Thickness with Magnetic Gages."

2.5 Steel Structures Painting Council, Good Painting Practice, Steel Structures Painting Manual, Volume I, Chapter 6, "Inspections."

2.6 Steel Structures Painting Council, Surface Preparation Specification No. 1, "Solvent Cleaning."

2.7 ASTM D4138, "Dry Film Thickness of Protective Coating Systems by Destructive Means."

2.8 MPR Calculation, "Statistical Analyses for Coating Thickness Tests" 83-161, D. Jacobs, 5-13-92.

2.9 Experimental Statistics Handbook 91, United States Department of Commerce, National Bureau of Standards.

2.10 ASTM G62, Standard Test Methods for Holiday Detection in Pipeline Coatings, 1979.

Article 3

EQUIPMENT

3.1 Clean and corroded carbon steel material for the test panels. Any type of low carbon steel is acceptable. The corroded carbon steel will have a thick coating (1/8 to 1/4-inch, if possible) of layered, flaky rust. The test panels will be as flat as possible, at least 30 in^2, and will have at least 1/4-inch of good steel remaining under the rust. As a minimum, the following test panels are needed:

- Establish Painting Process:
  - 3 clean (i.e., new steel; never rusted) to be used as control panels, and
  - 3 previously rusted/hand or power tool cleaned to resemble as closely as possible the drywell exterior surface after cleaning.

  Note: This allows three people to participate in the test, including one clean and one previously rusted test panel per person. Additional test panels will be required if more than three people participate, or many variations of the painting process are tested.

- Qualify Painting Process:
  - 10 previously rusted/hand or power tool cleaned to resemble as closely as possible the drywell exterior surface after cleaning.

  Note: Ten panels are needed regardless of how many people (up to ten) participate in this test.

3.2 Hand and power descaling tools to be used to clean and condition the test panel surfaces. The tools will typically be chosen from "Rust Removal and Steel Conditioning Tools for Use in the Oyster Creek Sandbed Area" dated February 18, 1992.

3.3 The coatings to be tested (DEVOE Pre-Prime 167 and Devran 184) and brushes and rollers for application.

3.4 Wet film thickness gage, non-destructive dry film thickness gage, and destructive dry film thickness gage. See References 2.4 and 2.7.

3.5 Solvent for removal of oil, grease and dirt from test panels (DevPrep 88) and thinner for tool clean-up after painting (DEVOE T-10).

3.6 Low voltage wet-sponge type holiday detector and wetting agent.

Article 4

TEST DESCRIPTION

4.1 ESTABLISH PAINTING PROCESS

4.1.1 Description

The candidate coating material will be applied to test panels using brushes and rollers in any combination which works well on the test panel surfaces. The following carbon steel test panel types will be used:

1. Clean (non-rusted, free of oil, grease and other contaminants and prepared in accordance with the coating manufacturer's recommendations) to be used as control tests.

2. Previously rusted (general wastage) and prepared using any combination of impact hand tools, hand wire brushing, hand abrading, hand scraping, and rotary or impact power tools specified in References 2.2 and 2.3. All loose rust shall be removed (rust is considered loose if it can be lifted with a dull putty knife). After cleaning, the test panels shall resemble as closely as possible the expected drywell exterior surface after cleaning.

The test panels will be as flat as possible and the steel (not including rust) will be at least .25 inches thick. If necessary, oil, grease, or other soluble contaminants will be removed from test panels in accordance with Reference 2.6. Product identification information and generic types will be recorded for each solvent, hand cleaning tool and power cleaning tool used to prepare the test panels.

In order to estimate the variability in this painting process due to differences among individual painting technique, more than one person is needed for these tests; at least three people should participate. Each person will apply the coating to one clean and one previously rusted test panel using brushes and rollers in a combination which works well on the test panel surfaces. The brush/roller combination will be documented on Data Sheet 1 (attached).

One or more primer coats and one or more top coats will be applied in accordance with manufacturer's recommendations, with the exception of application method. If possible, a different color will be used for each coat for ease of dry film thickness measuring (destructive means). To simulate drywell exterior configuration, all test panels will be mounted at approximately 38 degrees as shown in Figure 1. These tests (to establish the painting process) are to be performed outside the sand bed mock-up with adequate lighting and space to allow for a "best possible" paint application. Anti-contamination clothing is not required during these tests.

Comments will be recorded on the ease of brush and roller application of the coating, as well as any problems and solutions in applying the coating.

4.1.2 <u>Measurements</u>

The following will be measured for each coat of primer and topcoat recommended by the manufacturer:

1. Wet film thickness using a wet film thickness gage.
2. Dry film thickness in accordance with Reference 2.4 (non-destructive).
3. Dry film thickness in accordance with Reference 2.7 (destructive).

During application, the wet film thickness will be measured periodically and adjusted to obtain the manufacturer's recommended dry film thickness. Both the Pre-Prime 167 and Devran 184 are 100 percent solids, so that the wet and dry film thicknesses should be approximately the same.

Non-destructive dry film thickness will be measured for each coat after the manufacturer's recommended recoat time or when the coating has dried sufficiently so that the probe does not indent the surface. Three separate spot measurements (each spot measurement is an average of three readings - see Reference 2.4) will be made on each test panel after each coat of primer and top coat. The spots will be selected randomly. On each test panel, the readings for subsequent layers will be taken in the same approximate locations as the readings for previous layers to minimize the effect of surface roughness on the readings. For rough pitted test plates, two additional spot measurements will be made; one in a pit and one at a high point. These data points will be used to check for coating filling and thinning at pits and high points.

Destructive dry film thickness will be measured after all coats have been applied and the top coat has dried to recoat (manufacturer's recommended recoat time). Three separate spot measurements (each spot measurement consists of four readings - See Reference 2.7) will be made on each test panel.

The information outlined on Data Sheets 1 and 2 (attached) will be documented. Examples of completed data sheets are also attached.

4.2 QUALIFY PAINTING PROCESS

The paint will be applied to test panels using brushes and/or rollers with the application techniques developed during Section 4.1 above. The brush/roller combination will be documented on Data Sheet 1 (attached). Wet film thickness gages will not be used during application. Previously rusted test panels will be used which have been cleaned using the types of power and/or hand tools planned for use on the exterior drywell surface. The test panels will be as flat as possible and the steel (not including rust) will be at least .25 inches thick. If necessary, oil, grease, or other soluble contaminants will be removed from the test panels in accordance with Reference 2.6.

The work surface of the test panels will resemble as closely as possible the expected condition of the drywell exterior surface after hand or power tool cleaning. The working conditions will resemble as closely as possible the expected conditions during actual drywell sandbed area painting.

Specifically:

- The test panels will be mounted in the sandbed area mockup at Oyster Creek.
- The temperature will be between 60°F and 85°F.
- The relative humidity will be between 50 and 100 percent while the Pre-Prime 167 is applied and curing. There is no requirement as to the dew point.
- The relative humidity will be between zero and 100 percent while the Devran 184 is applied and cured. The temperature of the test panel must be at least 5°F higher than the dew point while the Devran 184 is applied and cured.
- The test personnel will wear the clothing/equipment that will be worn in the drywell sandbed area.
- Lighting will be similar to that expected in the drywell sandbed area.

Product identification information and generic types will be recorded on Data Sheet 1 (attached) for the solvent, cleaning tools, and coatings used on the test panels. During painting, the applicable information outlined on Data Sheet 1 will also be documented.

The following test and associated measurements will be performed for each coat of primer and top coat. The primer will be tested first. The confidence level with which the manufacturer's recommended film thickness can be obtained on the drywell exterior surface will be determined as follows:

- The same people who performed the testing in Section 4.1 (Establish Painting Process) will perform this testing (Qualify Painting Process).
- The coating will be applied to a total of ten test panels with brushes and/or rollers using the process established in Section 4.1.

- After the manufacturer's recommended recoat time, one spot measurement using the destructive or non-destructive dry film thickness measurement technique will be taken on each test panel and recorded on Worksheet 1. (An example of a completed Worksheet is attached)

- The mean and standard deviation of the coating thicknesses that were obtained during testing will be calculated as shown on Worksheet 1.

- The mean and standard deviation calculated above will be used to calculate factors for one-sided tolerance (K) as shown on Worksheet 1.

- The factors (K) calculated above will be used with Table A-7 from Reference 2.9 (attached) to determine two confidence levels; the confidence that the coating in the drywell will be above the minimum allowable thickness, and the confidence that the coating in the drywell will be below the maximum allowable thickness.

The above procedure will be repeated once for an additional primer coat (if required) and twice for the top coat. The first top coat will be applied over the primer, and the second top coat will be applied over the first top coat.

A holiday detection test will be performed on each test panel after all coats have been applied and the final top coat has dried to recoat. For this test, the panels will be removed from the inclined position and placed on a horizontal surface with the painted side facing upward. The test will be performed in accordance with ASTM G62, Method A (low voltage wet sponge test; Reference 2.10). A wetting agent will be used in accordance with the test equipment manufacturer's instructions. The information outlined on Data Sheet 3 (attached) will be documented. An example of a completed Data Sheet is also attached.

Two of the coated test panels (to be chosen by GPUN) will be provided to the Material Engineering group in Parsippany at the completion of process qualification testing.

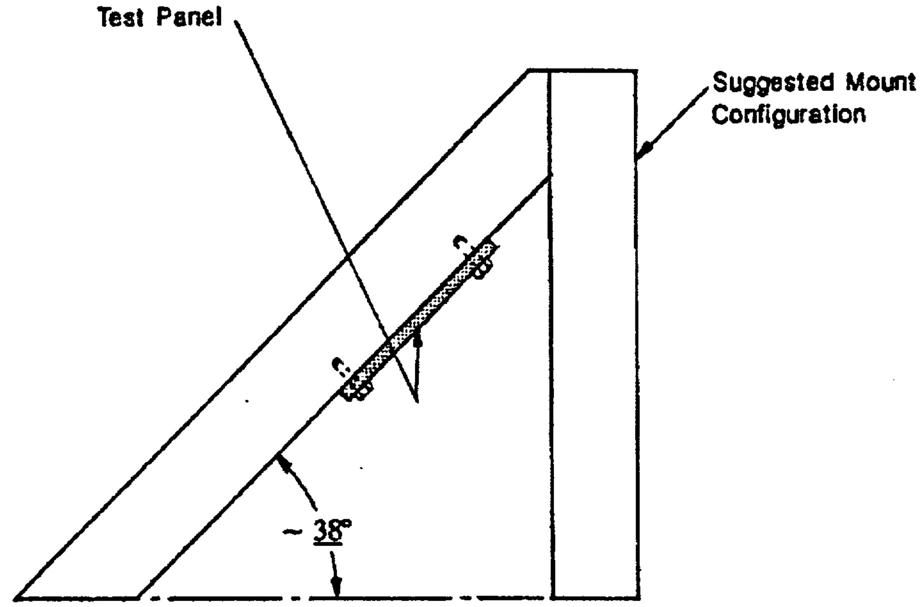

Figure 1. Test Panel Mounting

Article 5

QUALITY ASSURANCE

The drywell exterior coating is Other (i.e., not important to safety). Accordingly, the coating and this test do not fall under the operational QA program. The testing specified in this document will be performed in accordance with good commercial practice.

Data sheets used to record results will be signed and dated by person(s) who performed the testing and by a reviewer. These signatures will indicate that the data provided is considered correct and complete.

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: __________ Test Panel No.: __________ Test Panel Thickness: __________

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination (describe below)*

<u>Test Panel Preparation</u>:

Solvent Used (attach product info.): ______________________________

Cleaning Tools Used (attach product info.): ______________________________

____

Comments: ____

____

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type				
Type of Brush (or Roller; list roller nap size)				
Air Temperature (°F)				
Surface Temperature (°F)				
Relative Humidity				
Dew Point (°F)				
Dry Time Before Non-Destructive Measurement(hours)				
Dry Time Before Recoating (hours)				

*Comments: ____

____

Test Performed by: ______________

Results Reviewed by: ______________

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: __________ Test Panel No.: __________ Test Panel Thickness: __________

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination

<u>Wet Film Thickness</u>:

Instrument Type (attach product info.): ______________________________

Target Thickness per Coat: Primer ______________ Top Coat ______________

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: ______________________________

Primer Coat 2: ______________________________

Top Coat 1: ______________________________

Top Coat 2: ______________________________

Describe any Changes to Application Method Based on Measurements: __________

____

____

____

Data Sheet No. 2 (Cont.)

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs				
Sags				
Orange Peel				
Cracking				

Data Sheet No. 2 (Cont.)

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): ______________________________

Target Thickness per Coat: Primer ____________ Top Coat ____________

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): ______________________________

Spot 2 (Randomly selected location) : ______________________________

Spot 3 (Randomly selected location): ______________________________

Spot 4 (Pit): ______________________________

Spot 5 (High Point): ______________________________

Test Performed by: ____________
Results Reviewed by: ____________

Test Panel No.____

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*				
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): ______________________

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*				
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: ______________

Results Reviewed by: ______________

Data Sheet No. 3

HOLIDAY DETECTION

Date: __________ Test Panel No.: __________

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination

<u>Holiday Detection</u>:

Are holidays present in the coating? (circle one): Yes No

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: ____

____

____

____

____

WORK SHEET NO. 1

CONFIDENCE LEVEL CALCULATIONS

Date: ____________________ Test Panel Numbers: ________________________

Coating Type (circle one): Primer Top Coat

<u>Definitions/Equations</u>

s = standard deviation = $\sqrt{\dfrac{n\sum (x_i)^2 - (\sum x_i)^2}{n(n-1)}}$

$\bar{x}$ = mean (average coating thickness) = $\dfrac{\sum x_i}{n}$

n = total number of tests performed

x_i = one spot thickness measurement (the average of three or four individual measurements; References 2.4 and 2.7)

$\sum X_i$ = total of all spot measurements

x_U = maximum allowable coating thickness (x_{PU} for primer, x_{TU} for top coat)

x_L = minimum allowable thickness (x_{PL} for primer, x_{TL} for top coat)

K_U = factor for one-sided tolerance limited for maximum allowable coating thickness (Table A-7, attached)

K_L = factor for one-sided tolerance limit for minimum allowable coating thickness (Table A-7, attached)

$$K_U = \frac{x_U - \bar{x}}{S}$$

$$K_L = \frac{\bar{x} - x_L}{S}$$

P = proportion

γ_U = confidence level that coating thickness in drywell will be less than or equal to x_U

γ_L = confidence level that coating thickness in drywell will be greater than or equal to x_L

Date: ________
Test Panels: ________

WORKSHEET NO. 1 (CONT.)

Allowable Values

P = 0.90

x_{PL} = 2 mils x_{PU} = 3 mils

x_{TL} = 8 mils x_{TU} = 14 mils

Calculations

Thickness Gauge Used (circle one): Destructive   Non-Destructive

Thickness Measurements:

Test Panel Number	Spot Measurement (mils)	Test Panel Number	Spot Measurement (mils)

Mean and Standard Deviation Calculations

s = ________ (calculated from thickness measurements)

$\bar{x}$ = ________ (calculated from thickness measurements)

Confidence

K_L = ________

K_U = ________

γ_L = ________ (interpolated from Table A-7, attached)

γ_U = ________ (interpolated from Table A-7, attached)

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TABLE A-7. FACTORS FOR ONE-SIDED TOLERANCE LIMITS FOR NORMAL DISTRIBUTIONS

Factors K such that the probability is γ that at least a proportion P of the distribution will be less than $\bar{X} + Ks$ (or greater than $\bar{X} - Ks$), where $\bar{X}$ and s are estimates of the mean and the standard deviation computed from a sample size of n.

	$\gamma = 0.75$					$\gamma = 0.90$				
n \ P	0.75	0.90	0.95	0.99	0.999	0.75	0.90	0.95	0.99	0.999
3	1.464	2.501	3.152	4.396	5.805	2.602	4.258	5.310	7.340	9.651
4	1.256	2.134	2.680	3.726	4.910	1.972	3.187	3.957	5.437	7.128
5	1.152	1.961	2.463	3.421	4.507	1.698	2.742	3.400	4.666	6.112
6	1.087	1.860	2.336	3.243	4.273	1.540	2.494	3.091	4.242	5.556
7	1.043	1.791	2.250	3.126	4.118	1.435	2.333	2.894	3.972	5.201
8	1.010	1.740	2.190	3.042	4.008	1.360	2.219	2.755	3.783	4.955
9	0.984	1.702	2.141	2.977	3.924	1.302	2.133	2.649	3.641	4.772
10	0.964	1.671	2.103	2.927	3.858	1.257	2.065	2.568	3.532	4.629
11	0.947	1.646	2.073	2.885	3.804	1.219	2.012	2.503	3.444	4.515
12	0.933	1.624	2.048	2.851	3.760	1.188	1.966	2.448	3.371	4.420
13	0.919	1.606	2.026	2.822	3.722	1.162	1.928	2.403	3.310	4.341
14	0.909	1.591	2.007	2.796	3.690	1.139	1.895	2.363	3.257	4.274
15	0.899	1.577	1.991	2.776	3.661	1.119	1.866	2.329	3.212	4.215
16	0.891	1.566	1.977	2.756	3.637	1.101	1.842	2.299	3.172	4.164
17	0.883	1.554	1.964	2.739	3.615	1.085	1.820	2.272	3.136	4.118
18	0.876	1.544	1.951	2.723	3.595	1.071	1.800	2.249	3.106	4.078
19	0.870	1.536	1.942	2.710	3.577	1.058	1.781	2.228	3.078	4.041
20	0.865	1.528	1.933	2.697	3.561	1.046	1.765	2.208	3.052	4.009
21	0.859	1.520	1.923	2.686	3.545	1.035	1.750	2.190	3.028	3.979
22	0.854	1.514	1.916	2.675	3.532	1.025	1.736	2.174	3.007	3.952
23	0.849	1.508	1.907	2.665	3.520	1.016	1.724	2.159	2.987	3.927
24	0.845	1.502	1.901	2.656	3.509	1.007	1.712	2.145	2.969	3.904
25	0.842	1.496	1.895	2.647	3.497	0.999	1.702	2.132	2.952	3.882
30	0.825	1.475	1.869	2.613	3.454	0.966	1.657	2.080	2.884	3.794
35	0.812	1.458	1.849	2.588	3.421	0.942	1.623	2.041	2.833	3.730
40	0.803	1.445	1.834	2.568	3.395	0.923	1.598	2.010	2.793	3.679
45	0.795	1.435	1.821	2.552	3.375	0.908	1.577	1.986	2.762	3.638
50	0.788	1.426	1.811	2.538	3.358	0.894	1.560	1.965	2.735	3.604

Adapted by permission from *Industrial Quality Control*, Vol. XIV, No. 10, April 1958, from article entitled "Tables for One-Sided Statistical Tolerance Limits" by G. J. Lieberman.

TABLE A-7 (Continued). FACTORS FOR ONE-SIDED TOLERANCE LIMITS FOR NORMAL DISTRIBUTIONS

*The two starred values have been corrected to the values given by D. B. Owen in "Factors for One-Sided Tolerance Limits and for Variables Sampling Plans", Sandia Corporation Monograph SCR-607, available from the Clearing House for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Va. 22151. The Owen Tables indicate other errors in the table below, not exceeding 4 in the last digit.

	γ = 0.95					γ = 0.99				
n \ P	0.75	0.90	0.95	0.99	0.999	0.75	0.90	0.95	0.99	0.999
3	3.804	6.158	7.655	10.552	13.857	—	—	—	—	—
4	2.619	4.163	5.145	7.042	9.215	—	—	—	—	—
5	2.149	3.407	4.202	5.741	7.501	—	—	—	—	—
6	1.895	3.006	3.707	5.062	6.612	2.849	4.408	5.409	7.334	9.550*
7	1.732	2.755	3.399	4.641	6.061	2.490	3.856	4.730	6.411	8.348
8	1.617	2.582	3.188	4.353	5.686	2.252	3.496	4.287	5.811	7.566
9	1.532	2.454	3.031	4.143	5.414	2.085	3.242	3.971	5.389	7.014
10	1.465	2.355	2.911	3.981	5.203	1.954	3.048	3.739	5.075	6.603
11	1.411	2.275	2.815	3.852	5.036	1.854	2.897	3.557	4.828	6.284
12	1.366	2.210	2.736	3.747	4.900	1.771	2.773	3.410	4.633	6.032
13	1.329	2.155	2.670	3.659	4.787	1.702	2.677	3.290	4.472	5.826
14	1.296	2.108	2.614	3.585	4.690	1.645	2.592	3.189	4.336	5.651
15	1.268	2.068	2.566	3.520	4.607	1.596	2.521	3.102	4.224	5.507
16	1.242	2.032	2.523	3.463	4.534	1.553	2.458	3.028	4.124	5.374
17	1.220	2.001	2.486	3.415	4.471	1.514	2.405	2.962	4.038	5.268
18	1.200	1.974	2.453	3.370	4.415	1.481	2.357	2.906	3.961	5.167
19	1.183	1.949	2.423	3.331	4.364	1.450	2.315	2.855	3.893	5.078
20	1.167	1.926	2.396	3.295	4.319	1.424	2.275	2.807	3.832	5.003
21	1.152	1.905	2.371	3.262	4.276	1.397	2.241	2.768	3.776	4.932
22	1.138	1.887	2.350	3.233	4.238	1.376	2.208	2.729	3.727	4.866
23	1.126	1.869	2.329	3.206	4.204	1.355	2.179	2.693	3.680	4.806
24	1.114	1.853	2.309	3.181	4.171	1.336	2.154	2.663	3.638	4.755
25	1.103	1.838	2.292	3.158	4.143	1.319	2.129	2.632	3.601	4.706
30	1.059	1.778	2.220	3.064	4.022	1.249	2.029	2.516	3.446	4.508
35	1.025	1.732	2.166	2.994	3.934	1.195	1.957	2.431	3.334	4.364
40	0.999	1.697	2.126	2.941	3.866	1.154	1.902	2.365	3.250	4.255
45	0.978	1.669	2.092	2.897	3.811	1.122	1.857	2.313	3.181	4.168
50	0.961	1.646	2.065	2.863	3.766	1.096	1.821	2.269*	3.124	4.096

129324

(Regulatory Required)

MINI-MOD

FOR

CLEANING AND COATING THE DRYWELL EXTERIOR IN THE SAND BED AREA

July 29, 1992

PREPARATION Dawn Jacobs DATE 7-29-92

ENGINEERING APPROVAL Tom Trindwich DATE 7-29-92

QA CONCURRENCE L Lohner DATE 7-30-92

CLEANING AND COATING THE DRYWELL EXTERIOR IN THE SAND BED AREA

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TITLE Mini-Mod for Cleaning and Coating the Drywell Exterior in the Sand Bed Area

REV	SUMMARY OF CHANGE	APPROVAL	DATE
0	Initial issue.		

MINI-MOD

1.0 PURPOSE AND SCOPE

The purpose of this modification is to minimize corrosion of the drywell exterior in the sand bed area. The modification includes removal of sand from the sand bed, removal of rust and old paint from the drywell exterior and application of an epoxy coating system. The portion of the drywell to be cleaned and coated extends from approximately elevation 8' - 11 1/4" at the base of the sand bed to approximately elevation 13' - 4 1/2" at the top of the sand bed. Access to the sand bed area is divided into ten areas (or bays) separated by vertical reinforcing bar.

The following surfaces in the sand bed area are not required to be cleaned and coated as part of this modification:

- Undersides of vent pipes,
- Underside of grout plate at top of sand bed area,
- Exterior of steel pipes encasing vertical reinforcing bar within the sand bed area, and
- Concrete (except horizontal surfaces at the base of the sand bed).

It is not necessary to tape any of these surfaces to keep them free of paint. Also, it is not necessary to clean these surfaces if paint inadvertently is applied/spilled/dripped on them during drywell coating.

This Mini-Mod covers the following:

- Sand removal,
- Protection of drain systems, floors, and other surfaces that may be exposed to the epoxy coatings,
- Drywell surface preparation,
- Ventilation during sand removal, surface preparation, and coating,
- Application of the new coating system,

- Clean-up of the work area
- Disposal of waste, and
- Placement of sandbags in each manway hole to provide radiation shielding and a barrier to entry.

Although equipment set-up may be performing during plant operation, the work tasks to remove sand and clean and paint the drywell will be done only when the plant is not operating.

2.0 REFERENCES

2.1 OC-MM-402950-009, Mini-Mod, "Setup for Boring of Holes in Drywell Shield Wall"

2.2 SE Number 402950-009, Safety Evaluation, "Setup for Boring of Manway Holes in Shield Wall"

2.3 OC-MM-402950-007, Mini-Mod, "Boring of Holes in Drywell Shield Wall"

2.4 SE Number 402950-008, Safety Evaluation, "Boring of Manway Holes in Shield Wall"

2.5 GPUN Operational QA Plan No. 1000-PLN-7200.01

2.6 MPR-TP-83161-002, Test of Steel Cleaning Tools for Steel Removal, June 26, 1992

2.7 MPR-TP-83161-003, Worker Qualification for Cleaning and Coating the Drywell Exterior in the Sand Bed Area

2.8 MPR-INSP-83161-001, Inspection Requirements for Cleaning and Coating the Drywell Exterior in the Sand Bed Area

2.9 MPR-TP-83161-001, Test Plan for Qualifying the Painting Process for the Exterior Surface of the Drywell, Rev 2

2.10 American Society for Testing and Materials

D4257, Design and Use of Safety Alert Systems for Hazardous Work locations in the Coating and Lining Industry

2.11 Steel Structures Painting Council

SSPC-SP2 Surface Preparation No. 2
Hand Tool Cleaning

SSPC-SP3 Surface Preparation No. 3
Power Tool Cleaning

SSPC-PA-3 Paint Application Guide No. 3
A Guide to Safety in Paint Application

2.12 Product Literature - DEVOE Corporation

- Pre-Prime 167 (Epoxy primer)
- Devran 184 (Epoxy paint)
- Devmat 142S (Epoxy caulk)
- DevPrep 88 (Cleaner)

2.13 Technical Specification SP-9000-06-003, "Application and Repair of Service Level II and Balance of Plant Coatings."

2.14 Letter from DEVOE Coatings Company (Bill Mackay) to MPR (Dawn Jacobs) dated July 28, 1992.

3.0 QUALITY ASSURANCE REQUIREMENTS

3.1 Quality Classification

The quality classification of all work involved with the sand removal and steel surface preparation is Regulatory Required (RR). All work directly involved with removing sand from the sand bed area and removing rust and old paint from the drywell shall be done in accordance with the GPUN Operational QA Plan pertaining to the RR classification (Reference 2.5). The specific inspection requirements for removal of rust, old paint, oil and grease from the drywell are given in Reference 2.8.

The quality classification of all work involved with the application and inspection of a new epoxy coating is OTHER. The inspection requirements for application of the new epoxy coating are given in Reference 2.8.

4.0 DESIGN REQUIREMENTS

General operating conditions in the sand bed area and functional requirements for a coating for the drywell exterior in the sand bed area are listed below. The coating system (Devmat 142S caulk, Pre-Prime 167 primer, and Devran 184 paint) meets these requirements except where noted.

4.1 General Operating Conditions

Temperature: When cured, the coating system (Devmat 142S caulk, Pre-Prime 167 primer, and Devran 184 paint) is temperature resistant to 250°F. The air temperature in the sand bed area and the surface temperature of the drywell steel during operating conditions are less than 250°F.

Wetting and Drying: The sand bed area is normally dry and there are no planned activities to flood or wash this area with liquid. However, water has leaked into the drywell gap and reached the sand bed area in the past and may reach this area in the future. Water that has been sampled from this area in the past has been alkaline (Ph 8.9). Water leaks are expected to flow down the drywell gap, flow over the drywell surface in the sand bed area, and drain out through the trough and drain system at the base of the sand bed area. The coating system is resistant to those service conditions.

4.2 Functional Requirements

The function of the coating to be applied to the exterior surface of the drywell in the sand bed area is to provide corrosion protection.

Design Lifetime: The ideal coating for this application would have a service life of at least 20 years. However, it is recognized that practical coatings will require maintenance sooner than 20 years after application. This coating should first be inspected by direct visual in two bays at the next refueling outage to check for any early failures which might occur due to application errors and/or unforeseen problems. After this evaluation, remote video inspection of two bays should be performed at every refueling outage to evaluate the coating performance under exposure to radiation and to identify any needed maintenance. The inspection frequency may be changed based on experience.

Abrasion Resistance: The drywell exterior is not generally subject to abrasion. However, the coating should be sufficiently abrasion resistant to avoid damage from video cameras, temperature probes, radiation monitors, and other similar sensors which may be pushed into the sand bed area via the drain pipes, annular gaps around vent pipes, cathodic protection holes, or manways.

Adhesion: The coating should remain intact and attached to the drywell for the full range of General Operating Conditions and for the expected light abrasion during inspections and maintenance.

Direct Impact Resistance: The coating should remain intact and attached to the drywell for the expected light impacts during inspection and maintenance.

Weathering Resistance: The area to be coated is not exposed to weathering or direct light.

Decontaminability: The finished coating is not required to be smooth or to have any particular decontamination factor.

Relationship of the Protective Coating to the Engineered Safety Features: Since this coating is to be applied to the exterior of the containment vessel, there is no concern that it might delaminate and be washed to the containment sumps during a design basis accident. Accordingly, this coating is not safety related. From a maintenance standpoint, flaking or delamination is not desirable as this could clog the drains in the sand bed area and allow water to collect.

Thermal Conductivity: There are no requirements concerning thermal conductivity of this coating.

Maintenance: The ideal coating for this application would require no maintenance during the anticipated remaining plant life. However, it is recognized that practical coatings may require some inspection and maintenance.

Repairability: Areas of the coating which fail, become damaged or exhibit rust-through must be repairable using normal work skills and equipment available to the power plant. Repairs must be achievable within the limited physical access to the sand bed area.

Color: As an aid in ensuring continuous and adequate coverage during the application of each coating film, the color or tint of the material for one coat should provide a good visual contrast with the previous coat or substrate. The final coat of finish material shall be light gray or white to provide good light reflectance and easy detection of surface contamination and color changes indicating deterioration, and to make the need to repair a damaged or abraded area more evident.

Gamma Radiation: The coating should be resistant to gamma radiation. (The DEVOE coatings have not been tested for resistance to gamma radiation; therefore, inspections will be performed periodically.)

5.0 DESIGN DESCRIPTION

This modification involves removing sand from the sand bed area, cleaning rust and old paint from the drywell exterior and applying a new epoxy coating. This modification will be made in some or all of the ten bays. Technical Functions will determine (during the 14R outage) the bays in which to remove sand, clean and coat. Coating application will be performed in accordance with Reference 2.13, except that quality control requirements are waived.

Local access to the sand bed area will be provided by 20-inch diameter manway holes (see Figure 2, and References 2.3 and 2.4). After a manway has been bored at a particular bay, it is planned that sand will be removed using an electric motor driven vacuum system installed temporarily on approximately the negative 19'-6" elevation. This vacuum system is described in References 2.1 and 2.2.

Following sand removal, the drywell will be cleaned and coated. The vacuum system used for sand removal will also be used to vacuum rust and old paint debris from the sand bed. Cleaning of portions of the drywell may be performed while boring and/or sand removal is being performed in other areas, provided precautions are taken to protect personnel. These precautions are to be defined by Oyster Creek personnel during project planning and implementation.

It is preferable that no boring, sand removal, or rust removal work be in progress during caulking and coating application; the caulk and coatings contain volatile compounds that could ignite from sparks. It may be possible to caulk and paint if adequate precautions are taken (see Section 6.2).

Technical Functions may decide to perform only the sand removal and cleaning work during 14R and defer coating application to the 15R outage. After the drywell exterior has been cleaned, the steel surface will be free of active corrosion cells so that corrosion will be reduced. Accordingly, it is acceptable to clean but not coat the surface during 14R if time constraints prevent coating application. It is preferable to apply the coatings so that the steel surface will not be wet by any future water leaks into the sand bed area, and future corrosion will be minimized.

The coating system consists of one prime coat, a middle coat and a top coat. The primer (Devoe's Pre-Prime 167) is a low viscosity, penetrating epoxy intended to improve adhesion of the middle coat and topcoat. A 100% solids epoxy (Devoe's Devran 184) is used for both the middle coat and top coat. The middle coat will be pigmented red and the top coat will be pigmented gray. The painting process to be used will be qualified in accordance with Reference 2.9.

In bays selected for cleaning and coating, the drywell surface will be cleaned and coated from approximately elevation 8' - 11 1/4" at the base of the sand bed area to approximately elevation 13' - 4 1/2" at the top of the sand bed area. Specific cleaning and painting steps are presented in Section 6.0 of this document.

Prior to the end of the 14R outage, sand removed from the sand bed will be placed in bags which will be used to fill the completed manways to provide shielding and a barrier to manway entry. Up to six feet of sandbag pack will be placed in each manway based on the desired level of shielding.

6.0 INSTALLATION/OPERATION

6.1 Description of Work

The areas from which sand will be removed and which are to be cleaned and coated will be selected by GPUN's Technical Functions group; uncorroded or slightly corroded areas may not require sand removal, cleaning and coating.

In areas selected for sand removal, cleaning and coating, the following steps are to be performed in the order listed.

- Install temporary ventilation, lighting and power connections in the sand bed area.
- If required, install shielding in the sand bed area.
- Remove sand from the sand bed (see Section 6.9).
- Remove any thick rust (see Section 6.10).

At this point in the process, GPUN's Technical Functions Group will determine whether final surface preparation and coating application will be completed within the 14R outage. If it appears there is not enough time remaining to complete the steps listed below, those steps will be deferred to the 15R outage and sandbags will be placed in the manway holes. If coating application is to be completed, the following steps will be performed.

- Prepare drywell surface (see Section 6.11)
- Seal drywell-to-concrete gap (see Section 6.12)

- Apply coatings (see Section 6.13)
- Clean work area and dispose of waste (see Section 6.14)
- Place sandbags in the manway holes (see Section 6.14).

6.2 Precautions

6.2.1 The precautions in Reference 2.11 (SSPC-PA Guide 3, Guide to Safety in Paint Application) should be reviewed by work supervisors prior to starting cleaning and coating work.

6.2.2 The materials to be used are Devoe's Devmat 142S caulk, Pre-Prime 167 and Devran 184. The cleaner to be used to clean the drywell surface of any oil or grease is Devprep 88. An approved thinner will be used for clean-up. These materials should be handled as specified in the manufacturer's product literature (Reference 2.12) and Material Safety Data Sheets (MSDS).

6.2.3 The Devmat 142S caulk, Pre-Prime 167 primer, Devran 184 paint, and possibly the thinner contain volatile solvents which can create fire and explosion hazards. A fire or explosion could occur if the solvent vapor concentration reaches a hazard level and a flame or spark ignites the vapor. Accordingly, it is preferable that no boring, sand removal, rust removal, or surface preparation work be performed anywhere in the sand bed area while caulk, primer, or paint are being applied or are curing inside the sand bed area. If it is necessary to bore, remove sand, or clean some bays while caulking/coating others, extreme care must be taken to isolate the two tasks and to maintain low solvent vapor levels. Any arrangements made to allow simultaneous work as described above must be reviewed and approved by Oyster Creek's Industrial Heath and Safety and Operations Departments.

Devprep 88 cleaner has a water base and does not contain volatile solvents that could create a fire or explosion hazard. Accordingly, boring, rust removal/surface preparation may be performed in the sand bed area while Devprep 88 cleaning is being performed.

6.2.4 All electrical equipment used to mix caulk, primer or paint shall be explosion-proof.

6.2.5 Only vapor-proof light fixtures shall be used inside the sand bed area during caulking, primer application, paint application, and inspections of uncured caulk, primer or paint.

6.2.6 Paint spills shall not be allowed to enter floor drains. Floor drains shall be protected to prevent materials from entering.

6.2.7 Sand bed area ventilation must be installed and working prior to workers entering the sand bed area and prior to any surface preparation or coating application work. Sand bed area ventilation must be maintained while workers are in the sand bed area and while coatings are curing.

6.2.8 Extension cords providing electrical power to the sand bed area shall be equipped with Ground Fault Interruption (GFI) circuits.

6.2.9 Fans/motors used to remove paint fumes from the sand bed area must be suitable for use with paint fumes.

6.3 ALARA

Work shall be performed such that radiation levels are maintained as low as reasonably achievable. Shielding design and materials shall be available prior to 14R. Prior to the start of work in each bay, dose rates shall be checked and shielding shall be installed as directed by RadCon. Whole body TLDs shall be worn during work as directed by RadCon.

6.4 Temporary Ventilation Requirements

Whenever workers are in the sand bed area or manway, forced air ventilation through the sand bed area must be maintained. An air inlet rate of at least 250 CFM per bay is required. The inlet air should be maintained at about 60°F. With the heat generated by one worker, a few work lights, and one cleaning tool, the resulting air temperature inside the sand bed area should remain between 60°F and 80°F.

The rust removal process will generate a substantial amount of dust; therefore, the vacuum which will be used to collect rust and old paint chips may be left running during rust removal to assist in controlling the dust. The vacuum shall not be used as a sole source of ventilation. In addition, dust shall be minimized during cleaning and prevented from spreading outside the sand bed area by controlling air exhaust and the pace of work. (Water shall not be sprayed onto the drywell exterior as a method for minimizing dust.)

Paint fumes should be exhausted from the sand bed area using fans or blowers suitable for use with paint fumes (i.e., explosion proof). The fumes should be routed directly to the torus room air exhaust duct, which is part of the reactor building exhaust system. The vacuum system shall not be used during painting or when paint is curing since the paint fumes could combust in the vacuum. The vacuum may be used during DevPrep 88 cleaning since DevPrep 88 does not contain volatile solvents.

During application and curing of Pre-Prime 167, the relative humidity must be between 50 and 100%. Devran 184 may be applied and cured at any humidity level; however, the surface must be at least 5°F above the dew point to avoid water condensation during coating application. Devmat 142S caulk can be applied and can cure underwater; hence it can be applied to surfaces covered with water. Devoe recommends a relative humidity range of 30 to 100 percent and a temperature range of 45 to 100°F for caulk application and curing.

During paint curing (with no workers in the sand bed area or manway), the air inlet rate should be at least 250 CFM per bay. Air coolers (if any) should be turned off since the coatings cure faster in warmer temperatures. The positioning of the ventilation hoses must force air over the entire coated surface to promote curing.

The specific ventilation method(s) must be approved by the following groups at Oyster Creek: Technical Functions, Industrial Safety Department, and Operations Department.

6.5 <u>Temporary Vacuum Equipment</u>

It is planned that an electric motor driven vacuum will be installed temporarily on approximately the negative 19'-6" elevation for use in sand removal; the vacuum system is described in References 2.1 and 2.2. The vacuum system will also be used to collect rust and old paint removed from the drywell surface.

6.6 <u>Temporary Power Requirements</u>

Electrical power and compressed air will be needed to operate the rust removal tools.

<u>Electrical Power</u>: A four outlet extension cord rated for 15 amps (120 VAC) is needed inside the sand bed area during rust removal work. This outlet will be used to power one cleaning tool at a time, and to power work lights. This power cord shall be supplied with a Ground Fault Interruption (GFI) circuit.

<u>Compressed air</u>: One air hose (approximately 1/2 inch) is needed inside the sand bed area to provide 80 to 100 psi air to power one cleaning tool at a time.

6.7 Temporary Video and Communications

Portable, color video cameras will be used inside the sand bed area during cleaning and coating work. The cameras will be used for remote inspections of the drywell steel before and after cleaning, and for inspections during coating application.

A headset with microphone will be used inside the sand bed area during cleaning and coating work to check on worker safety and comfort, to allow the worker to request tools and supplies, and to assist in positioning the video cameras during remote inspections.

A coordination center will be set up to monitor all work in the sand bed area. This coordination center will receive the video and communications signals from the sand bed area cameras and communications equipment.

6.8 Approved Cleaning Tools

Tools for removal of sand, thick rust, and for drywell surface preparation are being tested to ensure they do not remove steel from the drywell surface or cause gouges (Reference 2.6). Only tools which have been tested and approved by GPUN will be used for sand removal or for drywell surface preparation.

6.9 Sand Removal

CAUTION

When removing sand close to the drywell surface and concrete shield wall, be careful not to damage steel or concrete.

6.9.1 In bays selected for sand removal, remove all remaining sand in open portions of the sand bed area (i.e., below the vent pipe) and remove as much sand as possible in the reinforcing bar areas. To break up any hardened sand, use hand or powered scrapers that have been qualified in accordance with Reference 2.6 and approved by GPUN. Use a vacuum to remove loose sand and small chunks. For large chunks that cannot be vacuumed, place them in a container and drag them out of the sand bed area through the manway.

At the extreme left and right edges of a bay, the pipes encasing reinforcing bars will restrict access. Remove sand as far into the reinforcing bar areas as possible. Document the locations and extent of areas where sand cannot be removed.

6.9.2 Store the sand in fifty-five gallon drums for later disposition by GPUN and/or use in sandbags to be placed in the manways.

6.9.3 Care should be taken not to damage concrete during sand removal. If concrete is accidentally damaged, GPUN will determine the actions (if any) to be taken on a case by case basis.

6.10 Removal of Thick Rust

CAUTION

Workers must be qualified in accordance with Reference 2.7 prior to performing rust removal work.

6.10.1 In bays selected for cleaning and coating, remove any thick rust from the drywell surface from approximately elevation 8' 11 1/4" at the base of the sand bed area to approximately elevation 13'-4 1/2" at the top of the sand bed area; see Figures 1, 2 and 3. Use hand or powered scrapers that have been qualified in accordance with Reference 2.6 and approved by GPUN. Do not use powered rotary tools to remove thick, scaly rust.

At the base of the sand bed area and as far as possible into the drywell-to-concrete gap, remove any thick rust on as much of the drywell surface as is accessible without removing concrete. It is not necessary to repair concrete that is accidentally chipped. At the top of the sand bed area, remove rust to within about two inches of the underside of the grout plate and the underside of the vent pipe.

At the extreme left and right edges of a bay, the pipes encasing reinforcing bars will restrict access. Remove heavy rust from the drywell in the reinforcing bar areas as far as possible. Document the locations and extent of areas where heavy rust cannot be removed.

6.10.2 Vacuum rust and debris out of the sand bed area as needed. Pieces of rust too large to vacuum may be broken up in the sand bed area and vacuumed, or placed in containers and dragged out through the manway.

6.11 Surface Preparation

CAUTION

Workers must be qualified in accordance with Reference 2.7 prior to performing rust removal work.

6.11.1 In bays selected for cleaning and coating, perform the surface preparation steps described below from the base of the sand bed area to within about two inches of the top of the sand bed area. The "top" of the sand bed area is defined by a grout plate in some areas and by the bottom of the vent pipe in others.

At the extreme left and right edges of a bay, the pipes encasing reinforcing bars will restrict access. Perform surface preparation steps as far into the reinforcing bar areas as possible. Document the locations and extent of areas where the surface preparation steps cannot be performed.

6.11.2 If grease or oil is visible, use DevPrep 88 cleaner on a rag to spot clean as needed. Wipe the cleaned area with a clean damp rag to remove as much of the DevPrep 88 as possible.

6.11.3 Prepare the steel surface using dry, mechanical cleaning methods that have been qualified in accordance with Reference 2.6 and approved by GPUN.

Remove all loose rust. Remove all loose old paint. Minimize dust during surface preparation by controlling the pace of work.

If there is any old paint tightly adhered to unrusted steel, remove as much paint as possible. It is acceptable to leave small, scattered patches of tightly adhered paint in place.

6.11.4 Vacuum debris from the drywell surface and the entire sand bed area.

6.11.5 Inspect the drywell surface in accordance with Reference 2.8

6.12 <u>Sealing Drywell-to-Concrete Gap at Base of Sand Bed Area</u>

CAUTIONS

a. *Before any thinners, caulk, or paints are brought into the sand bed area, ensure that appropriate ventilation and filtration systems are installed and operating. Continue operating the ventilation systems at least until the paints/caulks have cured.*

b. If sand removal or surface preparation is being performed in adjacent bays, install temporary air seals before bringing any thinners, caulk, or paints into the sand bed area.

6.12.1 In the reinforcing bar areas at the extreme left and right edges of the bay, vacuum and seal as far into the reinforcing bar area as possible. Document the locations and extent of areas where vacuuming and/or sealing cannot be performed.

6.12.2 Remove loose debris from the drywell-to-concrete gap.

6.12.3 Prepare a small amount of Pre-Prime 167. Pour and brush the Pre-Prime 167 into the corner where the drywell and concrete meet. If there is a gap, work the Pre-Prime 167 into the gap. Also, paint all horizontal concrete surfaces with Pre-Prime 167. It is acceptable to leave small areas of concrete unpainted (except at the drywell to concrete gap). It is not necessary to fill all concrete cracks with Pre-Prime 167 or to caulk the cracks with Devmat 142S. Follow the application requirements outlined in Section 6.13.7.

6.12.4 Allow the Pre-Prime 167 to cure for at least 18 hours.

6.12.5 After the Pre-Prime 167 has cured, check whether there is a gap visible. If there is a gap, estimate the amount of caulk needed to fill the gap and prepare that amount of Devmat 142S. Work the Devmat 142S into the gap and level the surface with a trowel or other tool.

6.12.6 Allow the Devmat 142S to cure for at least 24 hours.

6.13 <u>Coating Application</u>

<u>CAUTIONS</u>

a. Workers must be trained in accordance with Reference 2.7 prior to applying coatings to the drywell.

b. Any areas damaged after coating and prior to completion of the project shall be refinished per manufacturer's instructions.

c. If the first coat of Devran 184 is to be applied more than three days after the primer, or the second coat of Devran 184 is to be applied more than three days after the first coat, contact GPUN's Materials Engineering group. After this time, the epoxy becomes hard and *smooth, and intercoat adhesion becomes a concern. If the maximum recoat time is exceeded, it will be necessary to "rough-up" the existing coat of epoxy using disk sanders with coarse grinding disks (about 40 roughness), followed by a solvent wipe (such as xylene).*

6.13.1 All surface preparation within a bay is to be completed prior to start of primer application in that bay.

6.13.2 Scrub the entire surface with DevPrep 88 cleaner. Wash down the drywell surface with high pressure water at 1000 to 1500 psi. Allow the drywell surface to dry completely.

6.13.3 Prime and paint the drywell surface from the bottom of the sand bed area (the corner where the drywell and concrete meet at the base of the sand bed area), to within about one inch of the top of the sand bed area. The top of the sand bed area is defined by a grout plate in some areas and by the bottom of the vent pipe in others. When applying Pre-Prime 167 at the top of the sand bed area, overlap any old paint by about one inch. When applying the middle and top coats of Devran 184, overlap the old paint by about one inch just as with the Pre-Prime 167. When applying paint at the extreme left and right edges of a bay, paint as far as access permits; the pipes encasing reinforcing bar will probably restrict access. If new paint has already been applied in the adjacent bays, overlap that paint by a few inches. Document the locations and extent of areas that cannot be coated.

6.13.4 The total maximum paint application rate shall be 1.4 gallons/hour.

6.13.5 The following surfaces in the sand bed area are not to be cleaned and coated as part of this modification:

- Undersides of vent pipes,
- Underside of grout plate at top of sand bed area, and
- Exterior of steel pipes encasing vertical reinforcing bar within the sand bed area.

It is not necessary to tape any of these surfaces to keep them free of paint. Also, it is not necessary to clean these surfaces if paint inadvertently is applied/spilled/dripped on them during drywell coating.

6.13.6 Mechanical vibrators, air-driven mixers, or sparkproof electric-driven impellers may be used to thoroughly mix the coating after the required components have been measured properly. The two epoxy components shall be added only in the exact quantities specified by the paint manufacturer, and within the temperature and time limitations regarding pot life. Containers used for mixing shall be dry and clean and shall not be used for any other purpose (such as cleaner or thinner storage).

Thinners shall not be added to coating materials.

6.13.7 Follow these requirements during application and curing (Reference 2.14):

- Pre-Prime 167 may be applied and cured if the temperature is between 50 and 120°F and the relative humidity is between 50 and 100 percent. It may be applied to damp surfaces (for example, surfaces covered with light condensation). It may not be applied to surfaces covered with running or standing water.

- Devran 184 may be applied and cured at temperatures between 50 and 120°F and any humidity level. However, the surface must be dry, and the surface must be at least 5°F above the dew point to avoid water condensation during coating application.

- Devmat 142S caulk can be applied and can cure underwater; hence it can be applied to surfaces covered with water. Devoe recommends a relative humidity range of 30 to 100 percent and a temperature range of 45 to 100°F for caulk application and curing.

6.13.8 The Preprime 167 is a low-viscosity material. Apply a thin prime coat of Preprime 167. Allow the prime coat to cure for at least 18 hours before applying a middle coat. The middle coat shall be applied within three days of the prime coat.

6.13.9 The Devran 184 is a heavy-viscosity material. Do not thin; use as mixed. Do not apply Devran 184 more than two hours after mixing.

6.13.10 Apply the middle coat approximately 18 hours to three days after applying the prime coat. Apply the top coat approximately six hours to three days after applying the middle coat. These times are estimates based on approximately a 77°F working temperature. Relative humidity has a negligible impact on the cure times (per

Reference 2.14). Higher temperatures will result in faster curing, and lower temperatures will result in slower curing. Specific cure times shall be determined by the project engineer as necessary.

6.13.11 Allow the top coat to cure for at least six hours. Inspect the coating in accordance with Reference 2.8.

6.14 Clean-Up and Waste Disposal

6.14.1 After the coating has been inspected, remove the temporary ventilation, lighting, cameras, and power connections from the work area.

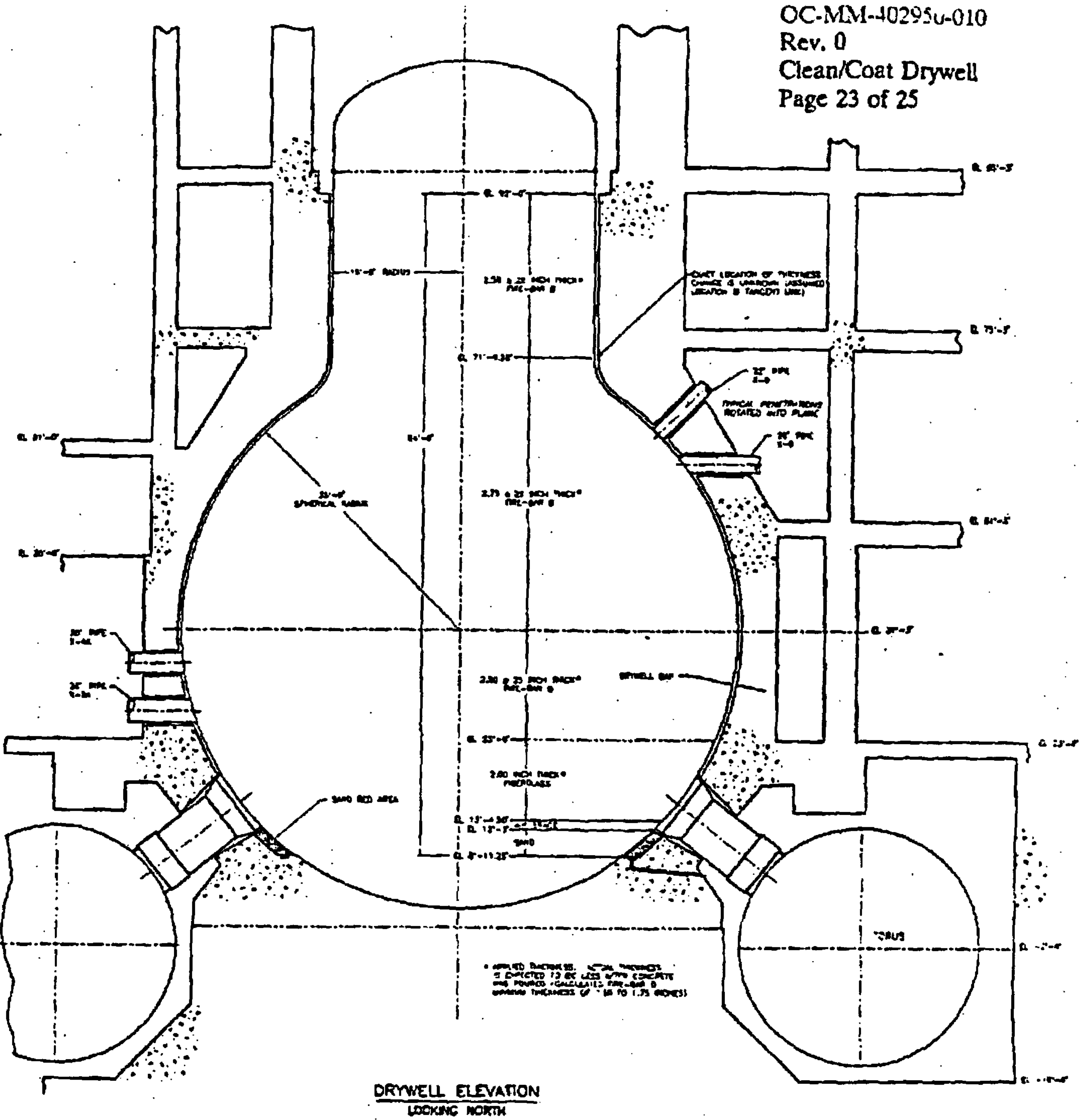
6.14.2 Verify that tools, debris, etc. are not left in the sand bed area or manway.

6.14.3 Sand, rust, and waste removed from the sand bed area shall be checked for asbestos and/or radiological contaminants. This shall be accomplished by taking random samples as directed by RadWaste, Chemistry, and Rad Con personnel. GPUN will disposition the waste for disposal based on results of the analyses.

6.15 Installation of Sandbags in Manways

Sand removed from the sand bed shall be bagged and the bags shall be placed in the manways to provide shielding and a barrier to entry. The specific type and size(s) of bags to be used shall be approved by GPUN's Tech Functions group and by Oyster Creek's Operations group. Up to six feet of sandbag pack shall be placed in each manway based on the desired level of shielding (as determined by Rad Con personnel).

The bags shall be stacked so that the pile of bags is stable and slopes away from the openings at either end of the manway. At the manway opening nearest the torus, the bags shall be stacked at approximately a 45 degree angle. No bags shall be placed within two feet of the lower edge of the outer manway opening (the opening nearest the torus). Bags shall not be placed against the drywell surface.



MATERIAL VOLUMES:
- FIRE-BAR D 3700 FT³
- FIBERGLASS 290 FT³
- SAND 850 FT³

OYSTER CREEK DRYWELL

FIGURE 1

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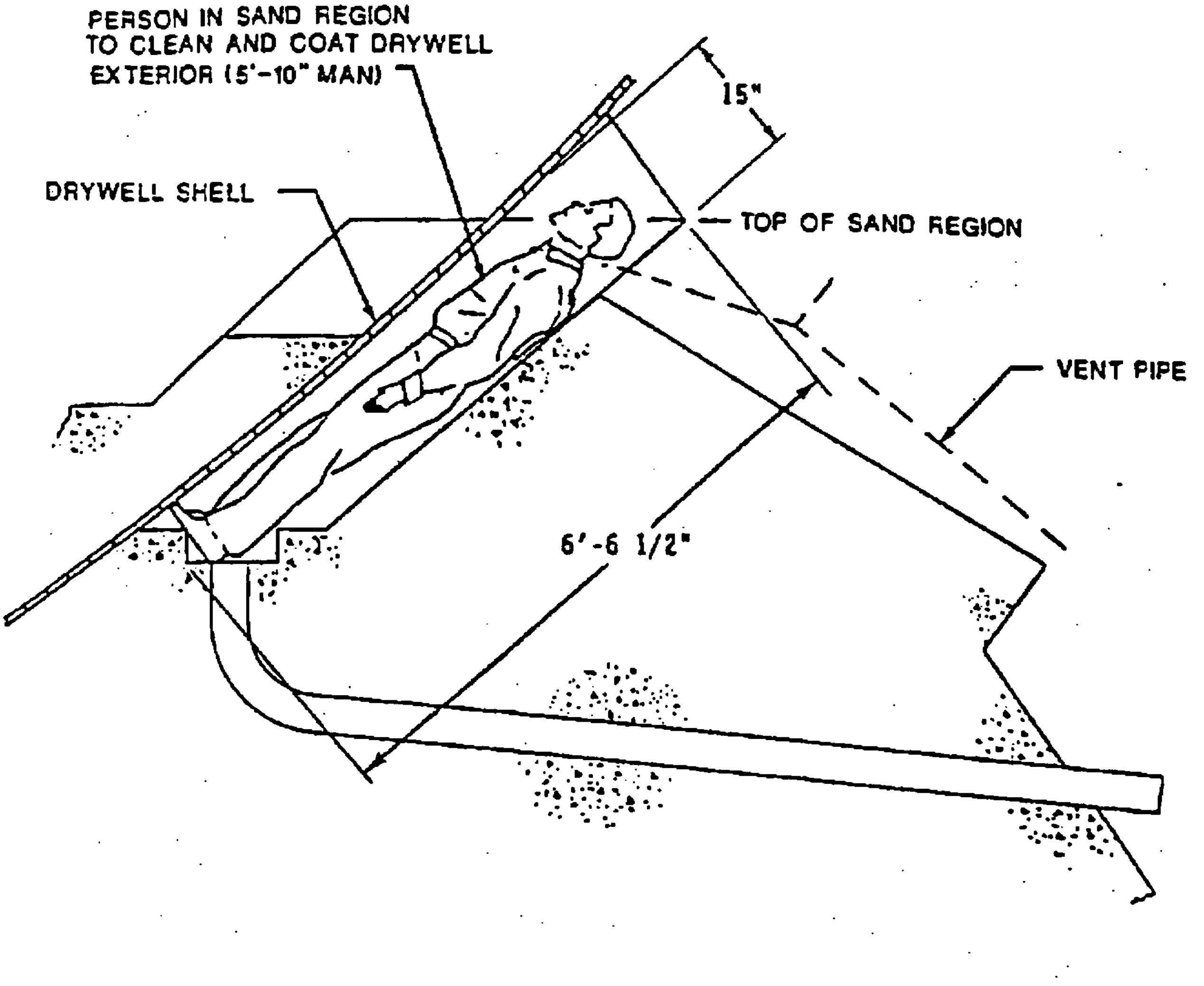
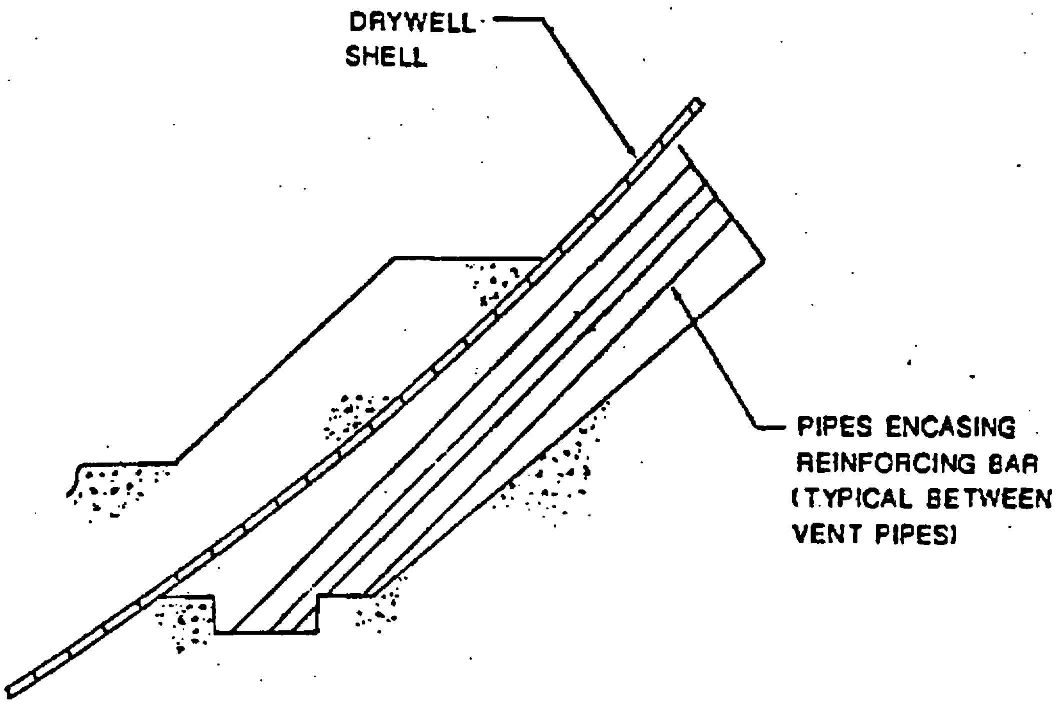
31692



LOCAL ACCESS FOR SAND REMOVAL
AND DRYWELL CLEANING AND COATING

FIGURE 2



SECTION VIEW OF SAND BED AREA
AT REINFORCING BARS

FIGURE 3

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☒ AA30 ☒ HO20 ☐ BA30 ☐ A100 ☐ HO30

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MPR	MPR-1322	–	0	–	243	RESULTS OF PAINTING PROCESS QUALIFICATION FOR THE DRYWELL EXTERIOR

Special Instructions

References/Attachments

Record – w/att.
A. CAVALLO – DRF A. BAIG – DRF

Approved: [signature] Date: 11/9/92

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MPR
ASSOCIATES, INC.

MPR-1322
Revision 0
August 7, 1992

~~DRAFT~~ ARB 11/9/92

Results of Painting Process Qualification Tests for the Drywell Exterior in the Sand Bed Area at Oyster Creek

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DRAFT

Results of Painting Process Qualification Tests for the Drywell Exterior in the Sand Bed Area at Oyster Creek

MPR-1322
Revision 0

August 7, 1992

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CONTENTS

Section 1

PURPOSE

The purpose of this report is to present the results of testing that was performed to qualify the coating process for the drywell exterior in the sand bed area. Specifically, testing was performed to:

1. Estimate the range of coating thicknesses that will be obtained in the drywell sand bed area with a specified confidence level,

2. Determine whether or not wet film thicknesses can be measured using commercially available gages on the rough drywell surface, and

3. Determine whether any specific precautions or application techniques are needed to achieve the desired dry film thicknesses and avoid imperfections in the finished coatings.

Section 2

SUMMARY

A set of tests were performed to establish a painting process for the drywell exterior and then a second set of tests were performed to qualify that process. Each set of tests was performed on rusted carbon steel test panels which were prepared (using hand and powered cleaning tools) to resemble as closely as possible the expected condition of the drywell exterior surface. Several smooth carbon steel test panels were painted as control panels.

To further simulate the condition of the drywell exterior, the test panels were cleaned with DEVOE DevPrep 88 cleaner and then washed with high pressure water (1000 to 1500 psi). All work was done in accordance with MPR-TP-83161-001, Rev 2, "Test Plan for Qualifying the Painting Process for the Exterior Surface of the Drywell" (Reference 1). The two sets of tests are described below.

ESTABLISH PAINTING PROCESS

These tests were performed outside the sand bed mock-up at Oyster Creek with adequate lighting and space to allow for a "best possible" paint application.

Personnel applied DEVOE Pre-Prime 167 and Devran 184 epoxy coatings to test panel surfaces using brushes and rollers in various combinations. During application, the wet film thickness was measured periodically and adjustments in application technique were made to obtain the recommended dry film thickness. No thinners were used to vary film thickness. Non-destructive dry film thickness measurements were taken for each coat. Destructive dry film thickness measurements were taken after all coats were applied as a check of the non-destructive measurements.

Upon completion of this testing, a process for achieving the desired film thicknesses without using any gages (wet or dry film thickness gages) was identified. That process is as follows:

- Mix the paints in accordance with the manufacturer's instructions.
- Use 1/4-inch nap rollers intended for use with epoxy paints for general area application.
- Use 2-inch china bristle brushes to force the paint into low spots on the steel surface.

- Load the rollers and brushes with as much paint as possible onto the rollers and brushes without causing the paint to drip off of the rollers and brushes during application.

- When applying the Pre-Prime 167, put on one coat and then apply another coat about five to ten seconds later.

- When painting over sharp edges in the steel, apply extra paint to build up the thickness.

QUALIFY PAINTING PROCESS

These tests were performed inside the sand bed mock-up with lighting conditions and space constraints similar to those expected in the actual sand bed. Personnel performing the tests wore anti-contamination clothing and respirators to simulate working conditions in the actual sand bed.

DEVOE Pre-Prime 167 and Devran 184 coatings were applied to test panel surfaces using brushes and rollers. The painting techniques developed during the previous testing were used. The dry film thickness of each coat was measured and was used to determine the expected ranges of coating thicknesses for the drywell exterior surface. Tests were also performed to determine if holidays or pinholes were present in the coatings.

Section 3

RESULTS

1. The ranges of coating thicknesses that are expected on 90 percent of the drywell surface with a 95 percent confidence level are listed below along with the manufacturer's recommended thickness ranges.

Coat	Expected Range Based on Tests	Manufacturer's Recommended Range (Reference 3)
Pre-Prime 167	0.4 to 1.7 mils	1.5 mils
Devran 184 (Top Coat #1)	4.9 to 16.0 mils	8 to 10 mils
Devran 184 (Top Coat #2)	3.2 to 19.3 mils	8 to 10 mils

2. The tests indicate that it is very difficult to measure film thicknesses accurately on the rough surfaces expected on the drywell exterior using either wet film thickness gages or non-destructive (magnetic) dry film thickness gages.

   Wet film thickness gages were difficult to read on the rough test panel surfaces and did not produce accurate readings. The wet film thickness of the Pre-Prime 167 (a clear coating) on test panels inside the mock-up could not be seen clearly enough through the respirator face masks to allow accurate readings. Wet film thickness measurements of each Devran 184 coat were consistently 8 to 12 mils on test panels inside the mockup; however, destructive dry film thickness measurements taken for this 100 percent solids coating on the same test panels ranged from 5 to 17 mils. Therefore, it does not appear that wet film thickness measurements provide accurate results on the rough test panel surfaces.

   Non-destructive (magnetic) dry film thickness gages produced highly variable results due to the roughness of the steel surface.

3. The tests provided the following "lessons learned" for the painting process (i.e., application equipment and techniques):

   - 1/4" nap roller intended for use with epoxy paints should be used for general area application. The longer nap rollers (1/2" nap) used during testing should not be used because fibers from those rollers tended to tear away from the roller and stick in the epoxy coating.

- 2" china bristle brushes should be used to force coatings into low spots.
- As much paint as possible should be used on brushes and rollers without causing the paint to drip off of the brushes and rollers during application to achieve the recommended minimum film thicknesses.
- The Pre-Prime 167 should be applied once, left momentarily (i.e., 5 to 10 seconds), and then applied a second time to achieve the recommended minimum film thicknesses.
- Wet film thickness gaging during painting is not required.
- Low voltage holiday tests performed on the test panels after all coats were applied and cured indicated that some holidays existed at discontinuities in the test panels (i.e., edges, bolt areas or raised ridges). To reduce the likelihood of holidays on the drywell exterior, painters should be instructed to brush extra paint onto sharp edges such as welds or other surface imperfections.
- Small skips in individual coatings were present on test panels painted in the mock-up (i.e., the previous coating could be seen); however, holidays were not detected at these locations (i.e., no bare metal was showing). To reduce the likelihood of skips on the drywell exterior, painters should be instructed to use extra care to check for complete coverage.

Section 4

DISCUSSION

TEST PANEL PREPARATION

The test panels used during these coating tests met all requirements specified in Reference 1. Rusted railroad tie-down plates approximately 6 inches by 8 inches by 1/2-inch thick were typically used to simulate the drywell exterior surface. The rusted test panels were prepared using a needle gun, roto-peen, and/or powered wire cup brush to resemble as closely as possible the expected condition of the drywell surface. All loose rust was removed from the panels. Control panels (non-rusted new steel plates for use in tests to establish the painting process) were prepared using a powered wire cup brush to remove light scale.

All test panels were cleaned after surface preparation using fresh water or DEVOE DevPrep 88 water-based cleaner. DevPrep 88 was applied with a two-inch paint brush. During tests outside the sand bed mock-up, panels cleaned with DevPrep 88 were sponged, hosed, or pressure washed (1000 to 1500 psi) with fresh water after DevPrep 88 application. It appears the method of cleaning or rinsing the test panels did not affect subsequent coating application or film thicknesses. However, the coating vendor recommends only high pressure water washing to completely remove the DevPrep 88 cleaner to avoid long term problems with coating performance. To simulate expected conditions on the drywell exterior surface, all test panels painted during process qualification testing (i.e., in the sand bed mock-up) were cleaned with DevPrep 88 and washed with 1000 to 1500 psi water.

TESTS TO ESTABLISH PAINTING PROCESS (see Appendix D for detailed data sheets)

Three people each painted four test panels using 1/2-inch nap rollers and/or two-inch china bristle brushes. The test panels were mounted at approximately a 38 degree angle as specified in Reference 1. When rollers and brushes were used in combination on a single test panel, the order of use was random (i.e., no controls were placed on whether the brush or roller was used first).

One coat of clear Pre-Prime 167 was applied at a target thickness of 1/2 mils. Two coats of Devran 184 were applied at a target thickness of 8 to 10 mils per coat. Personnel painting the test panels measured the wet film thickness of each coat and adjusted application as needed to achieve the target dry film thickness. Since Pre-Prime 167 and Devran 184 are 100% solids coatings, the dry film thickness is the same as the wet film thickness. The air and surface temperatures during coating application were between 70 and 85°F (air temperature is reported on the data sheets as dry bulb/wet bulb). The humidity was between 40 and 60 percent (53% during Pre-Prime 167 application), and the dew point was approximately 55 to 60°F. These temperatures and humidities were within the manufacturer's recommended range for coating application (Reference 2).

Non-destructive dry film thickness measurements were taken after each coat had cured. However, these measurements are thought to be unreliable due to the surface roughness of the test panels. Direct comparisons with destructive dry film thickness measurements cannot be made because measurements were performed at random locations on the test panels. In addition, a baseline measurement on a bare steel test panel was not performed (i.e., the gage was not calibrated for the specific test panel thickness). Therefore, non-destructive dry film thickness measurements taken during these coating tests were not used.

Destructive dry film thickness measurements were taken using a Tooke Paint Inspection Gage IV at three random locations on each test panel and at one high spot and one low spot on each test panel. Each thickness reading reported represents a single measurement (i.e., no averaging was performed before thicknesses were reported). The destructive measurements show that the Pre-Prime 167 coatings were typically up to 1 mil thick (thicknesses less than 1 mil were not measurable and are noted on the data sheets as "<1 mil"). The Devran 184 was typically four to ten mils per coat and was sometimes as thin as two mils per coat. Readings taken at high spots and low spots indicate that coating thickness is not dependent on location (i.e., no thick or thin trends were seen at high or low spots). The film thicknesses achieved during this portion of the testing were thinner than desired; therefore, it was decided that more paint would be used on the brushes and rollers during qualification testing in the mock-up than was used during this initial testing.

Visual inspections were performed after each coat had cured. Several runs in the Devran 184 were seen and two or three drips were typically present at the bottom edge and bolting areas of the test panels. Small bubbles and "blisters" (where bubbles had broken during curing) less than 1/16-inch in diameter were present in the coatings but did not penetrate the entire coating thickness. Wet sponge testing did not indicate any holidays in these runs, drips, bubbles, and blisters.

Visual inspections also revealed that fibers from the 1/2-inch nap rollers were stuck in the Devran 184 coating. This is not desirable because the fibers could create a moisture path (i.e., wick) to the steel. It was decided that shorter nap rollers should be used for qualification testing in the mock-up.

Low voltage holiday detection tests were performed on the test panels after all coats were applied and cured. Two holidays were detected on the test panels. One was at the edge of a hole cut in the test panel. A second holiday was detected away from discontinuities in the test panel. Visual inspections indicated no visible holes or holidays; however, several roller fibers were present in the coating at this location.

A summary of the lessons learned during these initial coating tests is:

- Rollers with nap shorter than 1/2-inch should be tested.
- Two-inch china bristle brushes are acceptable for use.
- More paint should be applied to brushes and rollers than was applied during this testing.
- Non-destructive dry film thickness readings are not reliable on the rough test panel surfaces.

TESTS TO QUALIFY PAINTING PROCESS (see Appendix C for detailed data sheets)

Three people painted a total of eleven test panels in the drywell sand bed area mock-up at Oyster Creek. Two-inch china bristle brushes and 1/4-inch nap rollers were used. Typically, the rollers were used to apply paint to the general surface area and the two-inch china bristle brushes were used to force paint into the low spots (the 1/4-inch nap was not effective in forcing the paint into low spots.) Anti-contamination clothing and respirators were worn to simulate working conditions in the actual sand bed area.

One coat of clear Pre-Prime 167 was applied at a target thickness of 1 1/2 mils. The Pre-Prime 167 was applied once, left for 5 to 10 seconds, then applied a second time. Two coats of Devran 184 were applied at a target thickness of 8 to 10 mils per coat. As much paint as possible was used on the brushes and rollers without the paint dripping off of the brushes and rollers during application. The air and surface temperatures during coating application were between 75 and 85°F, and the dew point was 58 to 66°F. The humidity during Pre-Prime 167 application was 42%, which is slightly below the coating manufacturer's recommended 50% minimum.

Personnel performing these tests reported that they made wet film thickness measurements after each coating was applied to determine whether readings could be taken with the space, lighting, and respirator constraints of the mock-up and that the application method or amount was not changed based on these wet film readings. The wet film thickness of the Pre-Prime 167 could not be measured through the respirator face masks. The wet film thickness readings of each Devran 184 coat were typically 8 to 12 mils; however, destructive dry film thickness measurements on the same test panels ranged from 5 to 17 mils. Therefore, it appears that wet film thickness measurements were unreliable on the rough test panel surfaces.

Non-destructive dry film thickness measurements were taken after each coat had cured. However, as with the process establishment tests, these measurements are thought to be unreliable due to the surface roughness of the test panels. Direct comparisons with destructive dry film thickness measurements cannot be made because non-destructive and destructive measurements were performed at random locations on the test panels. In addition, a baseline measurement on a rusted test panel was not performed (i.e., the gage was not calibrated for the specific test panel thickness). Therefore, non-destructive dry film thickness measurements taken during these coating tests were not used.

A baseline non-destructive dry film thickness measurement was taken on one smooth steel control panel painted outside of the mock-up (test panel 1G; painted at the same time as the panels inside the mockup) to determine if accurate non-destructive readings could be obtained. However, because non-destructive and destructive measurement locations were chosen randomly, no direct thickness comparisons can be made.

Destructive dry film thickness measurements were taken on eight random test panels using the same method as in the process establishment testing. The Pre-Prime 167 thicknesses ranged from 1/2 to 2 mils (measurements recorded as "<1 mil" were taken to be 1/2 mil). Only 15% of the Pre-Prime 167 measurements were less than 1 mil as compared to 70% during process establishment testing. The Devran 184 thicknesses typically ranged from 5 to 17 mils. The film thicknesses achieved during this portion of the testing are acceptable per the coating manufacturer (Reference 1). A statistical analysis using the destructive thickness measurements shows that film thicknesses of 0.4 to 1.7 mils for Pre-Prime 167, 4.9 to 16.0 mils for top coat #1 (Devran 184), and 3.2 to 19.3 mils for top coat #2 (Devran 184) will be achieved on 90% of the coated drywell surface with a 95% confidence level (Reference 4).

Visual inspections were performed after each coat had cured. As with the process establishment testing, minor runs, drips, bubbles, and blisters were seen in the coatings. However, wet sponge testing did not indicate any holidays in these areas. Skips (areas where the previous coating shows through) approximately 1 in^2 were seen in almost all of the coats; however, bare metal was not seen in any of the skips. It is expected that these skips are due to the working conditions and visibility constraints in the mock-up. Roller fibers were not seen in the coatings.

Low voltage holiday detection tests were performed after all coatings had cured. Some holidays existed at discontinuities in the test panels (i.e., edges, bolt areas, or raised ridges).

A summary of the lessons learned during the painting process qualification is:

- The 1/4-inch nap rollers used for testing are acceptable for use (the fibers do not stick in the coatings).

- The 1/4-inch nap rollers are not effective in forcing paint into low spots; therefore, the rollers should be used for general area application and the 2-inch china bristle brushes should be used to force paint into low spots.

- As much paint as possible should be used on brushes and rollers without the paint dripping off the brushes and rollers during application.

- Pre-Prime 167 should be applied, left momentarily (5 to 10 seconds) and then applied again.

- Wet film thickness readings of the clear Pre-Prime 167 cannot be obtained while wearing a respirator.
- Wet film thickness readings are not reliable on the rough test panel surface.
- Painters should be instructed to use extra care to achieve complete coverage with each coat and to apply extra paint on sharp edges or raised ridges.

Section 5

REFERENCES

1. MPR-TP-83161, Rev 2, "Test Plan for Qualifying the Painting Process for the Exterior Surface of the Drywell" (included in the Appendices to this report).

2. DEVOE letter dated July 28, 1992 from Bill Mackay to Dawn Jacobs (MPR).

3. DEVOE product literature for Pre-Prime 167 and Devran 184.

4. MPR Calculation 83161-DWJ-001, "Minimum and Maximum Coating Film Thicknesses Expected on the Drywell Exterior in the Sand Bed Area," Rev 0 (included in the Appendices to this report).

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Appendix A

MINIMUM AND MAXIMUM COATING FILM THICKNESSES EXPECTED IN THE SAND BED AREA

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CALCULATION TITLE PAGE

CLIENT	PAGE 1 OF 9
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PROJECT	TASK NO.
Oyster Creek Drywell Cleaning and Coating	83-161

CALCULATION TITLE	CALCULATION NO. (OPTIONAL)
Minimum and Maximum Coating Film Thicknesses Expected on the Drywell Exterior in the Sand Bed Area	83161-DWS-001

PREPARER(S)/DATE	CHECKER(S)/DATE	REVIEWER(S)/DATE	REV. NO.
D Jacobs 8-4-92	W. Denny Hobart 8-6-92	Tom Fredericks Tom Fredericks 8-4-92	0

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CALCULATION NO.	PREPARED BY	CHECKED BY	PAGE
33161-DWJ-001	D Jacobs	W. B. Hilbert	2

Purpose: To determine the Pre-Prime 167 and Devran 184 coating thicknesses that will be achieved on 90% of the Oyster Creek drywell exterior in the sand bed area with a 95% confidence level.

Results: The following coating thicknesses will be achieved on 90% of the drywell in the sand bed area with 95% confidence:

Coating	Expected Minimum Film Thickness	Expected Maximum Film Thickness
Pre-Prime 167	0.4 mils	1.7 mils
Devran 184 (Top Coat # 1)	4.9 mils	16.0 mils
Devran 184 (Top Coat # 2)	3.2 mils	19.3 mils

Calculation:

Eight test panels were painted with one coat of DEVOE Pre-Prime 167 and two coats of DEVOE Devran 184 using the painting process that will be used on the drywell exterior at Oyster Creek. A total of 39 independent destructive dry film thickness measurements were recorded for each coat of paint (typically 5 measurements per test panel per coat).

The mean and standard deviation of the thicknesses for each coat were calculated using:

$$s = \text{standard deviation} = \sqrt{\frac{n\sum (x_i)^2 - (\sum x_i)^2}{n(n-1)}}$$

$$\bar{x} = \text{mean (average coating thickness)} = \frac{\sum x_i}{n}$$

n = total number of thickness measurements taken

x_i = one individual thickness measurement

Individual thicknesses, means, and standard deviations are shown below:

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CALCULATION NO.	PREPARED BY	CHECKED BY	PAGE
83161-DWJ-001	D. Jacobs	W. B. Hobert	4

Pre-Prime 167:

Thickness Measurements: (From Reference 2; measurements recorded in Ref 2 as "<1 mil" are assumed to be 1/2 mil)

Test Panel Number	Spot Measurement (mils)	Test Panel Number	Spot Measurement (mils)
4A	2, 1, 1/2, 1/2, 1	6A	1, 1, 1, 1 *
5A	1, 1, 2, 1, 1	6B	1, 1, 2, 1, 1
5B	1/2, 1/2, 1, 1, 1	6C	1 1/2, 1, 1, 1, 1
5C	1/2, 1, 1, 1, 1/2		
5D	1, 1, 2, 1, 1		

* only 4 measurements were taken on this test panel

Mean and Standard Deviation Calculations

s = 0.387 (calculated from thickness measurements)

$\bar{x}$ = 1.038 (calculated from thickness measurements)

n = 39

Devran 184 (Top Coat #1):

Thickness Measurements: (from Reference 2)

Test Panel Number	Spot Measurement (mils)	Test Panel Number	Spot Measurement (mils)
4A	10, 15, 10, 15, 11	6A	13, 13, 12, 15 *
5A	8, 6, 13, 6, 12	6B	10, [illegible], [illegible], 15
5B	7, 7, 10, 14, 15	6C	11, 8, 11, 5, 5
5C	7, 10, 7, 13, [illegible]		
5D	15, 13, 12, 7, 11		

* only 4 measurements were taken on this test panel

Mean and Standard Deviation Calculations

s = [illegible] (calculated from thickness measurements)

$\bar{x}$ = [illegible] (calculated from thickness measurements)

n = 3[illegible]

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CALCULATION NO.	PREPARED BY	CHECKED BY	PAGE 5
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Devran 184 (Top Coat # 2):

Thickness Measurements: (from Reference 2)

Test Panel Number	Spot Measurement (mils)	Test Panel Number	Spot Measurement (mils)
4A	8, 7, 8, 8, 7	6A	10, 11, 10, 11 *
5A	16, 10, 17, 16, 32	6B	14, 11, 15, 11, 17
5B	15, 10, 15, 17, 7	6C	8, 8, 11, 8, 6
5C	17, 10, 13, 12, 8		
5D	11, 7, 9, 8, 6		

* only 4 measurements were taken on this test panel

Mean and Standard Deviation Calculations

s = 4.734 (calculated from thickness measurements)

$\bar{x}$ = 11.256 (calculated from thickness measurements)

n = 39

A factor for one-sided tolerance limit (k) of 1.704 was obtained from Table A-7 (Reference 1; attached) by letting:

P = .90 = proportion

γ = .95 = confidence level

n = 39 (interpolated in Table A-7)

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CALCULATION NO.	PREPARED BY	CHECKED BY	PAGE
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Maximum and minimum coating thicknesses that will be achieved on 90% of the coated drywell surface with a 95% confidence level were calculated from:

$$X_U = \bar{X} + (k)(s)$$

$$X_L = \bar{X} - (k)(s)$$

where: X_U = maximum coating thickness
X_L = minimum coating thickness
k = factor for one-sided tolerance limit
$\bar{X}$ = mean
s = standard deviation

Pre-Prime 167:

$X_U = 1.038 + (1.704)(0.387) = 1.7$ mils

$X_L = 1.038 - (1.704)(0.387) = 0.4$ mils

Devran 184: (Top Coat #1)

$X_U = 10.462 + (1.704)(3.259) = 16.0$ mils

$X_L = 10.462 - (1.704)(3.259) = 4.9$ mils

Devran 184: (Top Coat #2)

$X_U = 11.256 + (1.704)(4.734) = 19.3$ mils

$X_L = 11.256 - (1.704)(4.734) = 3.2$ mils

CALCULATION NO.	PREPARED BY	CHECKED BY	PAGE
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References:

1. Experimental Statistics Handbook 91, United States Department of Commerce, National Bureau of Standards, October 1966.
2. Results of Coating Tests Performed Inside the Sand Bed Mock-Up at Oyster Creek (Appendix C to MPR Report 1322).

83161-DWT-001

Prepared: D Gunber[illegible]
Checked: [illegible]

TABLE A-7. FACTORS FOR ONE-SIDED TOLERANCE LIMITS FOR NORMAL DISTRIBUTIONS

Factors K such that the probability is γ that at least a proportion P of the distribution will be less than $\bar{X} + Ks$ (or greater than $\bar{X} - Ks$), where $\bar{X}$ and s are estimates of the mean and the standard deviation computed from a sample size of n.

	$\gamma = 0.75$					$\gamma = 0.90$				
n \ P	0.75	0.90	0.95	0.99	0.999	0.75	0.90	0.95	0.99	0.999
3	1.464	2.501	3.152	4.396	5.805	2.602	4.258	5.310	7.340	9.651
4	1.256	2.134	2.680	3.726	4.910	1.972	3.187	3.957	5.437	7.128
5	1.152	1.961	2.463	3.421	4.507	1.698	2.742	3.400	4.666	6.112
6	1.087	1.860	2.336	3.243	4.273	1.540	2.494	3.091	4.242	5.556
7	1.043	1.791	2.250	3.126	4.118	1.435	2.333	2.894	3.972	5.201
8	1.010	1.740	2.190	3.042	4.008	1.360	2.219	2.755	3.783	4.955
9	0.984	1.702	2.141	2.977	3.924	1.302	2.133	2.649	3.641	4.772
10	0.964	1.671	2.103	2.927	3.858	1.257	2.065	2.568	3.532	4.629
11	0.947	1.646	2.073	2.885	3.804	1.219	2.012	2.503	3.444	4.515
12	0.933	1.624	2.048	2.851	3.760	1.188	1.966	2.448	3.371	4.420
13	0.919	1.606	2.026	2.822	3.722	1.162	1.928	2.403	3.310	4.341
14	0.909	1.591	2.007	2.796	3.690	1.139	1.895	2.363	3.257	4.274
15	0.899	1.577	1.991	2.776	3.661	1.119	1.866	2.329	3.212	4.215
16	0.891	1.566	1.977	2.756	3.637	1.101	1.842	2.299	3.172	4.164
17	0.883	1.554	1.964	2.739	3.615	1.085	1.820	2.272	3.136	4.118
18	0.876	1.544	1.951	2.723	3.595	1.071	1.800	2.249	3.106	4.078
19	0.870	1.536	1.942	2.710	3.577	1.058	1.781	2.228	3.078	4.041
20	0.865	1.528	1.933	2.697	3.561	1.046	1.765	2.208	3.052	4.009
21	0.859	1.520	1.923	2.686	3.545	1.035	1.750	2.190	3.028	3.979
22	0.854	1.514	1.916	2.675	3.532	1.025	1.736	2.174	3.007	3.952
23	0.849	1.508	1.907	2.665	3.520	1.016	1.724	2.159	2.987	3.927
24	0.845	1.502	1.901	2.656	3.509	1.007	1.712	2.145	2.969	3.904
25	0.842	1.496	1.895	2.647	3.497	0.999	1.702	2.132	2.952	3.882
30	0.825	1.475	1.869	2.613	3.454	0.966	1.657	2.050	2.884	3.794
35	0.812	1.458	1.849	2.588	3.421	0.942	1.623	2.041	2.833	3.730
40	0.803	1.445	1.834	2.568	3.395	0.923	1.598	2.010	2.793	3.679
45	0.795	1.435	1.821	2.552	3.375	0.908	1.577	1.956	2.762	3.638
50	0.788	1.426	1.811	2.538	3.358	0.894	1.560	1.965	2.735	3.604

Adapted by permission from *Industrial Quality Control*, Vol. XIV, No. 10, April 1958, from article entitled "Tables for One-Sided Statistical Tolerance Limits" by G. J. Lieberman.

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TABLE A-7 (Continued). FACTORS FOR ONE-SIDED TOLERANCE LIMITS FOR NORMAL DISTRIBUTIONS

*The two starred values have been corrected to the values given by D. B. Owen in "Factors for One-Sided Tolerance Limits and for Variables Sampling Plans", Sandia Corporation Monograph SCR-607, available from the Clearing House for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Va. 22151. The Owen Tables indicate other errors in the table below, not exceeding 4 in the last digit.

	γ = 0.95					γ = 0.99				
n \ P	0.75	0.90	0.95	0.99	0.999	0.75	0.90	0.95	0.99	0.999
3	3.804	6.158	7.655	10.552	13.857	—	—	—	—	—
4	2.619	4.163	5.145	7.042	9.215	—	—	—	—	—
5	2.149	3.407	4.202	5.741	7.501	—	—	—	—	—
6	1.895	3.006	3.707	5.062	6.612	2.849	4.408	5.409	7.334	9.530*
7	1.732	2.755	3.399	4.641	6.061	2.490	3.856	4.730	6.411	8.348
8	1.617	2.582	3.188	4.353	5.686	2.252	3.496	4.287	5.811	7.566
9	1.532	2.454	3.031	4.143	5.414	2.085	3.242	3.971	5.389	7.014
10	1.465	2.355	2.911	3.981	5.203	1.954	3.048	3.739	5.075	6.603
11	1.411	2.275	2.815	3.852	5.036	1.854	2.897	3.557	4.828	6.234
12	1.366	2.210	2.736	3.747	4.900	1.771	2.773	3.410	4.633	6.032
13	1.329	2.155	2.670	3.659	4.787	1.702	2.677	3.290	4.472	5.825
14	1.296	2.108	2.614	3.585	4.690	1.645	2.592	3.189	4.336	5.651
15	1.268	2.068	2.566	3.520	4.607	1.596	2.521	3.102	4.224	5.507
16	1.242	2.032	2.523	3.463	4.534	1.553	2.458	3.028	4.124	5.374
17	1.220	2.001	2.486	3.415	4.471	1.514	2.405	2.962	4.038	5.265
18	1.200	1.974	2.453	3.370	4.415	1.481	2.357	2.906	3.961	5.167
19	1.183	1.949	2.423	3.331	4.364	1.450	2.315	2.855	3.893	5.073
20	1.167	1.926	2.396	3.295	4.319	1.424	2.273	2.807	3.832	5.003
21	1.152	1.905	2.371	3.262	4.276	1.397	2.241	2.768	3.776	4.932
22	1.138	1.887	2.350	3.233	4.228	1.376	2.208	2.729	3.727	4.866
23	1.126	1.869	2.329	3.206	4.204	1.355	2.179	2.693	3.680	4.806
24	1.114	1.853	2.309	3.181	4.171	1.336	2.154	2.663	3.638	4.735
25	1.103	1.838	2.292	3.158	4.143	1.319	2.129	2.632	3.601	4.706
30	1.059	1.778	2.220	3.064	4.022	1.249	2.029	2.516	3.446	4.508
35	1.025	1.732	2.166	2.994	3.934	1.195	1.957	2.431	3.334	4.364
40	0.999	1.697	2.126	2.941	3.866	1.154	1.902	2.365	3.250	4.253
45	0.978	1.669	2.092	2.897	3.811	1.122	1.857	2.313	3.181	4.165
50	0.961	1.646	2.065	2.863	3.766	1.096	1.821	2.269*	3.124	4.096

MPR ASSOCIATES, INC.

Appendix B

TEST PLAN FOR QUALIFYING THE PAINTING PROCESS FOR THE EXTERIOR SURFACE OF THE DRYWELL

10/27/06 15:33:47

MPR-TP-83161-001

OTHER

TEST PLAN FOR

QUALIFYING THE PAINTING PROCESS FOR THE EXTERIOR SURFACE OF THE DRYWELL

OYSTER CREEK

NUCLEAR GENERATING STATION

PREPARATION Dawn Jacobs DATE 6/17/92

ENGINEERING APPROVAL [signature] DATE 6/17/92

REV. 2

	DOCUMENT NO. MPR-TP-83161-001 Page 2 of 16

TITLE Test Plan for Qualifying the Painting Process for the Exterior Surface of the Drywell

REV	SUMMARY OF CHANGE	APPROVAL	DATE
0	Original Issue		
1	Para. 3.1, 4.1.1, 4.2: revised to allow "at least three people" to participate in test instead of "three people." Para. 4.1.2: added two dry film thickness measurement spots (one in a pit and one in a high spot on the rusted surface). Changed "in the same location" to "in the same approximate location." Para. 4.2: added humidity range requirements and dew point requirement. Revised temperature range from 70-90°F to 60-80°F. Para. 4.2: specified that holiday detection (sponge test) shall be done with test panel horizontal with painted side up. Data Sheet 1: added surface temperature and dew point. Data Sheet 2: added dry film thickness measurements in a pit and at a high spot. Data Sheet 2: added Visual Inspections.		
2	Changed document number from OC-TP-402950-001 to MPR-TP-83161-001		

TABLE OF CONTENTS

Article 1

INTRODUCTION

1.1 PURPOSE

The purpose of this document is to provide a test plan for determining the range of coating thicknesses that can be expected on the exterior surface of the drywell in the sandbed area if DEVOE Pre-Prime 167 and Devran 184 paints are applied using brushes and rollers.

This document provides a test plan and evaluation methods to determine:

- Whether or not the recommended wet and dry film thicknesses can be obtained using brushes and rollers and whether any specific precautions or application techniques are needed,
- Whether or not the wet film thickness can be measured using commercially available film thickness gages on the rough drywell surface,
- An estimate of the range of coating thicknesses that will be obtained in the drywell sandbed area with a specified confidence level (statistical analysis), and
- Whether or not holidays or pinholes exist in the coating.

1.2 BACKGROUND

Portions of the drywell exterior surface at Oyster Creek Nuclear Station are corroded due to occasional water leakage from various sources The 1000 square feet which are potentially corroded will be inspected and, based on the inspection results, will be cleaned and coated to minimize future corrosion.

The drywell is a welded carbon steel pressure vessel made of ASTM A-212-61T, Grade B plate. Plates were welded from both sides; the welds are not ground flush on the exterior surface (Reference 2.1).

The drywell steel will be cleaned using various mechanical methods in accordance with Steel Structures Painting Council Surface Preparation Specifications (References 2.2 and 2.3). DEVOE Pre-Prime 167 and Devran 184 epoxy coatings will be applied in accordance with manufacturer's recommendations.

1.3 SCOPE

1.3.1 Establish Painting Process

These initial tests are to be performed outside the sand bed mock-up with adequate lighting and space to allow for a "best possible" paint application. Personnel performing the tests are not required to wear anti-contamination clothing.

Personnel will apply DEVOE Pre-Prime 167 and Devran 184 epoxy coatings to test panel surfaces using brushes and rollers in any combination which works well on the test panel surfaces. During application, the wet film thickness will be measured periodically and adjustments will be made to obtain the recommended dry film thickness. Non-destructive dry film thickness measurements will be taken for each coat. Destructive dry film thickness measurements will be taken after all coats are applied as a check of the non-destructive measurements.

Upon completion of this testing, a process for achieving the desired film thicknesses without using any gages (wet or dry film thickness gages) will have been identified. In addition, personnel will know how to use the wet film thickness gages on the rough drywell exterior (in case these tests indicate that it is necessary to measure wet film thicknesses during painting).

1.3.2 Qualify Painting Process

These tests are to be performed inside the sand bed mock-up with lighting conditions and space constraints similar to those expected in the actual sand bed. Personnel performing the tests are required to wear anti-contamination clothing, respirators, and any other equipment expected to be used in the actual sand bed.

DEVOE Pre-Prime 167 and Devran 184 will be applied to test panel surfaces using brushes and rollers with the painting techniques developed during the previous testing. Wet film thickness measurements will not be performed. The dry film thickness will be measured after each coat. Following testing, the confidence level with which the manufacturer's recommended coating thicknesses can be obtained on the drywell exterior surface will be calculated. Tests will also be performed to determine if holidays or pinholes are present in the coating.

Article 2

CODES, STANDARDS, AND REFERENCES

2.1 Chicago Bridge and Iron Drawing 9-0971, Pressure Suppression Containment Vessels

2.2 Steel Structures Paint'ng Council, Surface Preparation Specification No. 2, "Hand Tool Cleaning."

2.3 Steel Structures Painting Council, Surface Preparation Specification No. 3, "Power Tool Cleaning."

2.4 Steel Structures Painting Council, Paint Application Specification
No. 2, "Measurement of Dry Paint Thickness with Magnetic Gages."

2.5 Steel Structures Painting Council, Good Painting Practice, Steel Structures Painting Manual, Volume I, Chapter 6, "Inspections."

2.6 Steel Structures Painting Council, Surface Preparation Specification No. 1, "Solvent Cleaning."

2.7 ASTM D4138, "Dry Film Thickness of Protective Coating Systems by Destructive Means."

2.8 MPR Calculation, "Statistical Analyses for Coating Thickness Tests" 83-161, D. Jacobs, 8-13-92.

2.9 Experimental Statistics Handbook 91, United States Department of Commerce, National Bureau of Standards.

2.10 ASTM G62, Standard Test Methods for Holiday Detection in Pipeline Coatings, 1979.

Article 3

EQUIPMENT

3.1 Clean and corroded carbon steel material for the test panels. Any type of low carbon steel is acceptable. The corroded carbon steel will have a thick coating (1/8 to 1/4-inch, if possible) of layered, flaky rust. The test panels will be as flat as possible, at least 30 in^2, and will have at least 1/4-inch of good steel remaining under the rust. As a minimum, the following test panels are needed:

- Establish Painting Process:
  - 3 clean (i.e., new steel; never rusted) to be used as control panels, and
  - 3 previously rusted/hand or power tool cleaned to resemble as closely as possible the drywell exterior surface after cleaning.

  Note: This allows three people to participate in the test, including one clean and one previously rusted test panel per person. Additional test panels will be required if more than three people participate, or many variations of the painting process are tested.

- Qualify Painting Process:
  - 10 previously rusted/hand or power tool cleaned to resemble as closely as possible the drywell exterior surface after cleaning.

  Note: Ten panels are needed regardless of how many people (up to ten) participate in this test.

3.2 Hand and power descaling tools to be used to clean and condition the test panel surfaces. The tools will typically be chosen from "Rust Removal and Steel Conditioning Tools for Use in the Oyster Creek Sandbed Area" dated February 18, 1992.

3.3 The coatings to be tested (DEVOE Pre-Prime 167 and Devran 184) and brushes and rollers for application.

3.4 Wet film thickness gage, non-destructive dry film thickness gage, and destructive dry film thickness gage. See References 2.4 and 2.7.

3.5 Solvent for removal of oil, grease and dirt from test panels (DevPrep 88) and thinner for tool clean-up after painting (DEVOE T-10).

3.6 Low voltage wet-sponge type holiday detector and wetting agent.

Article 4

TEST DESCRIPTION

4.1 ESTABLISH PAINTING PROCESS

4.1.1 Description

The candidate coating material will be applied to test panels using brushes and rollers in any combination which works well on the test panel surfaces. The following carbon steel test panel types will be used:

1. Clean (non-rusted, free of oil, grease and other contaminants and prepared in accordance with the coating manufacturer's recommendations) to be used as control tests.
2. Previously rusted (general wastage) and prepared using any combination of impact hand tools, hand wire brushing, hand abrading, hand scraping, and rotary or impact power tools specified in References 2.2 and 2.3. All loose rust shall be removed (rust is considered loose if it can be lifted with a dull putty knife). After cleaning, the test panels shall resemble as closely as possible the expected drywell exterior surface after cleaning.

The test panels will be as flat as possible and the steel (not including rust) will be at least .25 inches thick. If necessary, oil, grease, or other soluble contaminants will be removed from test panels in accordance with Reference 2.6. Product identification information and generic types will be recorded for each solvent, hand cleaning tool and power cleaning tool used to prepare the test panels.

In order to estimate the variability in this painting process due to differences among individual painting technique, more than one person is needed for these tests; at least three people should participate. Each person will apply the coating to one clean and one previously rusted test panel using brushes and rollers in a combination which works well on the test panel surfaces. The brush/roller combination will be documented on Data Sheet 1 (attached).

One or more primer coats and one or more top coats will be applied in accordance with manufacturer's recommendations, with the exception of application method. If possible, a different color will be used for each coat for ease of dry film thickness measuring (destructive means). To simulate drywell exterior configuration, all test panels will be mounted at approximately 38 degrees as shown in Figure 1. These tests (to establish the painting process) are to be performed outside the sand bed mock-up with adequate lighting and space to allow for a "best possible" paint application. Anti-contamination clothing is not required during these tests.

Comments will be recorded on the ease of brush and roller application of the coating, as well as any problems and solutions in applying the coating.

4.1.2 Measurements

The following will be measured for each coat of primer and topcoat recommended by the manufacturer:

1. Wet film thickness using a wet film thickness gage.
2. Dry film thickness in accordance with Reference 2.4 (non-destructive).
3. Dry film thickness in accordance with Reference 2.7 (destructive).

During application, the wet film thickness will be measured periodically and adjusted to obtain the manufacturer's recommended dry film thickness. Both the Pre-Prime 167 and Devran 184 are 100 percent solids, so that the wet and dry film thicknesses should be approximately the same.

Non-destructive dry film thickness will be measured for each coat after the manufacturer's recommended recoat time or when the coating has dried sufficiently so that the probe does not indent the surface. Three separate spot measurements (each spot measurement is an average of three readings - see Reference 2.4) will be made on each test panel after each coat of primer and top coat. The spots will be selected randomly. On each test panel, the readings for subsequent layers will be taken in the same approximate locations as the readings for previous layers to minimize the effect of surface roughness on the readings. For rough pitted test plates, two additional spot measurements will be made; one in a pit and one at a high point. These data points will be used to check for coating filling and thinning at pits and high points.

Destructive dry film thickness will be measured after all coats have been applied and the top coat has dried to recoat (manufacturer's recommended recoat time). Three separate spot measurements (each spot measurement consists of four readings - See Reference 2.7) will be made on each test panel.

The information outlined on Data Sheets 1 and 2 (attached) will be documented. Examples of completed data sheets are also attached.

4.2 QUALIFY PAINTING PROCESS

The paint will be applied to test panels using brushes and/or rollers with the application techniques developed during Section 4.1 above. The brush/roller combination will be documented on Data Sheet 1 (attached). Wet film thickness gages will not be used during application. Previously rusted test panels will be used which have been cleaned using the types of power and/or hand tools planned for use on the exterior drywell surface. The test panels will be as flat as possible and the steel (not including rust) will be at least .25 inches thick. If necessary, oil, grease, or other soluble contaminants will be removed from the test panels in accordance with Reference 2.6.

The work surface of the test panels will resemble as closely as possible the expected condition of the drywell exterior surface after hand or power tool cleaning. The working conditions will resemble as closely as possible the expected conditions during actual drywell sandbed area painting.

Specifically:

- The test panels will be mounted in the sandbed area mockup at Oyster Creek.
- The temperature will be between 60°F and 85°F.
- The relative humidity will be between 50 and 100 percent while the Pre-Prime 167 is applied and curing. There is no requirement as to the dew point.
- The relative humidity will be between zero and 100 percent while the Devran 184 is applied and cured. The temperature of the test panel must be at least 5°F higher than the dew point while the Devran 184 is applied and cured.
- The test personnel will wear the clothing/equipment that will be worn in the drywell sandbed area.
- Lighting will be similar to that expected in the drywell sandbed area.

Product identification information and generic types will be recorded on Data Sheet 1 (attached) for the solvent, cleaning tools, and coatings used on the test panels. During painting, the applicable information outlined on Data Sheet 1 will also be documented.

The following test and associated measurements will be performed for each coat of primer and top coat. The primer will be tested first. The confidence level with which the manufacturer's recommended film thickness can be obtained on the drywell exterior surface will be determined as follows:

- The same people who performed the testing in Section 4.1 (Establish Painting Process) will perform this testing (Qualify Painting Process).
- The coating will be applied to a total of ten test panels with brushes and/or rollers using the process established in Section 4.1.

- After the manufacturer's recommended recoat time, one spot measurement using the destructive or non-destructive dry film thickness measurement technique will be taken on each test panel and recorded on Worksheet 1. (An example of a completed Worksheet is attached)
- The mean and standard deviation of the coating thicknesses that were obtained during testing will be calculated as shown on Worksheet 1.
- The mean and standard deviation calculated above will be used to calculate factors for one-sided tolerance (K) as shown on Worksheet 1.
- The factors (K) calculated above will be used with Table A-7 from Reference 2.9 (attached) to determine two confidence levels; the confidence that the coating in the drywell will be above the minimum allowable thickness, and the confidence that the coating in the drywell will be below the maximum allowable thickness.

The above procedure will be repeated once for an additional primer coat (if required) and twice for the top coat. The first top coat will be applied over the primer, and the second top coat will be applied over the first top coat.

A holiday detection test will be performed on each test panel after all coats have been applied and the final top coat has dried to recoat. For this test, the panels will be removed from the inclined position and placed on a horizontal surface with the painted side facing upward. The test will be performed in accordance with ASTM G62, Method A (low voltage wet sponge test; Reference 2.10). A wetting agent will be used in accordance with the test equipment manufacturer's instructions. The information outlined on Data Sheet 3 (attached) will be documented. An example of a completed Data Sheet is also attached.

Two of the coated test panels (to be chosen by GPUN) will be provided to the Material Engineering group in Parsippany at the completion of process qualification testing.

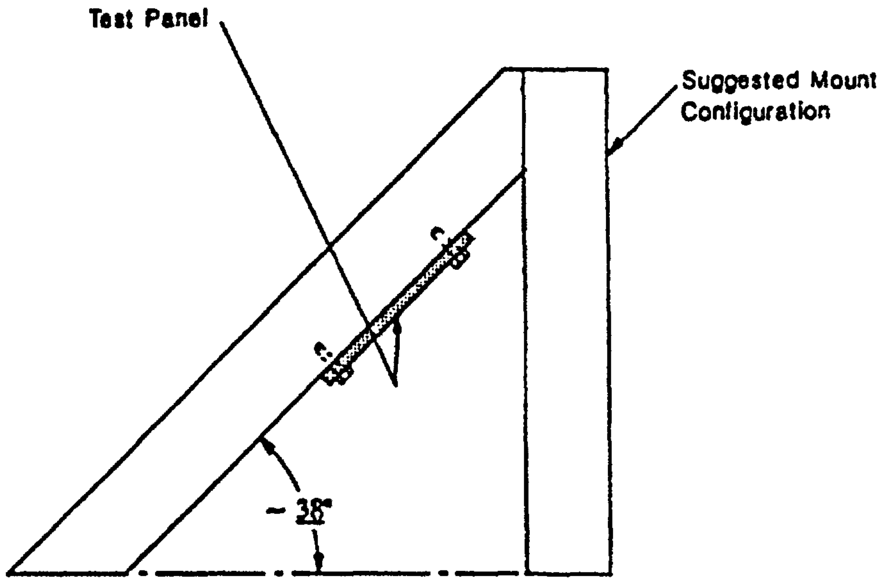


Figure 1. Test Panel Mounting

Article 5

QUALITY ASSURANCE

The drywell exterior coating is Other (i.e., not important to safety). Accordingly, the coating and this test do not fall under the operational QA program. The testing specified in this document will be performed in accordance with good commercial practice.

Data sheets used to record results will be signed and dated by person(s) who performed the testing and by a reviewer. These signatures will indicate that the data provided is considered correct and complete.

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: __________ Test Panel No.: __________ Test Panel Thickness: __________

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): ______________________________

Cleaning Tools Used (attach product info.): ______________________________

____

Comments: ______________________________

____

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type				
Type of Brush (or Roller; list roller nap size)				
Air Temperature (°F)				
Surface Temperature (°F)				
Relative Humidity				
Dew Point (°F)				
Dry Time Before Non-Destructive Measurement(hours)				
Dry Time Before Recoating (hours)				

*Comments: ______________________________

____

Test Performed by: __________

Results Reviewed by: __________

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: __________ Test Panel No.: __________ Test Panel Thickness: __________

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination

Wet Film Thickness:

Instrument Type (attach product info.): ______________________________

Target Thickness per Coat: Primer ______________ Top Coat ______________

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: ______________________________

Primer Coat 2: ______________________________

Top Coat 1: ______________________________

Top Coat 2: ______________________________

Describe any Changes to Application Method Based on Measurements: __________

____

____

____

Data Sheet No. 2 (Cont.)

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs				
Sags				
Orange Peel				
Cracking				

Data Sheet No. 2 (Cont.)

<u>Non-Destructive Dry Film Thickness</u>:

Instrument Type (attach product info.): ____________________

Target Thickness per Coat: Primer ____________ Top Coat ____________.

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): ____________________

Spot 2 (Randomly selected location) : ____________________

Spot 3 (Randomly selected location): ____________________

Spot 4 (Pit): ____________________

Spot 5 (High Point): ____________________

Test Performed by: ____________
Results Reviewed by: ____________

Test Panel No.____

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*				
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): ______________________

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*				
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: ______________

Results Reviewed by: ______________

Data Sheet No. 3

HOLIDAY DETECTION

Date: __________ Test Panel No.: __________

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination

Holiday Detection:

Are holidays present in the coating? (circle one): Yes No

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: ____

____

____

____

____

WORK SHEET NO. 1

CONFIDENCE LEVEL CALCULATIONS

Date: ____________________ Test Panel Numbers: __________________________

Coating Type (circle one): Primer Top Coat

Definitions/Equations

s = standard deviation = $\sqrt{\dfrac{n\sum(x_i)^2 - (\sum x_i)^2}{n(n-1)}}$

$\bar{x}$ = mean (average coating thickness) = $\dfrac{\sum x_i}{n}$

n = total number of tests performed

x_i = one spot thickness measurement (the average of three or four individual measurements; References 2.4 and 2.7)

$\sum X_i$ = total of all spot measurements

x_U = maximum allowable coating thickness (x_{PU} for primer, x_{TU} for top coat)

x_L = minimum allowable thickness (x_{PL} for primer, x_{TL} for top coat)

K_U = factor for one-sided tolerance limited for maximum allowable coating thickness (Table A-7, attached)

K_L = factor for one-sided tolerance limit for minimum allowable coating thickness (Table A-7, attached)

$$K_U = \frac{x_U - \bar{x}}{S}$$

$$K_L = \frac{\bar{x} - x_L}{S}$$

P = proportion

γ_U = confidence level that coating thickness in drywell will be less than or equal to x_U

γ_L = confidence level that coating thickness in drywell will be greater than or equal to x_L

Date: ________
Test Panels: ________

WORKSHEET NO. 1 (CONT.)

Allowable Values

$P = 0.90$

$x_{PL} = 2$ mils $x_{PU} = 3$ mils

$x_{TL} = 8$ mils $x_{TU} = 14$ mils

Calculations

Thickness Gauge Used (circle one): Destructive   Non-Destructive

Thickness Measurements:

Test Panel Number	Spot Measurement (mils)	Test Panel Number	Spot Measurement (mils)

Mean and Standard Deviation Calculations

$s =$ ________ (calculated from thickness measurements)

$\bar{x} =$ ________ (calculated from thickness measurements)

Confidence

$K_L =$ ________

$K_U =$ ________

$\gamma_L =$ ________ (interpolated from Table A-7, attached)

$\gamma_U =$ ________ (interpolated from Table A-7, attached)

TABLE A-7. FACTORS FOR ONE-SIDED TOLERANCE LIMITS FOR NORMAL DISTRIBUTIONS

Factors K such that the probability is γ that at least a proportion P of the distribution will be less than $\bar{X} + Ks$ (or greater than $\bar{X} - Ks$), where $\bar{X}$ and s are estimates of the mean and the standard deviation computed from a sample size of n.

	$\gamma = 0.75$					$\gamma = 0.90$				
n \ P	0.75	0.90	0.95	0.99	0.999	0.75	0.90	0.95	0.99	0.999
3	1.464	2.501	3.152	4.396	5.805	2.602	4.258	5.310	7.340	9.651
4	1.256	2.134	2.680	3.726	4.910	1.972	3.187	3.957	5.437	7.128
5	1.152	1.961	2.463	3.421	4.507	1.698	2.742	3.400	4.666	6.112
6	1.087	1.860	2.336	3.243	4.273	1.540	2.494	3.091	4.242	5.556
7	1.043	1.791	2.250	3.126	4.118	1.435	2.333	2.894	3.972	5.201
8	1.010	1.740	2.190	3.042	4.008	1.360	2.219	2.755	3.783	4.955
9	0.984	1.702	2.141	2.977	3.924	1.302	2.133	2.649	3.641	4.772
10	0.964	1.671	2.103	2.927	3.858	1.257	2.065	2.568	3.532	4.629
11	0.947	1.646	2.073	2.885	3.804	1.219	2.012	2.503	3.444	4.515
12	0.933	1.624	2.048	2.851	3.760	1.188	1.966	2.448	3.371	4.420
13	0.919	1.606	2.026	2.822	3.722	1.162	1.928	2.403	3.310	4.341
14	0.909	1.591	2.007	2.796	3.690	1.139	1.895	2.363	3.257	4.274
15	0.899	1.577	1.991	2.776	3.661	1.119	1.866	2.329	3.212	4.215
16	0.891	1.566	1.977	2.756	3.637	1.101	1.842	2.299	3.172	4.164
17	0.883	1.554	1.964	2.739	3.615	1.085	1.820	2.272	3.136	4.118
18	0.876	1.544	1.951	2.723	3.595	1.071	1.800	2.249	3.106	4.078
19	0.870	1.536	1.942	2.710	3.577	1.058	1.781	2.228	3.078	4.0[illegible]
20	0.865	1.528	1.933	2.697	3.561	1.046	1.765	2.206	3.052	4.0[illegible]
21	0.859	1.520	1.923	2.686	3.545	1.035	1.750	2.190	3.028	3.979
22	0.854	1.514	1.916	2.675	3.532	1.025	1.736	2.174	3.007	3.952
23	0.849	1.508	1.907	2.665	3.520	1.016	1.724	2.159	2.987	3.927
24	0.845	1.502	1.901	2.656	3.509	1.007	1.712	2.145	2.969	3.904
25	0.842	1.496	1.895	2.647	3.497	0.999	1.702	2.132	2.952	3.882
30	0.825	1.475	1.869	2.618	3.454	0.966	1.657	2.080	2.884	3.794
35	0.812	1.458	1.849	2.588	3.421	0.942	1.623	2.041	2.833	3.730
40	0.803	1.445	1.834	2.568	3.395	0.923	1.598	2.010	2.793	3.679
45	0.795	1.435	1.821	2.552	3.375	0.908	1.577	1.986	2.762	3.638
50	0.788	1.426	1.811	2.538	3.358	0.894	1.560	1.965	2.735	3.604

Adapted by permission from *Industrial Quality Control*, Vol. XIV, No. 10, April 1958, from article entitled "Tables for One-Sided Statistical Tolerance Limits" by G. J. Lieberman.

TABLE A-7 (Continued). FACTORS FOR ONE-SIDED TOLERANCE LIMITS FOR NORMAL DISTRIBUTIONS

*The two starred values have been corrected to the values given by D. B. Owen in "Factors for One-Sided Tolerance Limits and for Variables Sampling Plans", Sandia Corporation Monograph SCR-607, available from the Clearing House for Federal Scientific and Technical Information, U S Department of Commerce, Springfield, Va. 22151. The Owen Tables indicate other errors in the table below, not exceeding [illegible] the last digit.

	$\gamma = 0.95$					$\gamma = 0.99$				
n \ P	0.75	0.90	0.95	0.99	0.999	0.75	0.90	0.95	0.99	0.999
3	3.804	6.158	7.655	10.552	13.857	—	—	—	—	—
4	2.619	4.163	5.145	7.042	9.215	—	—	—	—	—
5	2.149	3.407	4.202	5.741	7.501	—	—	—	—	—
6	1.895	3.006	3.707	5.062	6.612	2.849	4.408	5.409	7.334	9.550*
7	1.732	2.755	3.399	4.641	6.061	2.490	3.856	4.730	6.411	8.348
8	1.617	2.582	3.188	4.353	5.686	2.252	3.496	4.287	5.811	7.566
9	1.532	2.454	3.031	4.143	5.414	2.085	3.242	3.971	5.389	7.014
10	1.465	2.355	2.911	3.981	5.203	1.954	3.048	3.739	5.075	6.603
11	1.411	2.275	2.815	3.852	5.036	1.854	2.897	3.557	4.828	6.284
12	1.366	2.210	2.736	3.747	4.900	1.771	2.773	3.410	4.633	6.032
13	1.329	2.155	2.670	3.659	4.787	1.702	2.677	3.290	4.472	5.826
14	1.296	2.108	2.614	3.585	4.690	1.645	2.592	3.189	4.336	5.651
15	1.268	2.068	2.566	3.520	4.607	1.596	2.521	3.102	4.224	5.507
16	1.242	2.032	2.523	3.463	4.534	1.553	2.458	3.028	4.124	5.374
17	1.220	2.001	2.486	3.415	4.471	1.514	2.405	2.962	4.038	5.268
18	1.200	1.974	2.453	3.370	4.415	1.481	2.357	2.906	3.961	5.167
19	1.183	1.949	2.423	3.331	4.364	1.450	2.315	2.855	3.893	5.078
20	1.167	1.926	2.396	3.295	4.319	1.424	2.275	2.807	3.832	5.003
21	1.152	1.905	2.371	3.262	4.276	1.397	2.241	2.768	3.776	4.932
22	1.138	1.887	2.350	3.233	4.238	1.376	2.208	2.729	3.727	4.866
23	1.126	1.869	2.329	3.206	4.204	1.355	2.179	2.693	3.680	4.806
24	1.114	1.853	2.309	3.181	4.171	1.336	2.154	2.663	3.638	4.755
25	1.103	1.838	2.292	3.158	4.143	1.319	2.129	2.632	3.601	4.706
30	1.059	1.778	2.220	3.064	4.022	1.249	2.029	2.516	3.446	4.508
35	1.025	1.732	2.166	2.994	3.934	1.195	1.957	2.431	3.334	4.364
40	0.999	1.697	2.126	2.941	3.866	1.154	1.902	2.365	3.250	4.255
45	0.978	1.669	2.092	2.897	3.811	1.122	1.857	2.313	3.181	4.168
50	0.961	1.646	2.065	2.863	3.766	1.096	1.821	2.269*	3.124	4.096

MPR ASSOCIATES, INC.

Appendix C

RESULTS OF COATING TESTS PERFORMED INSIDE THE SAND BED MOCK-UP AT OYSTER CREEK

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-17-92 Test Panel No.: 4-A Test Panel Thickness: 9/16"

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Dev Prep 88

Cleaning Tools Used (attach product info.): Needle Gun and Power Wire Cup Brush

Comments: Test Sample mounted on interior of mock-up in Building #10

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	None	N/A	NONE	NONE
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush		2" China Bristle Brush	2" China Bristle Brush
Air Temperature (°F)	88°/69°		80°/67°	76°/69°
Surface Temperature (°F)	87.8°		80.4°	75.6°
Relative Humidity	42°		50%	70%
Dew Point (°F)	58°		60°	66°
Dry Time Before Non-Destructive Measurement (hours)	24 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	24 Hrs		24 Hrs	~~24 Hrs+~~ N/A

*Comments:

Test Performed by: [signature]
Results Reviewed by: D. [signature]

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: 6-17-92 Test Panel No.: 4A Test Panel Thickness: 9/16"

Test Panel Type (circle one): Clean (i.e., new steel) ~~Previously Rusted~~ (circled)

Coating Application (circle one): Brush (circled) Roller Combination

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot): Removal of Gauge proved extremely difficult. Results

Primer Coat 1: Repeatable. No Set Location Noted

Primer Coat 2: N/A Reading Erratic to take.

Top Coat 1: Readings taken various areas 8 to 11 Mils

Top Coat 2: Reading Taken Various Areas 9 to 11 Mils

Describe any Changes to Application Method Based on Measurements: Wet Readings Taken in Error of Procedure. Procedure Required No Wet Readings To Be Taken.

Data Sheet No. 2 (Cont.)

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	NONE	N/A	~~NONE~~ 1-1/4 x 4"	NONE
Sags	NONE		NONE	NONE
Orange Peel	NONE		NONE	NONE
Cracking	NONE		NONE	NONE
~~HOLIDAY~~ SKIPS	#1		1 PIN HOLE	APPROX 1%
DRIPS			NONE	SEVERAL #3
				#2

#1 SEVERAL DRIPS AT BOTTOM OF TEST PANEL.

#2 APPEARS TO HAVE SEVERAL GRAINS OF SAND IN THE TOP COAT.

#3 DRIPS ON RAISED PORTION OF TEST PANEL.

Data Sheet No. 2 (Cont.)

4A

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): PosiTector 6000

Target Thickness per Coat: Primer 1½ M.I Top Coat 8 to 10 M.I.

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): 1.5 AVE

Spot 2 (Randomly selected location) : 3 AVE

*1 Spot 3 (Randomly selected location): 2.5 AVE

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

*1. Surface irregularities make accurate reading extremely difficult.

10/27/06 15:33:47

Test Panel No. 4-A

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1.5 Ave	N/A	8.5 : 9.7	22.6 17.8 21.3
Spot 2*	3 Ave		10.7 - 16.1	20.5 19.1 18.3
Spot 3*	8.5 Ave		10.5 - 18.6	15.9 16.0 26.7
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): N/A

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: D. Quarbe

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

uA

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage [illegible]

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	2.0	N/A	10.0	8.0
Spot 2*	1.0	N/A	15.0	7.0
Spot 3*	<1.0	N/A	10.0	8.0
Spot 4* (Pit)	<1.0	N/A	15.0	8.0
Spot 5* (High Point)	1.0	N/A	11.0	7.0

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6-29-92 Test Panel No.: 4A

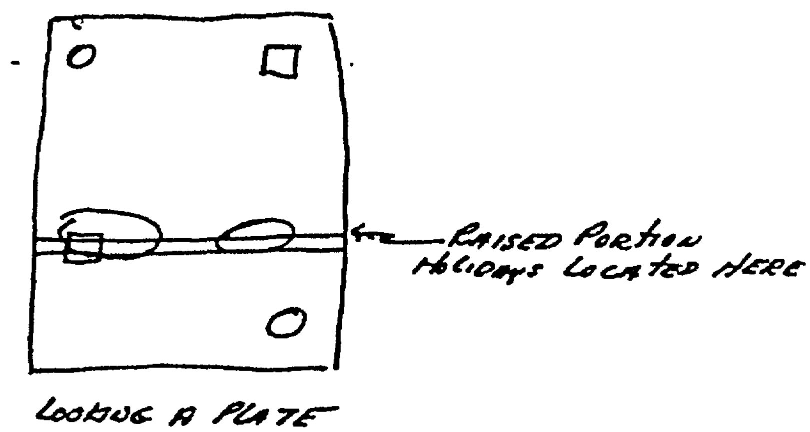
Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): **(Brush)** Roller Combination

Holiday Detection:

Are holidays present in the coating? (circle one): **(Yes)** No

If yes, show a sketch of the test panel and indicate the locations of the holidays:



Comments: HOLIDAY DETECTION TEST DONE WITH PANELS IN INSTALLED POSITION. HOLIDAY NOTED ABOVE LOCATED ON SHARP LIP (RAISED LIP) OF TEST PLATE.

10/27/06 15:33:47

Interior

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-17-92 Test Panel No.: 4B Test Panel Thickness: 9/16"

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted [circled]

Coating Application (circle one): Brush Roller Combination [circled] (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devlkep 88

Cleaning Tools Used (attach product info.): Needle Gun and Power Wire Cup Brush

Comments: Test plates mounted on interior of mock-up in Building #10

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	None	N/A	None	None
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush, 3/8" Nap Roller		2" China Bristle Brush, 3/8" Nap Roller	2" China Bristle Brush, 3/8" Nap Roller
Air Temperature (°F)	83°/67°		80°/67°	76°/67°
Surface Temperature (°F)	82.8°		80.4°	75.6°
Relative Humidity	42%		50%	70%
Dew Point (°F)	58°		[illegible]0°	66°
Dry Time Before Non-Destructive Measurement (hours)	24 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	24 Hrs		24 Hrs	N/A

*Comments: 3/8" Nap Roller does not allow for proper application of material. Requires a lot of brush work. Roller cannot properly coat pores

Test Performed by: [signature]
Results Reviewed by: D. Jacob[signature]

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS
VISUAL INSPECTIONS, AND
DRY FILM THICKNESS MEASUREMENTS

Date: 6-17-92 Test Panel No.: 4B Test Panel Thickness: 9/16"

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush Roller **(Combination)**

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: Readings Cannot Be Properly [illegible] Taken. Reading of Gauge Through Application difficult. No Set Locations Noted.

Primer Coat 2: N/A

Top Coat 1: Readings Easier to Take. Taken Various Areas on plate 8 to 12 Mils [illegible]

Top Coat 2: Readings taken Various Areas 8 to 9 Mils

Describe any Changes to Application Method Based on Measurements: Application of primer using ¼" Nap Roller proved inadequate. Primer is not forced into pits. ¼" Nap does not hold sufficient material for application. Requires a lot of brush work. WET READING TAKEN ARE IN ERROR OF PROCEDURE; Procedure REQUIRES NOT WET TO BE TAKEN.

Data Sheet No. 2 (Cont.)

4B

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	NONE	N/A	NONE	NONE
Sags	NONE		NONE	NONE
Orange Peel	NONE		NONE	NONE
Cracking	NONE		NONE	NONE
[illegible] SKIPS			2	1½" sq
SAND CONTAM.			1 SQ IN	1 sq in

Data Sheet No. 2 (Cont.)

4B

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): PosiTector 6000

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): .9 - 1.8

#1 Spot 2 (Randomly selected location) : .6 - 6.3

Spot 3 (Randomly selected location): 2.1 - 4.7

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: [signature]
Results Reviewed by: [signature]

#1. Surface irregularities makes accurate readings extremely difficult

Test Panel No. 4-6

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	.9 to 1.8	N/A	10.0 - 16.2	24.3 23.8 25.7
Spot 2*	.6 to 6.3		12.9 - 15.3	25.5 22.3 19.3
Spot 3*	2.1 to 9.7		9.7 - 15.5	31.2 30.1 21.9
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): N/A

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6-29-96 Test Panel No.: 4B

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)** [circled]

Coating Application (circle one): Brush Roller **(Combination)** [circled]

Holiday Detection:

Are holidays present in the coating? (circle one): Yes **(No)** [circled]

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Detection Test done with panels in as installed position.

Data Sheet No. 1 Jokerio

TEST PANEL PREPARATION AND COATING

Date: 6-17-92 Test Panel No.: 4C Test Panel Thickness: 9/16"

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devlcon 88

Cleaning Tools Used (attach product info.): [illegible] Gun and Power Wire Cup Brush

Comments: Test Samples mounted on [illegible] in Building #10.

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	None	N/A	None	None
Type of Brush (or Roller; list roller nap size)	2" China Bristle Bevel ¾" Nap Roller		2" China Bristle Bevel ¾" Nap Roller	2" China Bristle Bevel ¾" Nap Roller
Air Temperature (°F)	83°/67°		80°/68°	76°/69°
Surface Temperature (°F)	82.8°		80.4°	75.6°
Relative Humidity	42%		50%	70%
Dew Point (°F)	58°		60°	66°
Dry Time Before Non-Destructive Measurement (hours)	24 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	24 Hrs		24 Hrs	N/A

*Comments: ¾" Nap Roller does not allow for proper application of material [illegible]

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: *6-17-92* Test Panel No.: *4C* Test Panel Thickness: *9/16*

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush Roller **(Combination)**

Wet Film Thickness:

Instrument Type (attach product info.): *Wet Film Thickness Gauge*

Target Thickness per Coat: Primer *1½ Mils* Top Coat *8 to 10 Mils/Coat*

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: *Running of Gauge through Resperature extremely difficult. Readings cannot be properly taken. No set locations noted.*

Primer Coat 2: *N/A*

Top Coat 1: *Readings Easier to take. Taken various areas on Plates. 8 to 12 WFT ...*

Top Coat 2: *Readings taken various areas 10 to 12 Mils*

Describe any Changes to Application Method Based on Measurements: *Application of primer using ¼" Nap Roller proved inadequate. Primer is not forced into pits. ¼" Nap does not hold sufficient material for application to sample plate. ½" Nap Roller Recommend. Requires a lot of brush work.*

WFT READINGS TAKEN IN ERROR OF PROCEDURE. PROCEDURE REQUIRES NO WFT READING TO BE TAKEN.

Data Sheet No. 2 (Cont.)

4C

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	NONE	N/A	NONE	1 APPROX 1" LONG
Sags	NONE		NONE	NONE
Orange Peel	NONE		NONE	NONE
Cracking	NONE		NONE	NONE
DRIPS			SEVERAL	SEVERAL
HOLIDAYS SKIPS			APPROX 2½ SQ IN	LESS THAN 1 SQ"
*1				*1

*1 WET FILM GUAGE MARKS

Data Sheet No. 2 (Cont.)

4C

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Posi Teche 2000

Target Thickness per Coat: Primer 1½ mil Top Coat 9 to 10 Mil

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

#1. Spot 1 (Randomly selected location): 1.2 - 3.0

Spot 2 (Randomly selected location) : 2.0 - 4.1

Spot 3 (Randomly selected location): 1.1 - 2.7

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

#1. Surface irregularities makes accurate Reading Extremely difficult

Test Panel No. 7C

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1.2 to 3.0	N/A	11.0 - 18.2	19.1 27.0 21.2
Spot 2*	2.0 to 4.1		10.5 - 15.4	30.7 31.0 32.0
Spot 3*	1.1 to 2.7		11.6 - 20.1	25.1 26.7 24.0
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): N/A

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*				
Spot 4* (Pit)		N/A		
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/29/92 Test Panel No.: 4C

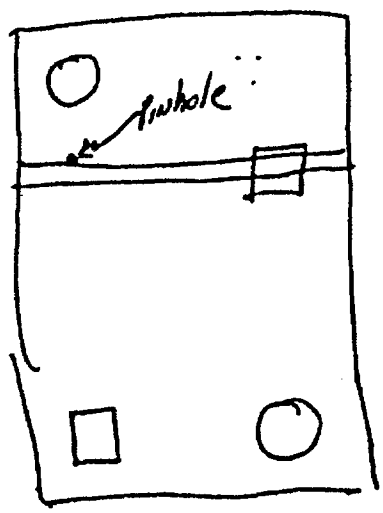
Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)** [circled]

Coating Application (circle one): Brush Roller **(Combination)** [circled]

Holiday Detection:

Are holidays present in the coating? (circle one): **(Yes)** [circled] No

If yes, show a sketch of the test panel and indicate the locations of the holidays:



Comments: Holiday Detection Test done with test panel in as mounted position. Holiday noted above located on Rusted portion of test panel.

Interior

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-17-92 Test Panel No.: 4D Test Panel Thickness: 9/16"

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devlkeep 88

Cleaning Tools Used (attach product info.): Needle Gun and Power Wire Cup Brush

Comments: Test sample mounted on interior of mock-up in Building #10

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	None		None	None
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush ¼" Nap Roller		2" China Bristle Brush ¼" Nap Roller	2" China Bristle Brush ¼" Nap Roller
Air Temperature (°F)	83°/67°		80°/67°	76°/69°
Surface Temperature (°F)	82.8°		80.4°	75.6°
Relative Humidity	42%		50%	70%
Dew Point (°F)	58°		60°	66°
Dry Time Before Non-Destructive Measurement (hours)	24 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	24 Hrs		24 Hrs	N/A

*Comments: ¼" Nap Roller does not allow for proper application of material. Requires a lot of brush work. Roller cannot properly coat pores

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: *6-17-92* Test Panel No.: *4D* Test Panel Thickness: *5/8*

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush Roller **(Combination)**

Wet Film Thickness:

Instrument Type (attach product info.): *Wet Film Thickness Gauge*

Target Thickness per Coat: Primer *1½ Mils* Top Coat *8 to 10 Mil*

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: *Readings cannot be properly taken. Reading of gauge through respirator extremely difficult. No set location noted.*

Primer Coat 2: *N/A*

Top Coat 1: *Readings to be easier to make* *Readings taken various location 8 to 10 Mils*

Top Coat 2: *Reading taken various location 10 to 12 Mils*

Describe any Changes to Application Method Based on Measurements: *Application of primer using ¼" Nap Roller proved inadequate. Primer is not forced into pits. ¼" Nap does not hold sufficient material for application to sample plate. Requires a lot of brush work. WET READINGS TAKEN IN ERROR OF PROCEDURE. PROCEDURE REQUIRES NO WET READINGS TO BE TAKEN*

Data Sheet No. 2 (Cont.)

4D

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None	N/A	None	None
Sags	None		None	None
Orange Peel	None		None	None
Cracking	None		None	None
[illegible] Skips			1 spot	Less than 1"
Dust Contam			Various small areas	
*				*

* small bubbles in coating

Data Sheet No. 2 (Cont.)

4D

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Positector 2000

Target Thickness per Coat: Primer 1½ Mil Top Coat 8 to 10 Mils

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): 1.8 - 5.3

#1 Spot 2 (Randomly selected location) : 1.7 - 3.1

Spot 3 (Randomly selected location): 1.3 - 3.0

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

\# Surface irregularities makes accurate readings extremely difficult.

4-U Test Panel No. [illegible]

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1.8 to 5.3	N/A	10.3 - 16.5	17.7 16.8 14.2
Spot 2*	1.7 to 3.1		5.0 - 10.1	16.6 22.0 22.1
Spot 3*	1.3 to 3.0		10.4 - 15.6	29.3 20.1 23.2
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): N/A

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/29/92 Test Panel No.: 4D

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted (circled)

Coating Application (circle one): Brush Roller Combination (circled)

Holiday Detection:

Are holidays present in the coating? (circle one): Yes No (circled)

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: HOLIDAY DETECTION TEST DONE WITH TEST PANELS IN AS MOUNTED POSITION.

INTERIOR

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-17-92 Test Panel No.: 5P Test Panel Thickness: 9/16"

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush Roller **(Combination)** (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devprep 88

Cleaning Tools Used (attach product info.): Needle Gun and Power Wire Cup Brush

Comments: Test sample mounted on interior surface of mock-up in Building #10

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	None	N/A	None	None
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush 1/2" Nap Roller		2" China Bristle Brush 1/4" Nap Roller	2" China Bristle Brush 1/4" Nap Roller
Air Temperature (°F)	83°/69°		80°/67°	76°/69°
Surface Temperature (°F)	82.8°		80.4	75.6°
Relative Humidity	42%		50%	70%
Dew Point (°F)	58°		60°	66°
Dry Time Before Non-Destructive Measurement (hours)	24 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	24 Hrs		24 Hrs	N/A

*Comments: 1/2" nap roller required to force primer into pores. 1/4" nap roller does not accomplish proper application of materials

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: 6-17-92 Test Panel No.: 5A Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)** [circled]

Coating Application (circle one): Brush Roller **(Combination)** [circled]

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1½ mils Top Coat 8 to 10 mils

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: Readings cannot be properly taken. Readings of gauge through roughness extremely difficult. No set location noted

Primer Coat 2: N/A

Top Coat 1: Readings somewhat easier to take. Taken various areas on face as practical 8 to 11 WFT ave

Top Coat 2: Readings taken various areas 10 to 11 mils

Describe any Changes to Application Method Based on Measurements: Application of primer using ¼" nap roller proved inadequate. Primer is not forced into pits. ¼" nap does not hold sufficient material for application to sample plate. ½" nap roller used on this plate. WFT readings taken in error of procedure. Procedure required no WFT readings to be taken

Data Sheet No. 2 (Cont.)

5A

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	NONE	N/A	NONE	NONE
Sags	NONE		NONE / 50 IN	NONE
Orange Peel	NONE		NONE	NONE
Cracking	NONE		NONE	NONE
BLISTERS			RANDOM	SEVERAL
DRIPS			SEVERAL	SEVERAL
SKIPS				1" SQ IN
*				*

* WET FILM GUAGE MARKS

Data Sheet No. 2 (Cont.)

5A

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): PosiTector 2000

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

#1 Spot 1 (Randomly selected location): 2.3 - 3.9

Spot 2 (Randomly selected location) : 1.0 - 4.5

Spot 3 (Randomly selected location): 1.1 - 4.9

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: [signature]

Results Reviewed by: B. Jacobs

#1 Surface irregularities made it difficult take accurate Readings

Test Panel No. 34

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	2.3 to 3.9	N/A	9.0 - 16.7	33.5 31.9 27.7
Spot 2*	1.0 to 4.5		12.8 - 18.8	26.0 32.3 31.9
Spot 3*	1.1 to 4.9		14.2 - 18.7	39.6 46.9 42.1
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): N/A

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*		N/A		
Spot 3*				
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: D.E. Dami

Results Reviewed by: D. Jacobs

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

5A

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Point Inspection Gage 1

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1.0	N/A	8.0	16.0
Spot 2*	1.0	N/A	6.0	10.0
Spot 3*	2.0	N/A	13.0	17.0
Spot 4* (Pit)	1.0	N/A	6.0	16.0
Spot 5* (High Point)	1.0	N/A	12.0	32.0

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6-29-92 Test Panel No.: 5A

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush Roller **(Combination)**

Holiday Detection:

Are holidays present in the coating? (circle one): Yes **(No)**

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Detection Readings taken when test plates in mounted position.

Interior

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-17-92 Test Panel No.: 5B Test Panel Thickness: 9/16"

Test Panel Type (circle one): Clean (i.e., new steel) **Previously Rusted** (circled)

Coating Application (circle one): Brush Roller **Combination** (circled) (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devprep 88

Cleaning Tools Used (attach product info.): Needle Gun and Power Wire Cup Brush

Comments: Test sample mounted on interior of mock-up in Building #10

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	None	N/A	None	None
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush ½" Nap Roller		2" China Bristle Brush ¼" Nap Roller	2" China Bristle Brush ¼" Nap Roller
Air Temperature (°F)	83°/69°		80°/67°	76°/69°
Surface Temperature (°F)	88.8°		80.4°	75.6°
Relative Humidity	42%		50%	70%
Dew Point (°F)	58°		60°	66°
Dry Time Before Non-Destructive Measurement (hours)	24 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	24 Hrs		24 Hrs	N/A

*Comments: ½" Nap Roller Required to force primer into areas. ¼" Nap Roller does not accomplish proper application of material

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 2 (Cont.)

5B

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None	N/A	NONE	NONE
Sags	None		NONE	NONE
Orange Peel	None		NONE	NONE
Cracking	None		NONE	NONE
DRIPS			SEVERAL	SEVERAL
DUST CONTAM			SLIGHT	SLIGHT
~~[illegible]~~ SKIPS			2	NONE
BLISTERS			SLIGHT	SLIGHT

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS
VISUAL INSPECTIONS, AND
DRY FILM THICKNESS MEASUREMENTS

Date: 6-17-92 Test Panel No.: 5B Test Panel Thickness: 9/16"

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)** [circled]

Coating Application (circle one): Brush Roller **(Combination)** [circled]

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: Readings around be properly taken. Reading of Gauge through Application extremely difficult. No set locations noted

Primer Coat 2: N/A

Top Coat 1: Readings easier to take. Taken various areas on plate 8 to 12 WFT mils

Top Coat 2: Readings taken various areas 10 to 11 WFT.

Describe any Changes to Application Method Based on Measurements: Application of primer using ¾" nap rollers proved inadequate. Primer is not forced into pits. In addition roller does not hold sufficient material for application. ½" nap roller used on this test plate. WFT readings taken in error to procedure. Procedure requires no WFT to be taken.

Data Sheet No. 2 (Cont.)

5B

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): PosiTector 6000

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

#1 Spot 1 (Randomly selected location): 1.9 - 3.3

Spot 2 (Randomly selected location) : 1.3 - 2.9

Spot 3 (Randomly selected location): 1.0 - 1.9

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

#1 Surface irregularity made accurate DFT readings difficult.

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1.9 to 3.3		7.2 - 13.6	16.6 15.1 15.4
Spot 2*	1.3 to 2.9		14.9 - 20.3	26.1 32.9 25.1
Spot 3*	1.0 to 1.9	N/A	8.1 - 10.5	29.0 22.8 33.1
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): N/A

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

5B

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	<1.0	N/A	7.0	15.0
Spot 2*	<1.0	N/A	7.0	10.0
Spot 3*	1.0	N/A	10.0	12.0
Spot 4* (Pit)	1.0	N/A	14.0	17.0
Spot 5* (High Point)	1.0	N/A	15.0	7.0

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: D. [signature]

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/29/92 Test Panel No.: 5B

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush Roller **(Combination)**

Holiday Detection:

Are holidays present in the coating? (circle one): Yes **(No)**

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: HOLIDAY DETECTION TEST DONE WITH PANELS IN AS INSTALLED POSITION.

Data Sheet No. 1 *Interior* 6

TEST PANEL PREPARATION AND COATING

Date: *6-17-92* Test Panel No.: *5C* Test Panel Thickness: *9/16"*

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush Roller **(Combination)** (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): *Devprep 88*

Cleaning Tools Used (attach product info.): *Needle Gun and Power Wire Cup Brush*

Comments: *Test samples mounted on interior building #10 Mockup*

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	*None*	*N/A*	*None*	*None*
Type of Brush (or Roller; list roller nap size)	*2" China Bristle Brush 1/2" Nap Roller*		*2" China Bristle Brush 1/4" Nap Roller*	*2" China Bristle Brush 1/4" Nap Roller*
Air Temperature (°F)	*83/67*		*80°/67°*	*~~80°~~ 76 /69°*
Surface Temperature (°F)	*82.8°*		*80.4°*	*75.6°*
Relative Humidity	*48%*		*50%*	*70%*
Dew Point (°F)	*58°*		*60°*	*66°*
Dry Time Before Non-Destructive Measurement (hours)	*24 Hrs*		*24 Hrs*	*24 Hrs +*
Dry Time Before Recoating (hours)	*24 Hrs*		*24 Hrs*	*N/A*

*Comments: *1/2" Nap Roller required to force primer into pores. 1/4" Nap Roller does not accomplish proper application of materials*

Test Performed by: *[signature]*
Results Reviewed by: *D. Jacobs*

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: 6-17-92 Test Panel No.: 5C Test Panel Thickness: 7/16"

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)** [circled]

Coating Application (circle one): Brush Roller **(Combination)** [circled]

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1 1/2 Mils Top Coat 8 to 10 Mils

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: Readings couldn't be properly taken. Reading of Gauge through Respiratory extremely difficult. No Set locations noted

Primer Coat 2: N/A

Top Coat 1: Readings Easier to Take Taken various areas on Plate 8 to 12 WET AP.

Top Coat 2: Taken Various Areas on Plate 11 to 12 WET

Describe any Changes to Application Method Based on Measurements: Application of primer using 1/4" Nap Roller inadequate. Primer is not forced into pits. In addition, Roller does not hold sufficient material for application. 1/2" Nap Roller used on this plate. WET Readings Taken in order to Procedure. Procedure requires no WET Readings to be taken.

Data Sheet No. 2 (Cont.)

5C

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	NONE	N/A	NONE	1 APPRX 3" LONG
Sags	NONE		NONE	NONE
Orange Peel	NONE		NONE	NONE
Cracking	NONE		NONE	NONE
~~[illegible]~~ SKIPS			APP. 2 SQ IN	SLIGHT
DRIPS			MINOR	NONE
BLISTER				SLIGHT
DUST. CONT.				SLIGHT

* *

* WET FILM GUAGE MARKS

Data Sheet No. 2 (Cont.)

5C

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): PosiTector 6000

Target Thickness per Coat: Primer 1½ mil Top Coat 8 to 10 mil

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): 2.5

Spot 2 (Randomly selected location) : 2.0

\#1. Spot 3 (Randomly selected location): 1.4 - 4.5

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

\#1. Surface irregularity makes accurate reading extremely difficult.

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	2.5	N/A	11.4 - 15.2	23.9 19.6 27.6
Spot 2*	2.0		10.4 - 16.1	20.8 22.3 29.2
Spot 3*	1.4 to 4.5		10.9 - 14.0	19.0 24.4 18.9
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): N/A

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

5C

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	<1.0	N/A	7.0	12.0
Spot 2*	1.0	N/A	10.0	10.0
Spot 3*	1.0	N/A	7.0	15.0
Spot 4* (Pit)	1.0	N/A	15.0	12.0
Spot 5* (High Point)	<1.0	N/A	9.0	8.0

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/29/92 Test Panel No.: 5C

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)** [circled]

Coating Application (circle one): Brush Roller **(Combination)** [circled]

Holiday Detection:

Are holidays present in the coating? (circle one): Yes **(No)** [circled]

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: HOLIDAY DETECTION TEST DONE WITH TEST PLATES IN AS INSTALLED POSITION.

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-17-92 Test Panel No.: 5D Test Panel Thickness: 3/16

Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): Brush Roller (Combination) (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devlkee 88

Cleaning Tools Used (attach product info.): Needle Gun & Power Wire Cup Brush

Comments: Test sample mounted on interior of mock-up in Building #10.

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	None	N/A	NONE	NONE
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush 1/4" Nap Roller		2" China Bristle Brush 1/4" Nap Roller	2" China Bristle Brush 1/4" Nap Roller
Air Temperature (°F)	83°/67°		80°/67°	76°/69°
Surface Temperature (°F)	82.8°		80.4°	75.6°
Relative Humidity	42 %		50 %	70°
Dew Point (°F)	58°		60°	66°
Dry Time Before Non-Destructive Measurement(hours)	24 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	24 Hrs		24 Hrs	N/A

*Comments: 1/4" nap roller does not allow for proper application of material. Requires a lot of brush work. Roller cannot properly coat areas.

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: *6-17-92* Test Panel No.: *5D* Test Panel Thickness: *9/16*

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)** [circled]

Coating Application (circle one): Brush Roller **(Combination)** [circled]

Wet Film Thickness:

Instrument Type (attach product info.): *Wet Film Thickness Gauge*

Target Thickness per Coat: Primer *1½ Mils* Top Coat *8 to 10 Mils*

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: *Readings cannot be properly taken. Reading of Gauge [illegible] extremely difficult. No set locations [illegible]*

Primer Coat 2: *N/A*

Top Coat 1: *Readings easier to take. Readings taken various areas on plate 10 Mils Ave*

Top Coat 2: *Readings taken various areas 11 to 12 Mils*

Describe any Changes to Application Method Based on Measurements: *Application of primer using ¼" nap roller proved inadequate. Primer is not forced into pits. Requires extensive brush work. ½" nap roller recommended. Wet readings taken in error to procedure. Wet reading per procedure was not to be taken*

Data Sheet No. 2 (Cont.)

5D

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None	N/A	NONE	NONE
Sags	NONE		NONE	NONE
Orange Peel	NONE		NONE	NONE
Cracking	NONE		NONE	NONE
DRIPS	#1		SEVERAL	SEVERAL
~~Ho[illegible]~~ SKIPS			15q in	Along High Point

#1 Drip on bottom of Test Panel

Data Sheet No. 2 (Cont.)

5D

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Positector 2000

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mil

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): 4.8 - 7.1

Spot 2 (Randomly selected location) : 2.1 - 7.1

\#1 Spot 3 (Randomly selected location): 2.3 - 5.7

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

\#1. Surface irregularities makes surface readings extremely difficult.

5-D

Test Panel No. 5D

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	4.0 to 7.1	N/A	10.6-18.9	29.8 28.9 29.4
Spot 2*	2.1 to 7.1		15.5-22.0	19.9 23.9 22.2
Spot 3*	2.3 to 5.7		12.8-16.3	23.7 24.9 23.0
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): N/A

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

5D

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1.0	N/A	15.0	11.0
Spot 2*	1.0	N/A	13.0	7.0
Spot 3*	2.0	N/A	12.0	9.0
Spot 4* (Pit)	1.0	N/A	7.0	8.0
Spot 5* (High Point)	1.0	N/A	11.0	6.0

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/29/92　　Test Panel No.: 5D

Test Panel Type (circle one): Clean (i.e., new steel)　　**Previously Rusted** (circled)

Coating Application (circle one): Brush　Roller　**Combination** (circled)

<u>Holiday Detection</u>:

Are holidays present in the coating? (circle one): Yes　**No** (circled)

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Detection test was performed with the test deck in an inclined position.

Interior

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-17-92 Test Panel No.: 617 Test Panel Thickness: 9/16"

Test Panel Type (circle one): Clean (i.e., new steel) **Previously Rusted** (circled)

Coating Application (circle one): Brush Roller **Combination** (circled) (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devprep 88

Cleaning Tools Used (attach product info.): Needle Gun and Power Wire Cup Brush

Comments: Test samples mounted on interior of mockup in Building #10

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	None	N/A	None	None
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush, 1/4" Nap Roller		2" China Bristle Brush, 1/4" Nap Roller	2" China Bristle Brush, 1/4" Nap Roller
Air Temperature (°F)	83°/67°		80°/67°	76°/67°
Surface Temperature (°F)	82.8°		80.4°	75.6°
Relative Humidity	42%		50%	70%
Dew Point (°F)	58°		60°	66°
Dry Time Before Non-Destructive measurement (hours)	24 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	24 Hrs		24 Hrs	N/A

*Comments: 1/4" Nap Roller does not allow for proper application of material. Requires a lot of brush work. Roller doesn't properly coat areas

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

C-54

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: 6-17-92 Test Panel No.: 6A Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)** [circled]

Coating Application (circle one): Brush Roller **(Combination)** [circled]

__Wet Film Thickness:__

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: Readings cannot be properly taken. Reading of Gauge through Rust/scale difficult. No set locations noted

Primer Coat 2: N/A

Top Coat 1: Readings Easier to take. Readings taken Various areas on plate 10 to 11 mils

Top Coat 2: Readings taken Various areas 10 to 11 Mils

Describe any Changes to Application Method Based on Measurements: Application of primer using ¼" Nap Roller proved inadequate. Primer is not forced into pits. ¼" Nap Roller does not hold sufficient material for application to test plate. Brush work needed. WFT Readings Taken in excess of Procedure. Procedure Requires no WFT Readings to be taken

Data Sheet No. 2 (Cont.)

6A

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None	N/A	NONE	NONE
Sags	None		NONE	NONE
Orange Peel	None		NONE	NONE
Cracking	None.		NONE	NONE
SKIPS			APP. 1 SQ IN	LESS THAN 1"
DRIPS			SLIGHT	SLIGHT

Data Sheet No. 2 (Cont.)

6A

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): PosiTector 2000

Target Thickness per Coat: Primer 1½ Mil Top Coat 8 to 10 Mil

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): 3.4 - 4.0

\#1 Spot 2 (Randomly selected location) : 2.1 - 3.7

Spot 3 (Randomly selected location): 3.5 - 3.8

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

\#1 Surface irregularities makes accurate surface readings extremely difficult.

Test Panel No. [illegible]

6.A

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	3.4 to 4.0	N/A	12.8 - 20.7	26.0 23.3 26.9
Spot 2*	2.1 to 3.7		13.9 - 19.4	25.1 24.7 29.2
Spot 3*	3.5 to 3.8		15.3 - 18.6	21.2 28.0 26.7
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): N/A

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

6A

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*		N/A		
Spot 3*				
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Thickness Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1.0	N/A	15.0	10.0
Spot 2*	1.0	N/A	13.0	11.0
Spot 3*	1.0	N/A	12.0	10.0
Spot 4* (Pit)	≠1	N/A	≠1	≠1
Spot 5* (High Point)	1.0	N/A	15.0	11.0

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]

Results Reviewed by: [signature]

≠ Could not get a through cut of pit.

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6-29-92 Test Panel No.: 6A

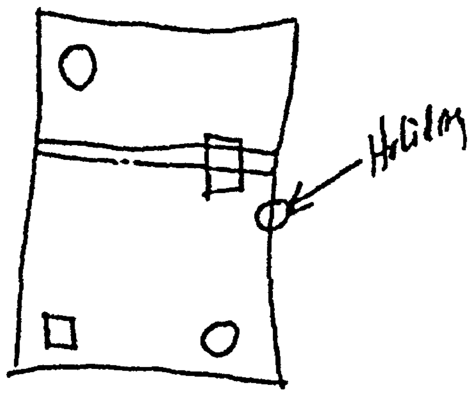
Test Panel Type (circle one): Clean (i.e., new steel) **Previously Rusted** (circled)

Coating Application (circle one): Brush Roller **Combination** (circled)

<u>Holiday Detection</u>:

Are holidays present in the coating? (circle one): **Yes** (circled) No

If yes, show a sketch of the test panel and indicate the locations of the holidays:



Comments: Holiday Detection Test Taken when plate was in mounted position.

Data Sheet No. 1 Interior

TEST PANEL PREPARATION AND COATING

Date: 6-17-92 Test Panel No.: 6B Test Panel Thickness: 3/16"

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devprep 88

Cleaning Tools Used (attach product info.): Needle Gun and Power Wire Cup Brush

Comments: Test Sample mounted on interior of mock-up in Building #10

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	None	N/A	None	None
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush		2" China Bristle Brush	2" China Bristle Brush
Air Temperature (°F)	83°/67°		80°/67°	76°/69°
Surface Temperature (°F)	82.8°		80.4°	76.6°
Relative Humidity	42%		50%	70%
Dew Point (°F)	58°		60°	66°
Dry Time Before Non-Destructive Measurement (hours)	24 Hrs		24 Hrs	24 Hrs
Dry Time Before Recoating (hours)	24 Hrs		24 Hrs	N/A

*Comments:

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS
VISUAL INSPECTIONS, AND
DRY FILM THICKNESS MEASUREMENTS

Date: 6-17-92 Test Panel No.: 6B Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)** [circled]

Coating Application (circle one): **(Brush)** [circled] Roller Combination

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mil

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: Pressing of Gauge through Primer Extremely difficult. Primer Application adequate. No Set Locations Noted

Primer Coat 2: N/A

Top Coat 1: Readings Easier to take. Readings taken Various areas on plate 9 to 12 Mils

Top Coat 2: Readings taken Various on plate 10 to 12 Mils

Describe any Changes to Application Method Based on Measurements: Application of primer using brush slow, but adequate. Good at forcing primer into pores. WET READINGS TAKEN IN ERROR OF PROCEDURE. PROCEDURE REQUIRES NO WET TO BE TAKEN.

Data Sheet No. 2 (Cont.)

6B

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	NONE	N/A	NONE	~~NONE~~ 1 APPROX 2"L
Sags	NONE		NONE	NONE
Orange Peel	NONE		NONE	NONE
Cracking	NONE		NONE	NONE
SKIPS	#1		3 SQ IN	SLIGHT
DRIPS			SLIGHT	SEVERAL
SAND CONTAM.			SLIGHT	SLIGHT

#1 SEVERAL drips on Bottom of Panel. SEVERAL AREAS of SAND Contamination. BRUSHED OFF AS BEST AS POSSIBLE.

Data Sheet No. 2 (Cont.)

6B

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Posi Tector 2000

Target Thickness per Coat: Primer 1½ Mil Top Coat 8 to 10 Mil

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): 3.0 - 5.8

#1 Spot 2 (Randomly selected location) : 14.9 19.9 RUST STILL ON SURF

Spot 3 (Randomly selected location): 24.3 40.1 RUST STILL ON SURF

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

#1 Surface irregularities make accurate reading extremely difficult. Due to location of test plate over rebar bed, not all rust scale removed, making reading extremely high.

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	3.0 to 5.0	N/A	13.7-25.5	29.7 20.0 39.9
Spot 2*	14.9 to 19.9		8.1 - 14.0	19.1 20.5 29.8
Spot 3*	24.3 to 40.1		14.4 .36.1	34.8 50.1 36.3
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): N/A

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

~~7B~~ 6B D.9.

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gauge IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1.0	N/A	10.0	14.0
Spot 2*	1.0	N/A	8.0	11.0
Spot 3*	2.0	N/A	8.0	15.0
Spot 4* (Pit)	1.0	N/A	7.0	11.0
Spot 5* (High Point)	1.0	N/A	15.0	17.0

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6-29-92   Test Panel No.: 6B

Test Panel Type (circle one): Clean (i.e., new steel)   **(Previously Rusted)** [circled]

Coating Application (circle one): **(Brush)** [circled]   Roller   Combination

<u>Holiday Detection</u>:

Are holidays present in the coating? (circle one): Yes   **(No)** [circled]

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Detector Test Done when plates are in mounted Position.

Data Sheet No. 1 Interior.

TEST PANEL PREPARATION AND COATING

Date: 6-17-99 Test Panel No.: 6C Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Dix Chee 88

Cleaning Tools Used (attach product info.): Needle Gun and Power Wire Cup Brush. Used Power Scaler Gun.

Comments: Test sample mounted on interior of mock-up in building #10.

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	None	N/A	None	None
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush 1/4" Nap Roller		2" China Bristle Brush 1/4" Nap Roller	2" China Bristle Brush 1/4" Nap Roller
Air Temperature (°F)	83°/67°		80°/67°	76°/67°
Surface Temperature (°F)	82.8°		80.4°	75.6°
Relative Humidity	42%		50%	70%
Dew Point (°F)	58°		60°	66°
Dry Time Before Non-Destructive Measurement (hours)	24 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	24 Hrs		24 Hrs	N/A

*Comments: 1/4" Nap Roller does not allow for proper application on rusted, requires a lot of brush work. Roller cannot properly coat piece.

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: 6-17-92 Test Panel No.: 6C Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **Previously Rusted** (circled)

Coating Application (circle one): Brush Roller **Combination** (circled)

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: Readings cannot be properly taken. Reading of gauge through application extremely difficult, no set location noted

Primer Coat 2: N/A

Top Coat 1: Readings easier to take. Readings taken various areas 10 to 12 Mils

Top Coat 2: Readings taken various areas 10 to 12 Mils

Describe any Changes to Application Method Based on Measurements: Application of primer using ¼" nap roller proved inadequate. Primer is not forced into pit. Requires additional brush work. ¼" roller also does not hold sufficient material. WET READINGS TAKEN IN ERROR OF PROCEDURE. Procedure does not request wet readings.

Data Sheet No. 2 (Cont.)

6C

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	NONE	N/A	NONE	NONE
Sags	NONE		NONE	NONE
Orange Peel	NONE		NONE	NONE
Cracking	NONE		NONE	NONE
SKIPS			LESS THAN 1 SQ IN	SLIGHT
DRIPS			SLIGHT	SEVERAL
SAND CONTAM				SLIGHT

Data Sheet No. 2 (Cont.)

6C

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): PosiTector 2000

Target Thickness per Coat: Primer 1½ Mil Top Coat 8 to 10 Mils

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): 11.1 - 26.5 Rust still on surface

#1 Spot 2 (Randomly selected location) : 19.8 . 26.4 Rust still on surface

Spot 3 (Randomly selected location): 5.6 - 13.3 Rust still on surface

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

#1 Surface irregularities made accurate readings impossible. Surface contaminates/corrosion products on test panel surface cause a extremely high DFT reading. Corrosion on plate difficult to remove due to location of plate over rebar bed.

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	11.1 to 26.5	N/A	25.2-34.4	46.9 50.7 53.5
Spot 2*	19.5 to 26.4		27.2-40.4	37.4 54.6 93.3
Spot 3*	5.6 to 13.3		13.6-16.4	21.0 20.2 18.8
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): N/A

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*		N/A		
Spot 3*				
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

6C

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1.5	N/A	11.0	8.0
Spot 2*	1.0	N/A	8.0	8.0
Spot 3*	1.0	N/A	11.0	11.0
Spot 4* (Pit)	1.0	N/A	5.0	8.0
Spot 5* (High Point)	1.0	N/A	5.0	6.0

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: Douglas E. Klaus

Results Reviewed by: G. Jacobs

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/29/92 Test Panel No.: 6C

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush Roller **(Combination)**

<u>Holiday Detection</u>:

Are holidays present in the coating? (circle one): Yes **(No)**

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Detection Test taken with plate in mounted position

Exterior
Done at same
time as interior

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-17-92 Test Panel No.: 1G Test Panel Thickness: 1/4"

Test Panel Type (circle one): (Clean) (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller (Combination) (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): NONE

Cleaning Tools Used (attach product info.): Power wire cup brush

Comments: New metal

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	N/A		N/A	None
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush 1/4" Nap Roller		2" China Bristle Brush 1/4" Nap Roller	2" China Bristle Brush 1/4" Nap Roller
Air Temperature (°F)	83°/67°	80°/70	80°/67°	76°/69°
Surface Temperature (°F)	82.8°		80.4	75.6°
Relative Humidity	42%	N/A	50%	70%
Dew Point (°F)	58°		60°	66°
Dry Time Before Non-Destructive Measurement (hours)	24 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	24 Hrs		24 Hrs	N/A

*Comments: Primer Coating Application attached on exterior work sheet.

Test Performed by: [signature]
Results Reviewed by: [signature]

C-75

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: 6-17-92 Test Panel No.: 1G Test Panel Thickness: 1/4"

Test Panel Type (circle one): (Clean) (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller (Combination)

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: Various Areas on Face, Gauge Marks Touched up.

Primer Coat 2: N/A

Top Coat 1: Various Areas on Face, Gauge Marks Touched up 8 to 10 WET Ave.

Top Coat 2: Various Areas on Face, Gauge Marks Touched up 9 TO 12 WET

Describe any Changes to Application Method Based on Measurements: Reading of WET Readings Difficult Due to Clearness of Primer. WET Readings Taken in Error to Procedure. Procedure Requires no WET Readings To Be Taken.

Data Sheet No. 2 (Cont.)

1G

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None	N/A	None	None
Sags	None		None	None
Orange Peel	None		None	None
Cracking	None		None	None
	#1		#1 (Primer)	#1 (Primer)
				#2

#1 Several Drips on bottom of Panel

#2 Coating surface show evidence of coating thick while applying by Roller.

Data Sheet No. 2 (Cont.)

1G

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): PosiTector 2000

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): .1 . .4

Spot 2 (Randomly selected location) : .1 . .4

Spot 3 (Randomly selected location): .1 . .7

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: [signature]
Results Reviewed by: D. Jacobs

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	.1 to .4		5.5 5.8	23.8, 21.0 25.3
Spot 2*	.1 to .4		7.4 8.0	16.0 17.8 18.3
Spot 3*	.1 to .7	N/A	8.0 8.6	17.1 24.0 18.9
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): N/A

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*				
Spot 2*				
Spot 3*		N/A		
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

16

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No. 1	Primer Coat No. 2	Top Coat No. 1	Top Coat No. 2
Spot 1*				
Spot 2*				
Spot 3*				
Spot 4* (Pit)				
Spot 5* (High Point)				

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): ____________________

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No. 1	Primer Coat No. 2	Top Coat No. 1	Top Coat No. 2
Spot 1*	1½ ±	N/A	9	12
Spot 2*	1	N/A	10	10
Spot 3*	<1	N/A	8	8
Spot 4* (Pit)	N/A	— FLAT NEW	METAL —	—
Spot 5* (High Point)	N/A	— FLAT NEW	METAL —	—

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: [signature]
Results Reviewed by: [signature]

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6-29-92 Test Panel No.: 16

Test Panel Type (circle one): Clean (i.e., new steel) [circled] Previously Rusted

Coating Application (circle one): Brush Roller Combination [circled]

Holiday Detection:

Are holidays present in the coating? (circle one): Yes No [circled]

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Detection Test Done with Panels in installed position. Removal of plate from mounting surface could possibly damage coating giving false Readings.

Dawn

MPT Reading on Control Sample (1G)

Test Panel Marked at 002

[signature]

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-10-92 Test Panel No.: 9H Test Panel Thickness: 1/4"

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devilbiss 88 & Pressure wash

Cleaning Tools Used (attach product info.): Power Wire Cup Brush

Comments: Clean Steel - No Mill Scale - New

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	N/A	N/A	N/A	N/A
Type of Brush (or Roller; list roller nap size)	2" Bristle Brush 1/2" nap-9" Roller		2" Bristle Brush 1/2" nap-9" Roller	2" Bristle Brush 1/2" nap-9" Roller
Air Temperature (°F)	73°		71°/62°	83°/67°
Surface Temperature (°F)	70°		72°	88.8°
Relative Humidity	53%		60%	42%
Dew Point (°F)	54°		60°	58°
Dry Time Before Non-Destructive Measurement (hours)	144 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	144 Hrs		24 Hrs	N/A

*Comments: Noted slight discoloration on top coat

Test Performed by: D. Davis
Results Reviewed by: D. Jacobs

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS
VISUAL INSPECTIONS, AND
DRY FILM THICKNESS MEASUREMENTS

Date: 6-10-92 Test Panel No.: 3H Test Panel Thickness: 1/4"

Test Panel Type (circle one): (Clean) (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1 1/2 M. Top Coat 8 To 10 Mils

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: Smooth Flat Surfaces - Reading Taken on Face

Primer Coat 2: N/A

Top Coat 1: Smooth Flat Surface. - Reading Taken on Face

Top Coat 2: Smooth Flat Surface. Reading Taken on Face

Describe any Changes to Application Method Based on Measurements: Application on Smooth plate made proper WET of Primer application Readings easy, but had tendency to run.

Data Sheet No. 2 (Cont.)

3H

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	NONE		~~26 26 7.2~~ None	/Ea None
Sags	NONE		~~40 36 41~~ None	None
Orange Peel	NONE		~~8.2 23.3 22~~ None	None
Cracking	NONE	JR	None	None
	#1			#1
				#2

#1. Several small drips on plate edge
#2 Roller Hair in Paint

Data Sheet No. 2 (Cont.)

3H

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Positector 2000 Positect Dry Film Thickness Gauge

Target Thickness per Coat: Primer 1.5 Mil Top Coat 8 to 10 Mils/Coat.

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

- Spot 1 (Randomly selected location): .25 To .5
- Spot 2 (Randomly selected location) : .25 to .5
- Spot 3 (Randomly selected location): .25 to .5
- Spot 4 (Pit): N/A
- Spot 5 (High Point): N/A

Test Performed by: D. Davis
Results Reviewed by: D. Jacobs

Test Panel No. 3H

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	.25 to .5	N/A	8.6 7.6 7.2	8.2 9.9 7.0
Spot 2*	.25 to .5		4.0 3.6 4.1	11.1 9.8 10.5
Spot 3*	.25 to .5		8.2 23.3 12.2	13.2 15.8 13.4
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	<1	N/A	4	4
Spot 2*	1	N/A	6	7
Spot 3*	1	N/A	10	7
Spot 4* (Pit)	N/A —	— FLAT	NEW ME	TAL —
Spot 5* (High Point)	N/A —	— FLAT	NEW ME	TAL —

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: ________
Results Reviewed by: D. Jacobs

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/30/92 Test Panel No.: 3H

Test Panel Type (circle one): (Clean) (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller (Combination)

Holiday Detection:

Are holidays present in the coating? (circle one): Yes (No)

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Detection Test Done As Painted Mounted Position

10/27/06 15:33:47

Exterior

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-10-92 Test Panel No.: 1H Test Panel Thickness: 1/4"

Test Panel Type (circle one): (Clean) (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller (Combination) (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devprep 88 and Pressure wash.

Cleaning Tools Used (attach product info.): Power wire cup brush.

Comments: Clean steel - No mill scale - New material

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	N/A	N/A	N/A	N/A
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush and 1/2" nap 9" Roller		2" China Bristle Brush & 1/2" nap Roller	2" China Bristle Brush & 1/2" nap Roller
Air Temperature (°F)	73°		71°/62°	83°/69°
Surface Temperature (°F)	70°		72°	87.8°
Relative Humidity	53%		60%	42%
Dew Point (°F)	54°		56°	51°
Dry Time Before Non-Destructive Measurement (hours)	144 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	144 Hrs		24 Hrs	N/A

*Comments: Noted slight discoloration in top coat

Test Performed by: D. Davis
Results Reviewed by: D. Jacobs

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS
VISUAL INSPECTIONS, AND
DRY FILM THICKNESS MEASUREMENTS

Date: 6-10-92 Test Panel No.: 1H Test Panel Thickness: 1/4"

Test Panel Type (circle one): (Clean) (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller (Combination)

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1 1/2 M Top Coat 8 to 10 Mil

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: Smooth Surface. Readings Taken of Face.

Primer Coat 2: N/A

Top Coat 1: Readings taken on Face of test Plate

Top Coat 2: Readings taken on Face of test plate

Describe any Changes to Application Method Based on Measurements: None Noted

Data Sheet No. 2 (Cont.)

1H

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None	N/A	~~5.7 4.2 9.4~~ None [illegible]	1 for 2"
Sags	None		~~7.9 7.3 6.0~~ None [illegible]	None
Orange Peel	None		~~6.0 6.1 8.8~~ None [illegible]	None
Cracking	None		None	None
			*1	*2
Drips				2 Small

*1 Roller Hair (nap) noted

*2 Roller Hair (nap) noted

Data Sheet No. 2 (Cont.)

1H

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Posi Tector 2000

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils/Coat

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): .5

Spot 2 (Randomly selected location) : .5

Spot 3 (Randomly selected location): .5

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: D. Davis
Results Reviewed by: D. Jacobs

Test Panel No. 14

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	.5	N/A	5.7 9.2 4.4	10.2 11.0 12.6
Spot 2*	.5		7.9 7.3 6.6	11.0 9.8 10.2
Spot 3*	.5		6.0 6.1 8.8	12.9 13.8 12.4
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	<1	N/A	9	10
Spot 2*	<1	N/A	4	7
Spot 3*	<1	N/A	10	6
Spot 4* (Pit)	N/A	— FLAT	NEW	METAL —
Spot 5* (High Point)	N/A	— FLAT	NEW	METAL —

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: __________
Results Reviewed by: D. Jacobs

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/30/92 Test Panel No.: 1#

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination

Holiday Detection:

Are holidays present in the coating? (circle one): Yes No

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Detector Test Done in as [illegible] position.

D-12

Cypress

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-10-92 Test Panel No.: 36 Test Panel Thickness: 1/4"

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Degreaser 88 and Pressure Wash.

Cleaning Tools Used (attach product info.): Power Wire Cup Brush.

Comments: New Steel - Free of Rust and Mill Scale.

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	N/A	N/A	N/A	
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush & 1/2" Nap 9" Roller		2" China Bristle Brush & 1/2" Nap 9" Roller	2" China Bristle Brush & 1/2" Nap 9" Roller
Air Temperature (°F)	73°		71°/62°	83°/67°
Surface Temperature (°F)	70°		72°	82.0°
Relative Humidity	53%		60%	42%
Dew Point (°F)	54°		56°	58°
Dry Time Before Non-Destructive Measurement (hours)	144 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	144 Hrs		24 Hrs	N/A

*Comments: Noted Slight Discoloration in Top Coat

Test Performed by: D. Davis
Results Reviewed by: [illegible]

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS
VISUAL INSPECTIONS, AND
DRY FILM THICKNESS MEASUREMENTS

Date: 6-10-92 Test Panel No.: 3G Test Panel Thickness: 1/4"

Test Panel Type (circle one): (Clean) (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller (Combination)

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1 1/2 Mils Top Coat 8 to 10 Mils/Coat

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: ON FACE OF PLATE, EASY TO TAKE READING

Primer Coat 2: N/A

Top Coat 1: Easy to take Readings

Top Coat 2: Easy to take Readings

Describe any Changes to Application Method Based on Measurements: None Noted

Data Sheet No. 2 (Cont.)

3G

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None		~~48 62 56~~ None	None
Sags	None		~~48 43 58~~ None	None
Orange Peel	None		~~45 52 4.1~~ None	None
Cracking	None	N/A	None	None
				#1

#1 Roller hair in coating

Data Sheet No. 2 (Cont.)

Non-Destructive Dry Film Thickness: Positester 2000

Instrument Type (attach product info.): Posi Test Dry Film Thickness Gauge

Target Thickness per Coat: Primer 1.5 Mils Top Coat 8 to 10 Mils/Coat

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): .5 to 1.5

Spot 2 (Randomly selected location) : .5 to 1.5

Spot 3 (Randomly selected location): .5 to 1.5

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: D. Davis
Results Reviewed by: D. Jacobs

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	.5 to 1.5		4.8 5.2 5.6	13.6 12.4 11.1
Spot 2*	.5 to 1.5		4.8 4.3 5.8	13.7 14.2 14.1
Spot 3*	.5 to 1.5	N/A	4.5 3.2 4.1	13.3 14.8 15.3
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	<1	N/A	5	12
Spot 2*	<1	N/A	7	6
Spot 3*	<1	N/A	5	14
Spot 4* (Pit)	N/A ——	FLAT	NEW ME	TAL ——
Spot 5* (High Point)	N/A ——	FLAT	NEW ME	TAL ——

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: ________

Results Reviewed by: D. Jacobs

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6-30-92 Test Panel No.: 36

Test Panel Type (circle one): **(Clean)** (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller **(Combination)**

Holiday Detection:

Are holidays present in the coating? (circle one): Yes **(No)**

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Testing Done in vertical position on mounting Board

CXKKNR

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-10-92 Test Panel No.: 1B Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): Brush (Roller) Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Wash with water only!

Cleaning Tools Used (attach product info.): Lab Hammer unit and Pour Brush

Comments: All loose scale/contaminates removed. Sample still has some adherent rust on surface.

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	N/A	N/A	N/A	None
Type of Brush (or Roller; list roller nap size)	½" nap 9" Roller		½" Nap Roller	½" nap Roller
Air Temperature (°F)	73°		91°/62°	83°/69°
Surface Temperature (°F)	70°		72°	82.8°
Relative Humidity	53%		60%	42%
Dew Point (°F)	54°		56°	58°
Dry Time Before Non-Destructive Measurement (hours)	144 Hrs		24 Hrs	24 Hrs
Dry Time Before Recoating (hours)	144 Hrs		24 Hrs	N/A

*Comments: Noted slight discoloration in top coat

Test Performed by: D. Davis
Results Reviewed by: B. Jacob

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: 6-10-92 Test Panel No.: 1B Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): Brush (Roller) Combination

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils/Coat

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: Readings Taken on Face of Sample. Readings Difficult due to surface Roughness of Sample.

Primer Coat 2: N/A

Top Coat 1: Readings Difficult due to Surface Roughness of Sample

Top Coat 2: Readings Difficult due to Surface Roughness of Sample.

Describe any Changes to Application Method Based on Measurements: Accurate Readings (WFT) difficult due to surface irregularities. Application of primer using ½" Nap Roller insures material being forced into pores of steel.

Data Sheet No. 2 (Cont.)

1B

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None		None	None
Sags	None		None	None
Orange Peel	None		None	None
Cracking	None		None	None
			#1	#1

#1. Some roller hair in surface.

Data Sheet No. 2 (Cont.)

1B

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Positector 2000

Target Thickness per Coat: Primer 1½ Mil Top Coat 8 to 10/coat

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

- Spot 1 (Randomly selected location): 1.0 to 4.0
- Spot 2 (Randomly selected location) : 1.0 to 4.0
- Spot 3 (Randomly selected location): 1.0 to 4.0
- Spot 4 (Pit): N/A
- Spot 5 (High Point): N/A

Test Performed by: D. Davis
Results Reviewed by: B. Jardin

Test Panel No. 18

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	4.8 12.4 6.6 5.1 (5.1)	N/A	4.8 5.6 5.1 (5.1)	23.5 14.7 11.4
Spot 2*	1.0 to 4.0		8.6 5.2 5.5	9.1 8.8 8.0
Spot 3*	1.0 to 4.0		5.6 4.5 4.8	11.3 8.4 10.5
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1	N/A	5	14
Spot 2*	<1	N/A	3	6
Spot 3*	1 1/2	N/A	4	6
Spot 4* (Pit)	<1	N/A	6	7
Spot 5* (High Point)	<1	N/A	3	4

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: ____________

Results Reviewed by: S. Jacobs

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/30/92 Test Panel No.: 13

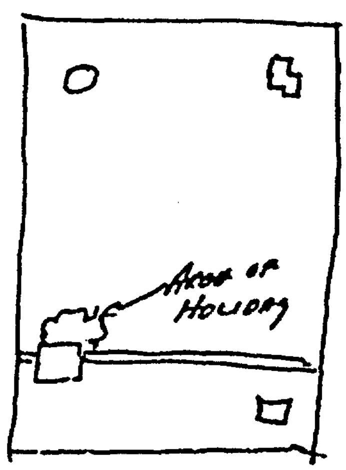
Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush **(Roller)** Combination

Holiday Detection:

Are holidays present in the coating? (circle one): **(Yes)** No

If yes, show a sketch of the test panel and indicate the locations of the holidays:



Comments: Holiday Detection Test Done in mounted position

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-10-92 Test Panel No.: 1C Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): (Brush) Roller Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devcon 88 & Hand/Sponge Rinse

Cleaning Tools Used (attach product info.): Cutty Hammer unit and Power Brush

Comments: All loose scale/contaminates removed. Sample still has some adherent rust on surface.

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	N/A	N/A	N/A	N/A
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush		2" China Bristle Brush	2" China Bristle Brush
Air Temperature (°F)	73°		71°/62°	83°/67°
Surface Temperature (°F)	70°		72°	87.8°
Relative Humidity	53%		60%	42%
Dew Point (°F)	54°		56°	58°
Dry Time Before Non-Destructive Measurement(hours)	144 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	144 Hrs		24 Hrs	N/A

*Comments: Noted slight discoloration in top coat

Test Performed by: D. Davis
Results Reviewed by: [signature]

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS
VISUAL INSPECTIONS, AND
DRY FILM THICKNESS MEASUREMENTS

Date: 6-10-92 Test Panel No.: 1C Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): **(Brush)** Roller Combination

Wet Film Thickness:

Instrument Type (attach product info.): WET FILM THICKNESS GAUGE

Target Thickness per Coat: Primer 1 1/2 M. Top Coat 8 TO 10

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: READINGS TAKEN ON SAMPLE FACE. READING WET DIFFICULT ON ROUGH SURFACES

Primer Coat 2: N/A

Top Coat 1: Readings on Rough Surfaces difficult to take

Top Coat 2: Readings on Rough Surfaces Difficult to take

Describe any Changes to Application Method Based on Measurements: Accurate Readings of coatings application difficult due to surface roughness

Data Sheet No. 2 (Cont.)

1C

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None		None	None
Sags	None		None	None
Orange Peel	None		None	None
Cracking	None	N/A	None	None
				#1, #2, #3

#1 Several drips on bottom of Panel
#2 Several Lite skips
#3. Noted several Small (1/16" D) blisters

Data Sheet No. 2 (Cont.)

1C

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Positector 2000

Target Thickness per Coat: Primer 1½ Mils Top Coat 8 to 10 Mils/Coat

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): .5 to 1.5

Spot 2 (Randomly selected location) : .5 to 1.5

Spot 3 (Randomly selected location): .5 to 1.5

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: D. Davis
Results Reviewed by: D. Jacobs

Test Panel No. 1C

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	.5 to 1.5	N/A	8.7 10.7 8.4	15.0 12.2 14.7
Spot 2*	.5 to 1.5		5.5 9.7 10.2	24.0 15.5 20.4
Spot 3*	.5 to 1.5		6.4 11.0 9.9	13.0 16.2 14.7
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	<1	N/A	6	10
Spot 2*	1	N/A	7	8
Spot 3*	1	N/A	8	12
Spot 4* (Pit)	<1	N/A	12	10
Spot 5* (High Point)	<1	N/A	9	16

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: ____________
Results Reviewed by: G. Jacobs

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-10-92 Test Panel No.: 2C Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush **(Roller)** Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Water Wash only!

Cleaning Tools Used (attach product info.): Needle Gun and Power wire Cup Brush.

Comments: All loose scale/contaminates removed. Sample still has adherent rust on surface.

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	N/A	N/A	N/A	
Type of Brush (or Roller; list roller nap size)	½" Nap 9" Roller		½" Nap 9" Roller	½" Nap 9" Roller
Air Temperature (°F)	73°		71°/68°	83°/67°
Surface Temperature (°F)	70°		72°	87.8°
Relative Humidity	53%		60%	42%
Dew Point (°F)	54°		56°	58°
Dry Time Before Non-Destructive Measurement (hours)	144 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	144 Hrs		24 Hrs	N/A

*Comments: Note: slight discoloration in top coat

Test Performed by: D. Davis
Results Reviewed by: D. [illegible]

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS
VISUAL INSPECTIONS, AND
DRY FILM THICKNESS MEASUREMENTS

Date: 6-10-92 Test Panel No.: 2C Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): Brush (Roller) Combination

Wet Film Thickness:

Instrument Type (attach product info.): WET FILM THICKNESS GAUGE

Target Thickness per Coat: Primer 1½ m Top Coat 8 to 10 mils/Coat

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot): ON SURFACE OF TEST PLATE. MEASUREMENTS

Primer Coat 1: difficult due to ROUGHNESS OF TEST PLATE.

Primer Coat 2: N/A

Top Coat 1: WET READINGS difficult due to surface roughness

Top Coat 2: Readings DIFFICULT due to surface Roughness

Describe any Changes to Application Method Based on Measurements: Accurate WET Reading difficult due to surface roughness.

Data Sheet No. 2 (Cont.)

2C

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None	NA	None ~~3.5 5.2 4.5~~ OK	None
Sags	None		None ~~5.3 5.3 6.6~~ OK	None
Orange Peel	None		None ~~4.4 5.3 4.8~~ OK	None
Cracking	None		None	None
			#1	#1
				#2
				#3

#1 Roller hairs noted.

#2 Several Drips on Bottom of plate

#3 Noted several Blisters on plate smaller than 1/16" in Dia.

10/27/06 15:33:47

Test Panel No. [illegible]

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1.5	N/A	3.5 5.2 4.5	8.2 12.7 11.5
Spot 2*	1.5		5.3 5.2 6.6	7.4 8.4 8.8
Spot 3*	1.5		4.4 5.3 4.8	9.3 6.5 6.2
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	<1	N/A	2	4
Spot 2*	<1	N/A	3	6
Spot 3*	<1	N/A	4	10
Spot 4* (Pit)	<1	N/A	3	6
Spot 5* (High Point)	1	N/A	5	5

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: __________
Results Reviewed by: D. Jacobs

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/30/92 Test Panel No.: 2C

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush **(Roller)** Combination

Holiday Detection:

Are holidays present in the coating? (circle one): Yes **(No)**

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Detector Test Done in Single panel mounted position

Cx TERIOR

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-10-92 Test Panel No.: 2B Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **Previously Rusted** (circled)

Coating Application (circle one): **Brush** (circled) Roller Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devprep 88 and [illegible] wash

Cleaning Tools Used (attach product info.): Needle Gun and [illegible] wire cup brush

Comments: All loose scale/contaminates removed. Sample still has adherent rust on surface.

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	N/A		N/A	N/A
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush		2" China Bristle Brush	2" China Bristle Brush
Air Temperature (°F)	73°		71°/62°	83°/67°
Surface Temperature (°F)	70°		72°	82.8°
Relative Humidity	53%		60%	48%
Dew Point (°F)	54°		56°	58°
Dry Time Before Non-Destructive Measurement (hours)	144 HHrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	144 Hrs		24 Hrs	N/A

*Comments: Noted slight discoloration in top coat

Test Performed by: D. Davis
Results Reviewed by: D. Jacobs

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: 6-10-92 Test Panel No.: 2D Test Panel Thickness: 9/10"

Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): (Brush) Roller Combination

Wet Film Thickness:

Instrument Type (attach product info.): Wet film thickness gauge

Target Thickness per Coat: Primer 1½ M. Top Coat 8 to 10 Mils/Coat

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Readings taken on sample face

Primer Coat 1: Rough steel making readings difficult

Primer Coat 2: N/A

Top Coat 1: Rough steel making readings difficult

Top Coat 2: Rough steel making readings difficult

Describe any Changes to Application Method Based on Measurements: Accurate wet readings difficult due to surface roughness.

Data Sheet No. 2 (Cont.)

2D

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None		~~5.3 17.3 10.7~~ 0.0 None	None
Sags	None		~~27.5 5.4 8.0~~ 0.0 None	None
Orange Peel	None	N/A	~~8.0 12.4 9.5~~ 0.0 None	None
Cracking	None		None	None
				Several Drips
				#1

#1. Noted several blisters (less than 1/16" Dia) on plate

Data Sheet No. 2 (Cont.)

2D

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Positector 2000

Target Thickness per Coat: Primer 1½ Mil Top Coat 8 to 10 Mils/Coat

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): 1.0 TO 1.75

Spot 2 (Randomly selected location) : 1.0 To 1.75

Spot 3 (Randomly selected location): 1.0 To 1.75

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: D. Davis
Results Reviewed by: D. Jacobs

Test Panel No. --

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No. 1	Primer Coat No. 2	Top Coat No. 1	Top Coat No. 2
Spot 1*	1.0 to 1.75		5.2 12.3 10.7	13.6 11.9 16.7
Spot 2*	1.0 to 1.75		23.5 5.4 8.0	11.8 17.3 12.6
Spot 3*	1.0 to 1.75	N/A	8.0 17.4 9.5	15.2 16.9 12.0
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No. 1	Primer Coat No. 2	Top Coat No. 1	Top Coat No. 2
Spot 1*	<1	N/A	9	5
Spot 2*	1	N/A	4	7
Spot 3*	<1	N/A	11	10
Spot 4* (Pit)	1 1/2	N/A	13	14
Spot 5* (High Point)	<1	N/A	6	6

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: ____________

Results Reviewed by: D. Jacobs

D-91

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/30/92 Test Panel No.: 2D

Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): (Brush) Roller Combination

Holiday Detection:

Are holidays present in the coating? (circle one): Yes (No)

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Detector Test Done in plate mounted position.

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Data Sheet No. 1

Date: 6-10-92 Test Panel No.: 2E Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **Previously Rusted** (circled)

Coating Application (circle one): Brush Roller **Combination** (circled) (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): DEVPREP 88 AND PRESSURE WASH.

Cleaning Tools Used (attach product info.): NEEDLE GUN AND POWER WIRE CUP BRUSH

Comments: ALL LOOSE SCALE/CONTAMINATES REMOVED. Sample Still HAS ADHERENT RUST ON SURFACE.

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	N/A	N/A	NONE	NONE
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush & ½" Nap 9" Roller		2" China Bristle Brush & ½" Nap 9" Roller	2" China Bristle Brush & ½" Nap 9" Roller
Air Temperature (°F)	79°		71°/68°	83°/69°
Surface Temperature (°F)	70°		72°	82.8°
Relative Humidity	53%		60%	48%
Dew Point (°F)	[illegible]		56°	58°
Dry Time Before Non-Destructive Measurement(hours)	144 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	144 Hrs		24 Hrs	N/A

*Comments: NOTED SLIGHT DISCOLORATION IN TOP COAT.

Test Performed by: D. Davis
Results Reviewed by: [illegible signature]

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: 6-10-92 Test Panel No.: 2E Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush Roller **(Combination)**

Wet Film Thickness:

Instrument Type (attach product info.): WET FILM THICKNESS GAUGE

Target Thickness per Coat: Primer 1 1/2 Mil Top Coat 8 to 10 Mil

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Readings Taken on Sample Face.

Primer Coat 1: Rough Surface Making Reading Difficult

Primer Coat 2: N/A

Top Coat 1: Rough Surface Making Reading Difficult

Top Coat 2: Rough Surface Making Reading Difficult

Describe any Changes to Application Method Based on Measurements: Accurate Wet Readings difficult due to surface irregularities. 1/2" Nap Roller does force primer material into pores of steel.

Data Sheet No. 2 (Cont.)

2E

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Positector 2000

Target Thickness per Coat: Primer 1½ Mil Top Coat 8 to 10 Mils/Coat

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): .5 To 1.25

Spot 2 (Randomly selected location) : .5 to 1.25

Spot 3 (Randomly selected location): .5 to 1.25

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: D Davis
Results Reviewed by: L. Jacobs

Data Sheet No. 2 (Cont.)

2E

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	NONE	N/A	~~28 46 58~~ NONE	1 Run Side of Panel
Sags	NONE		~~8.8 5.5 7.5~~ NONE	NONE
Orange Peel	NONE		~~41.7 61.0 13.6~~ NONE	NONE
Cracking	NONE		NONE	NONE
			*1	*2, *3

*1 Some roller hair noted in coating

*2 Several Drips noted on high point & Bottom of Panel

*3 Several Small (less than 1/16" D) blisters on panel

Test Panel No. 6E

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	.5 to 1.25	N/A	7.8 4.5 3.8	19.4 15.2 14.8
Spot 2*	.5 to 1.25		8.8 5.5 9.5	16.X 14.7 15.9
Spot 3*	.5 to 1.25		4.7 6.8 11.6	12.5 9.7 13.0
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	<1	N/A	4	12
Spot 2*	<1	N/A	4	7
Spot 3*	1	N/A	5	7
Spot 4* (Pit)	<1	N/A	4	7
Spot 5* (High Point)	<1	N/A	4	13

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: ____________
Results Reviewed by: D. Jacobs

Data Sheet No. 3

HOLIDAY DETECTION

Date: __________ Test Panel No.: __________

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted

Coating Application (circle one): Brush Roller Combination

Holiday Detection:

Are holidays present in the coating? (circle one): Yes ·No

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: ____

____

____

____

____

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-10-92 Test Panel No.: 3C Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): Brush (Roller) Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): WATER WASH ONLY!

Cleaning Tools Used (attach product info.): NEEDLE GUN AND POWER WIRE CUP BRUSH

Comments: ALL LOOSE SCALE/CONTAMINATES REMOVED. STILL HAS ADHERENT RUST ON SURFACE

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	N/A	N/A	N/A	N/A
Type of Brush (or Roller; list roller nap size)	9"-½" Nap Roller		½" Nap Roller	½" Nap Roller
Air Temperature (°F)	73°		71°/68°	83°/69°
Surface Temperature (°F)	70°		72°	87.8°
Relative Humidity	53%		60%	42%
Dew Point (°F)	54°		56°	58°
Dry Time Before Non-Destructive Measurement (hours)	144 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	144 Hrs		24 Hrs	N/A

*Comments: Noted slight discoloration in top coat

Test Performed by: D. Davis
Results Reviewed by: D. [illegible]

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS
VISUAL INSPECTIONS, AND
DRY FILM THICKNESS MEASUREMENTS

Date: 6-10-92 Test Panel No.: 9C Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)** [circled]

Coating Application (circle one): Brush **(Roller)** [circled] Combination

Wet Film Thickness:

Instrument Type (attach product info.): WET FILM THICKNESS GAUGE

Target Thickness per Coat: Primer 1 1/2 mils Top Coat 8 to 10 Mils/Coat

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Primer Coat 1: ON FACE OF TEST SAMPLE. MEASUREMENT DIFFICULT DUE TO ROUGHNESS OF TEST PLATE.

Primer Coat 2: N/A

Top Coat 1: Measurements Difficult Due to surface Roughness

Top Coat 2: Measurements Difficult Due to surface Roughness

Describe any Changes to Application Method Based on Measurements: Accurate WFT Readings difficult to take due to surface Roughness.

Data Sheet No. 2 (Cont.)

3C

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None		None ~~47 45 15~~ [illegible]	1 Edge of Plate
Sags	None		None ~~73 90 75~~ [illegible]	None
Orange Peel	None		None ~~7.3 47 5~~ [illegible]	None
Cracking	None	N/A	None	None
			#1	#1
				#2

#1 Roller hair (nap) noted.
#2 1 Drip on Bottom of Plate

Data Sheet No. 2 (Cont.)

3C

Non-Destructive Dry Film Thickness: Positector 6000

Instrument Type (attach product info.): Positect Dry Film Thickness Gauge

Target Thickness per Coat: Primer 1½ Mil Top Coat 8 to 10 Mils/Coat

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): 1.0 to 2.0

Spot 2 (Randomly selected location) : 1.0 to 2.0

Spot 3 (Randomly selected location): 1.0 to 2.0

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: D. Davis
Results Reviewed by: D. Jacobs

Test Panel No. 3C

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1.0 to 2.0	N/A	4.7 4.5 6.5	16.2 13.2 15.1
Spot 2*	[illegible] to 2.0		3.3 [illegible] 3.5	[illegible] 11.2 15.6
Spot 3*	1.0 to 2.0		7.3 4.7 5.3	18.3 16.2 17.3
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1	N/A	4	7
Spot 2*	<1	N/A	5	6
Spot 3*	<1	N/A	5	8
Spot 4* (Pit)	<1	N/A	5	9
Spot 5* (High Point)	1	N/A	5	7

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: ____________

Results Reviewed by: [illegible signature]

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/30/92 Test Panel No.: 3C

Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): Brush (Roller) Combination

Holiday Detection:

Are holidays present in the coating? (circle one): Yes (No)

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Detector Test Done in As Mounted position

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-10-92 Test Panel No.: 3D Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)** [circled]

Coating Application (circle one): **(Brush)** [circled] Roller Combination (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): DEVPREP 88 AND HAND/SPONGE RINSE

Cleaning Tools Used (attach product info.): NEEDLE GUN AND POWER WIRE CUP BRUSH.

Comments: ALL LOOSE SCALE/CONTAMINATES REMOVED. SAMPLE STILL HAS ADHERENT RUST ON SURFACE.

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	N/A	N/A	N/A	N/A
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush		2" China Bristle Brush	2" China Bristle Brush
Air Temperatura (°F)	73°		71°/68°	82°/67°
Surface Temperature (°F)	70°		72°	82.8°
Relative Humidity	53%		60%	48%
Dew Puint (°F)	54°		56°	58°
Dry Time Before Non-Destructive Measurement (hours)	144 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	144 Hrs		24 Hrs	N/A

*Comments: Noted slight discoloration in top coat

Test Performed by: D. Davis
Results Reviewed by: [signature]

D-55

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS
VISUAL INSPECTIONS, AND
DRY FILM THICKNESS MEASUREMENTS

Date: 6-10-92 Test Panel No.: 30 Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): **(Brush)** Roller Combination

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1/2 Mils Top Coat 8 to 10 Mil / Coat

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot): surface of test plate. Measurements difficult

Primer Coat 1: Due to roughness of test plate.

Primer Coat 2: N/A

Top Coat 1: Measurement difficult due to roughness of test plate.

Top Coat 2: Measurement difficult due to roughness of test plate.

Describe any Changes to Application Method Based on Measurements: However wet readings difficult due to roughness of test plates.

Data Sheet No. 2 (Cont.)

3D

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None		None ~~66 66 73~~ [illegible]	1 Row 1½" Long
Sags	None		None ~~53 112 81~~ [illegible]	None
Orange Peel	None		None ~~61 64 68~~ [illegible]	None
Cracking	None	N/A	None	None
				#1

#1 2 Drips bottom of Plate

Data Sheet No. 2 (Cont.)

3D

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Positector 2000 Positect Dry Film Thickness Gauge

Target Thickness per Coat: Primer 1.5 Mils Top Coat At 10 Mils/Coat

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): .75 TO 1.25

Spot 2 (Randomly selected location) : .75 to 1.25

Spot 3 (Randomly selected location): .75 to 1.25

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: D. Davis
Results Reviewed by: D. Jacobs

Test Panel No. 3D

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	.75 to 1.25		6.6 6.6 7.3	8.5 14.0 12.6
Spot 2*	.75 to 1.25		5.3 11.2 8.1	14.6 12.8 14.3
Spot 3*	.75 to 1.25	N/A	6.1 6.4 6.5	15.0 12.6 15.7
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	<1	N/A	4	6
Spot 2*	<1	N/A	4	9
Spot 3*	<1	N/A	5	10
Spot 4* (Pit)	1	N/A	10	12
Spot 5* (High Point)	<1	N/A	7	18

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: __________
Results Reviewed by: D. Jacobs

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/30/92 Test Panel No.: 3 D

Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): (Brush) Roller Combination

Holiday Detection:

Are holidays present in the coating? (circle one): Yes (No)

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Detector Test Done in Mounted Position

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-10-92 Test Panel No.: 3E Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) Previously Rusted (circled)

Coating Application (circle one): Brush Roller Combination (circled) (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Devised 88 and pressure wash.

Cleaning Tools Used (attach product info.): Needle guns and power wire cup brush.

Comments: All loose scale/contaminates removed. Sample still has adherent rust on surface.

Coatings:

	Primer		Top Coat	
	Coat 1	Coat 2	Coat 1	Coat 2
Thinner Type	N/A	N/A	N/A	N/A
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush & ½" Nap 9" Roller		2" China Bristle Brush & ½" Nap 9" Roller	2" China Bristle Brush & ½" Nap 9" Roller
Air Temperature (°F)	73°		71°/62°	83°/67°
Surface Temperature (°F)	70°		72°	82.3°
Relative Humidity	53%		60%	42%
Dew Point (°F)	54°		56°	58°
Dry Time Before Non-Destructive Measurement(hours)	144 Hrs		24 Hrs	24 Hrs +
Dry Time Before Recoating (hours)	144 Hrs		24 Hrs	N/A

*Comments: Noted slight discoloration in top coat

Test Performed by: D. Davis
Results Reviewed by: D. Jacoda

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS
VISUAL INSPECTIONS, AND
DRY FILM THICKNESS MEASUREMENTS

Date: 6-10-92 Test Panel No.: 3E Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush Roller **(Combination)**

Wet Film Thickness:

Instrument Type (attach product info.): WET FILM THICKNESS GAUGE

Target Thickness per Coat: Primer 1½ Mil Top Coat 8 to 10 Mils/Coat

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot): ON SURFACE OF TEST PLATE. MEASUREMENTS DIFFICULT

Primer Coat 1: DUE TO ROUGHNESS OF TEST PLATE

Primer Coat 2: n/a

Top Coat 1: Difficult to Get WET Readings due to Surface Roughness

Top Coat 2: Surface Roughness makes WET Readings difficult to get.

Describe any Changes to Application Method Based on Measurements: Accurate WET Readings difficult to get due to test panel Roughness.

Data Sheet No. 2 (Cont.)

3E

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None		None ~~46 7.1 55~~ [illegible]	None
Sags	None		None ~~95 54 78~~ [illegible]	None
Orange Peel	None		None ~~80 57 48~~ [illegible]	None
Cracking	None	NA	None	None
			#1	#1
				#2

#1 Roller hair (nap) noted.

#2 Several small blisters (less than 1/16" Dia) noted.

Data Sheet No. 2 (Cont.)

3E

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Positector 2000 Positest Dry Film Thickness Gauge

Target Thickness per Coat: Primer 1.5 Mils Top Coat 8 to 10 Mils/Coat

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): .5 to 1.0

Spot 2 (Randomly selected location) : .5 to 1.0

Spot 3 (Randomly selected location): .5 to 1.0

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: D. DAVIS
Results Reviewed by: D. Jacobs

Test Panel No. 32

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	.5 to 1.0	N/A	4.6 7.1 5.5	16.4 15.3 16.9
Spot 2*	.5 to 1.0		7.5 5.4 7.8	17.2 15.3 15.6
Spot 3*	.5 to 1.0		8.0 5.7 4.8	20.2 17.4 20.0
Spot 4* (Pit)	N/A		N/A	N/A
Spot 5* (High Point)	N/A		N/A	N/A

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	<1	N/A	5	13
Spot 2*	<1	N/A	7	10
Spot 3*	<1	N/A	7	14
Spot 4* (Pit)	<1	N/A	9	9
Spot 5* (High Point)	1	N/A	10	9

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: __________
Results Reviewed by: D. Jacobs

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/30/92 Test Panel No.: 3E

Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): Brush Roller (Combination)

Holiday Detection:

Are holidays present in the coating? (circle one): Yes (No)

If yes, show a sketch of the test panel and indicate the locations of the holidays:

Comments: Holiday Test Done in Mounted Position

Data Sheet No. 1

TEST PANEL PREPARATION AND COATING

Date: 6-10-92 Test Panel No.: 3F Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): Brush Roller (Combination) (describe below)*

Test Panel Preparation:

Solvent Used (attach product info.): Deionized & Pressure Wash

Cleaning Tools Used (attach product info.): Rota Hammer unit & Power Brush

Comments: All loose scale/contaminates removed. Sample still has adherent rust on surface

Coatings:

	Primer Coat 1	Primer Coat 2	Top Coat Coat 1	Top Coat Coat 2
Thinner Type	N/A	N/A	N/A	N/A
Type of Brush (or Roller; list roller nap size)	2" China Bristle Brush & ½" nap 9" Roller		2" China Bristle Brush & ½" nap 9" Roller	2" China Bristle Brush & ½" nap 9" Roller
Air Temperature (°F)	73°		71°/68°	83°/67°
Surface Temperature (°F)	70°		72°	82.8°
Relative Humidity	53%		61%	48%
Dew Point (°F)	54°		56°	58
Dry Time Before Non-Destructive Measurement (hours)	144 Hrs		24 Hrs	24 Hrs
Dry Time Before Recoating (hours)	144 Hrs		24 Hrs	N/A

*Comments: Noted slight discoloration in top coat

Test Performed by: D. Davis
Results Reviewed by: D. Jacobs

Data Sheet No. 2

WET FILM THICKNESS MEASUREMENTS VISUAL INSPECTIONS, AND DRY FILM THICKNESS MEASUREMENTS

Date: 6-10-92 Test Panel No.: 3F Test Panel Thickness: 9/16

Test Panel Type (circle one): Clean (i.e., new steel) **(Previously Rusted)**

Coating Application (circle one): Brush Roller **(Combination)**

Wet Film Thickness:

Instrument Type (attach product info.): Wet Film Thickness Gauge

Target Thickness per Coat: Primer 1 1/2 Mil Top Coat 8 To 10 Mils/Coat

Measurement Locations and Values (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot): Readings Taken on Face of Sample.

Primer Coat 1: WET. Readings Difficult on Rough Surface

Primer Coat 2: N/A

Top Coat 1: Readings Difficult on Rough Surface

Top Coat 2: Readings Difficult to take on the Rough Surface

Describe any Changes to Application Method Based on Measurements: Accurate readings of applied coatings difficult due to Rough Surface

Data Sheet No. 2 (Cont.)

3F

Visual Inspection

After each layer of paint has cured, inspect the paint surface for the conditions listed below. Estimate the percentage of the surface that has each condition. If conditions other than those listed exist, add them to the data table.

Condition	Percentage of Surface Effected			
	Primer		Top-Coat	
	Coat No. 1	Coat No. 2	Coat No. 1	Coat No. 2
Runs	None	N/A	None ~~65 37 10~~ 00	None
Sags	None		None ~~32 27 29~~ 00	None
Orange Peel	None		None ~~48 37 18~~ 00	None
Cracking	None		None	None
			#1	#1
				#2
				#3

#1. Polka haze noted in coating

#2. Drips on bottom of panel

#3. Noted several blisters on panel less than 1/16" in Dia

Data Sheet No. 2 (Cont.)

3F

Non-Destructive Dry Film Thickness:

Instrument Type (attach product info.): Positector 2000 Positect Dry Film Thickness Gauge

Target Thickness per Coat: Primer 1.5 Mil Top Coat 8 to 10 Mils/Coat

Measurement Locations (attach sketches to show locations on steel samples, and indicate whether measurement location is a pit or high spot):

Spot 1 (Randomly selected location): 1.0 TO 1.5

Spot 2 (Randomly selected location) : 1.0 to 1.5

Spot 3 (Randomly selected location): 1.0 to 1.5

Spot 4 (Pit): N/A

Spot 5 (High Point): N/A

Test Performed by: D. Davis
Results Reviewed by: D. Jacobs

Test Panel No. 3F

Data Sheet No. 2 (Cont'd)

WET FILM AND DRY FILM THICKNESS MEASUREMENTS

Non-Destructive Film Thickness (Cont'd):

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1.0 to 1.5		6.5 5.3 2.0	13.5 9.0 5.8
Spot 2*	1.0 to 1.5		2.2 2.3 2.9	6.1 5.0 6.2
Spot 3*	1.0 to 1.5	N/A	4.5 3.3 1.8	10.5 11.9 9.9
Spot 4* (Pit)	N/A		N/A	
Spot 5* (High Point)	N/A		N/A	

*Each spot thickness is the average of three readings as specified in Reference 2.4. Show individual readings and averages above.

Destructive Film Thickness (measure only once after all coats have cured):

Instrument Type (attach product info.): Tooke Paint Inspection Gage IV

Measurement Locations: Use same spot locations as Non-Destructive Dry Film Thickness measurements.

Thicknesses (mils):

	Primer Coat No.		Top Coat No.	
	1	2	1	2
Spot 1*	1 1/2	N/A	6	5
Spot 2*	1	N/A	4	5
Spot 3*	<1	N/A	3	6
Spot 4* (Pit)	<1	N/A	3	5
Spot 5* (High Point)	<1	N/A	3	3

*Each spot thickness is the average of four readings as specified in Reference 2.7. Show individual readings and averages above.

Test Performed by: ______

Results Reviewed by: D. Jacobs

Data Sheet No. 3

HOLIDAY DETECTION

Date: 6/30/92 Test Panel No.: 3F

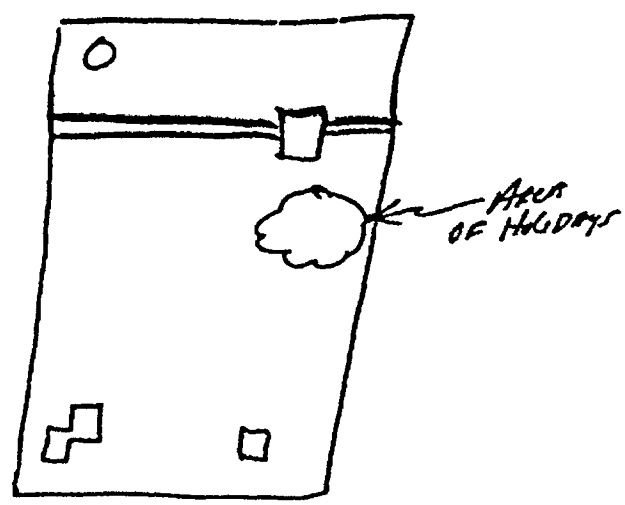
Test Panel Type (circle one): Clean (i.e., new steel) (Previously Rusted)

Coating Application (circle one): Brush Roller (Combination)

Holiday Detection:

Are holidays present in the coating? (circle one): (Yes) No

If yes, show a sketch of the test panel and indicate the locations of the holidays:



Comments: Holiday Detection Test Done in Elevated Position