RAS 14254

APPLICANT'S EXHIBIT 40

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Oyster Creek License Renewal Presentation to ACRS Subcommittee

January 18, 2007

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AmerGen Representatives

- Fred Polaski
- John O'Rourke
- Howie Ray
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- Dr. Hardayal Mehta
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- Jon Cavallo
- Ahmed Ouaou

Agenda

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- Drywell Shell Corrosion
  - Physical Overview
  - Cause and Corrective Actions
  - Drywell Shell Thickness Analysis
  - Sand Bed Region
  - Embedded Portions of the Drywell Shell
  - Upper Shell

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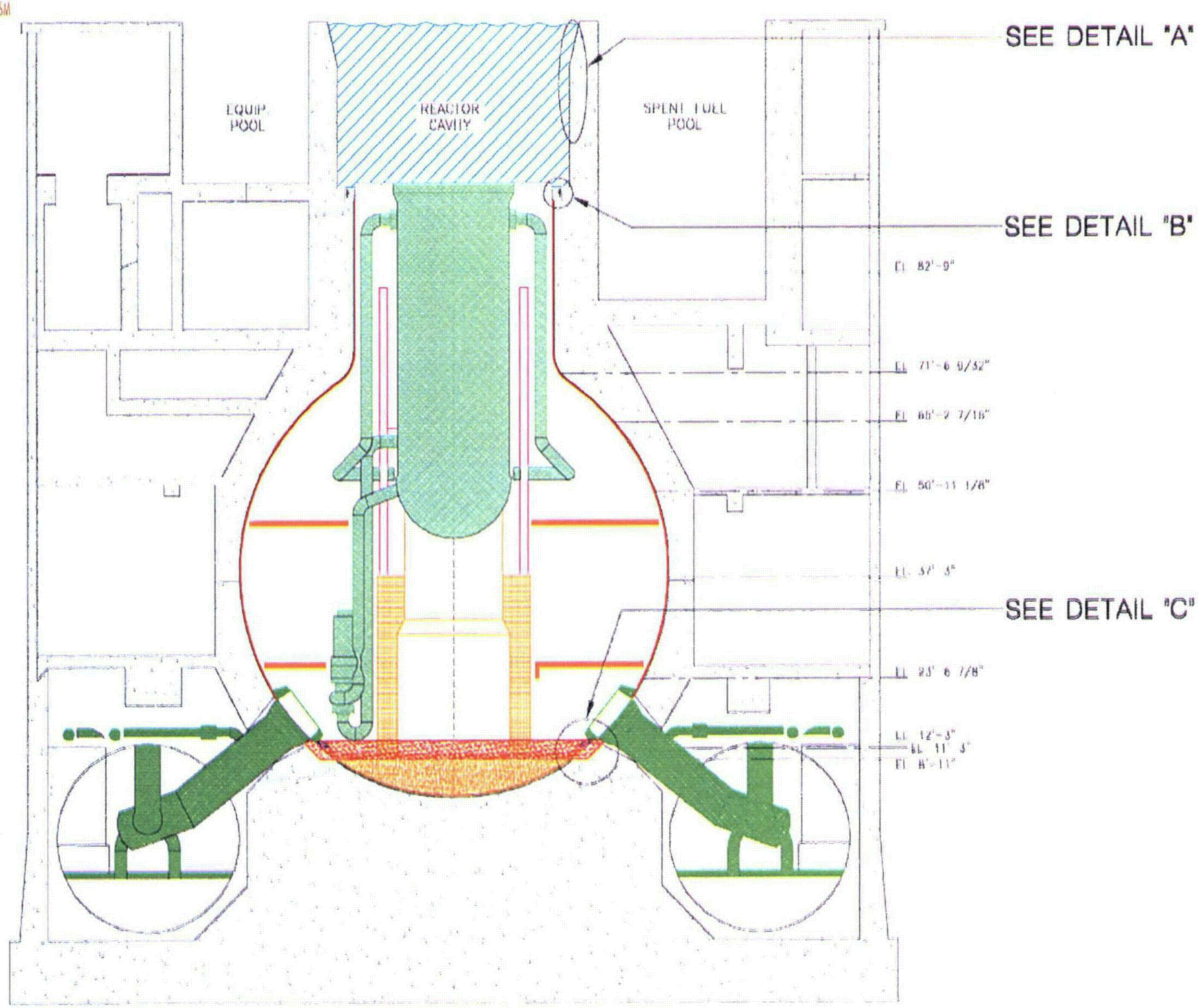
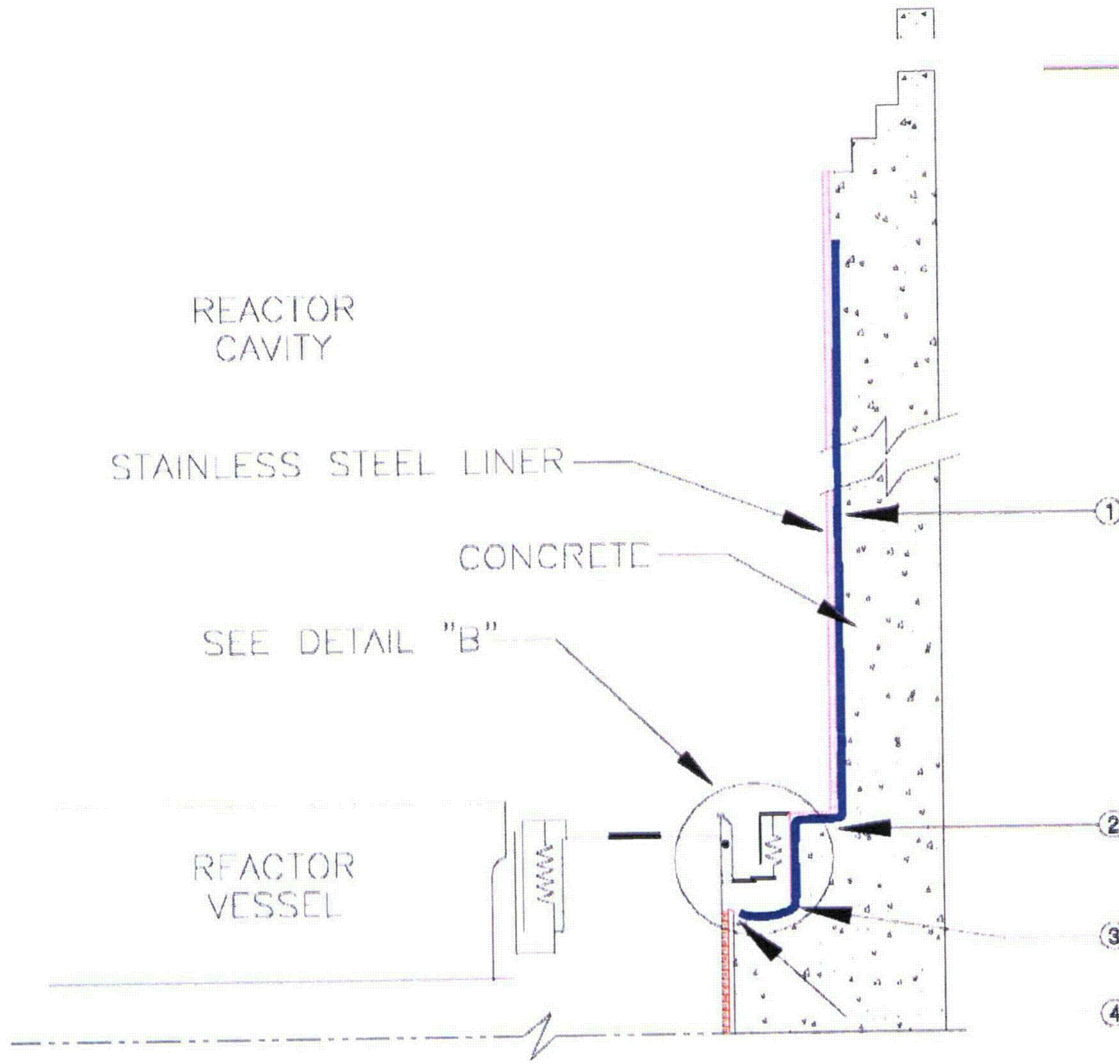
Drywell Shell Corrosion Cause and Corrective Actions


EQUIP. POOL
REACTOR CAVITY
SPENT FUEL POOL
SEE DETAIL "A"
SEE DETAIL "B"
SEE DETAIL "C"



DRYWELL AND REACTOR CAVITY SECTION
DETAIL "A"

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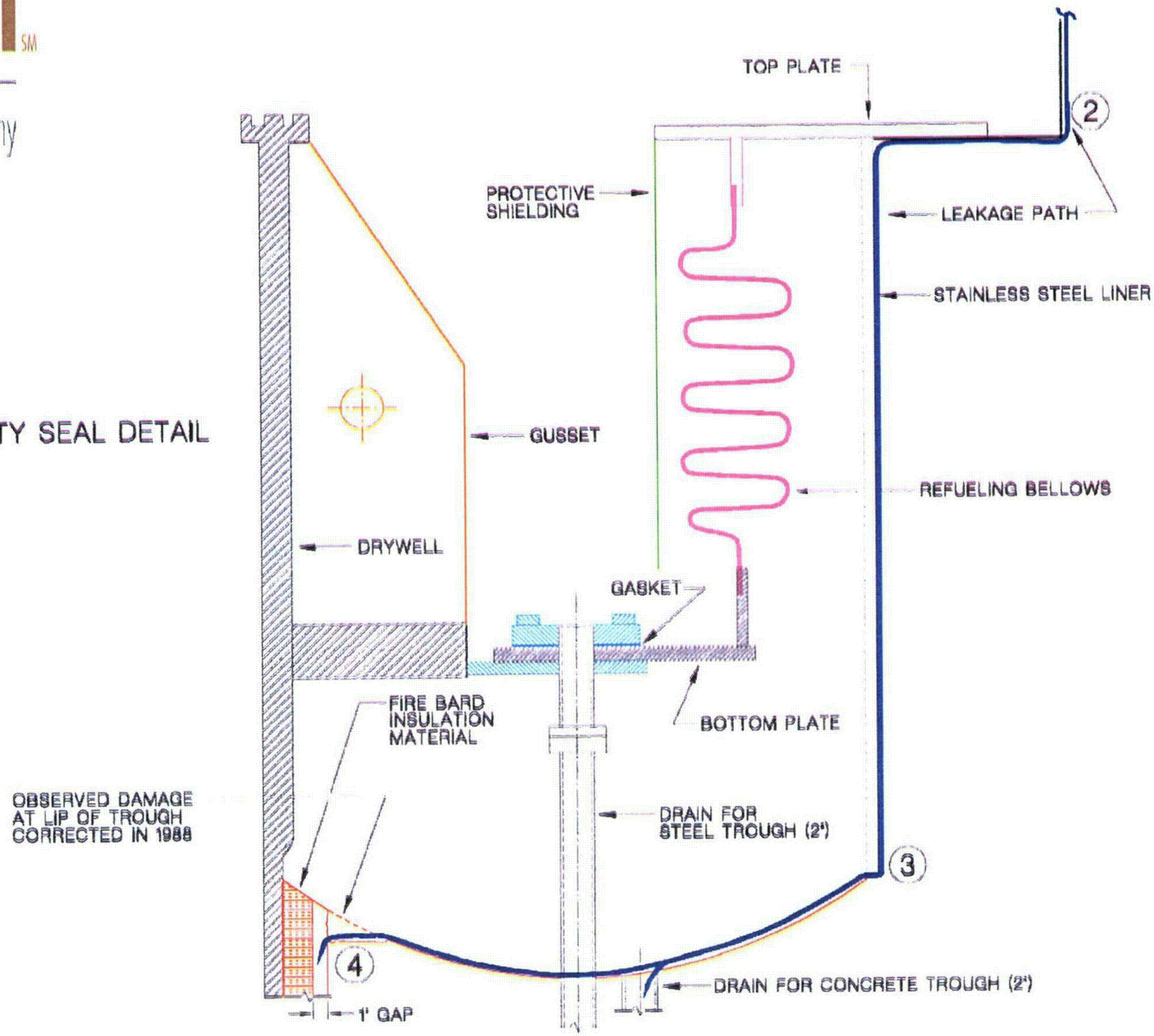
DRYWELL TO REACTOR CAVITY SEAL DETAIL
DETAIL "B"



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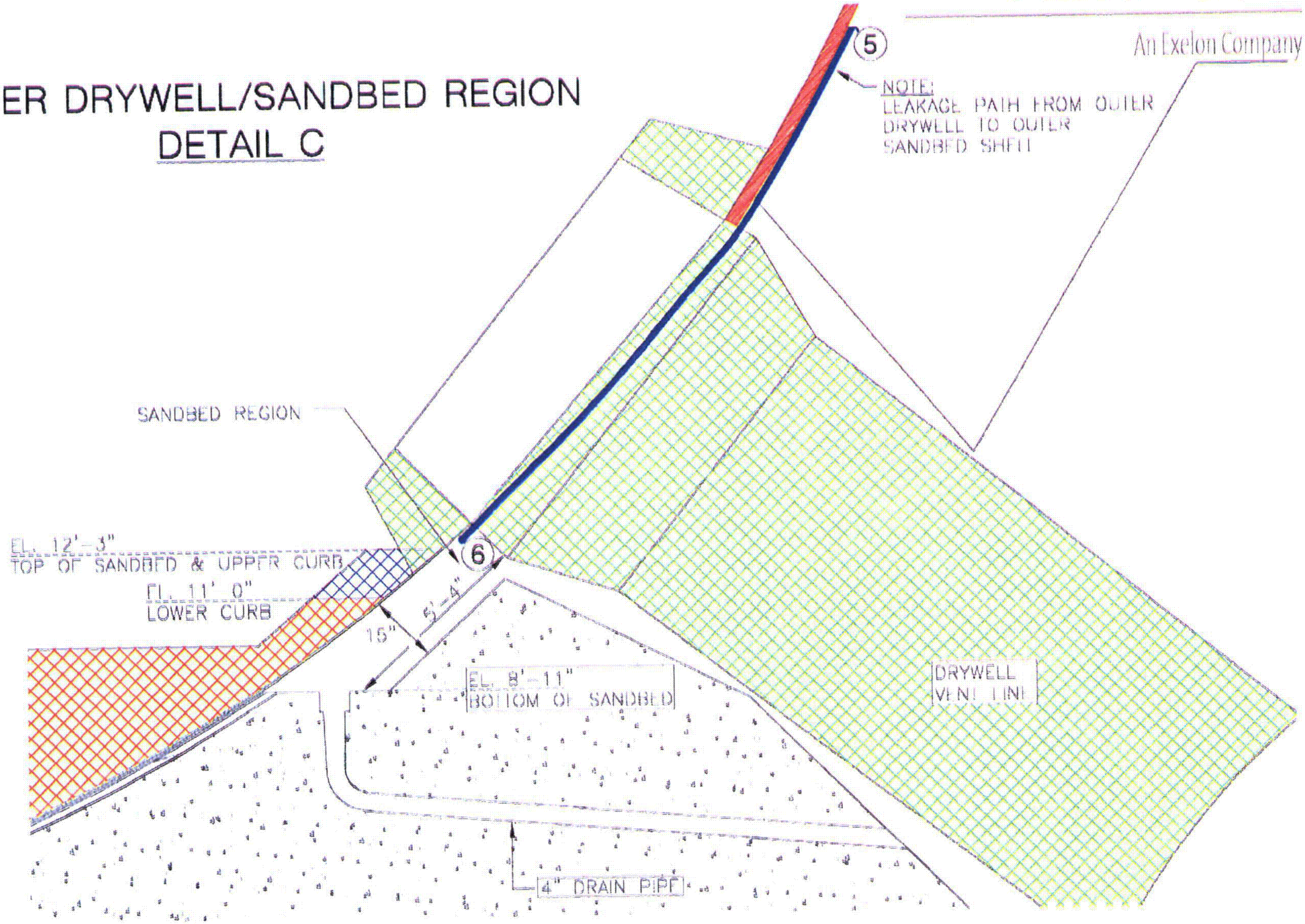
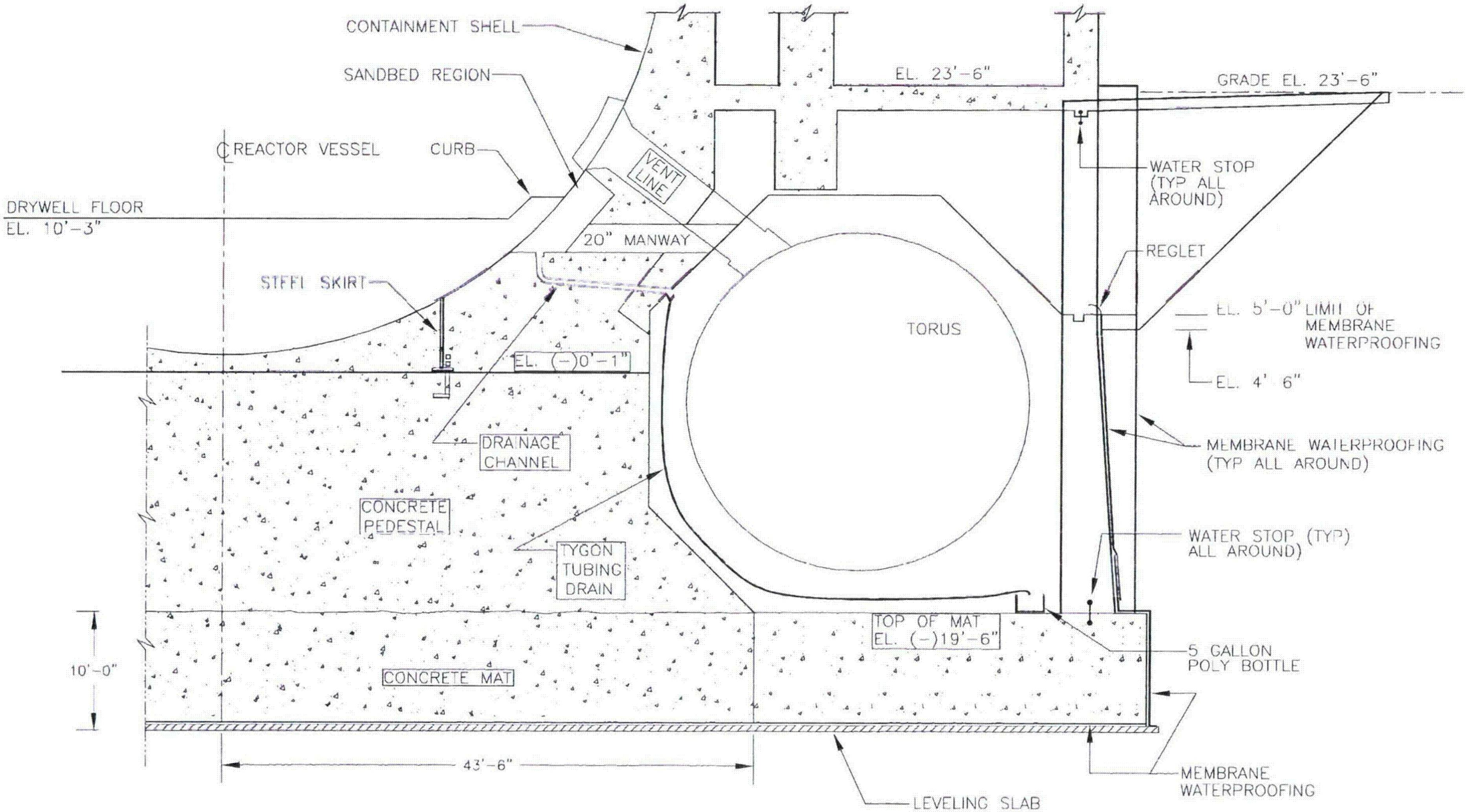
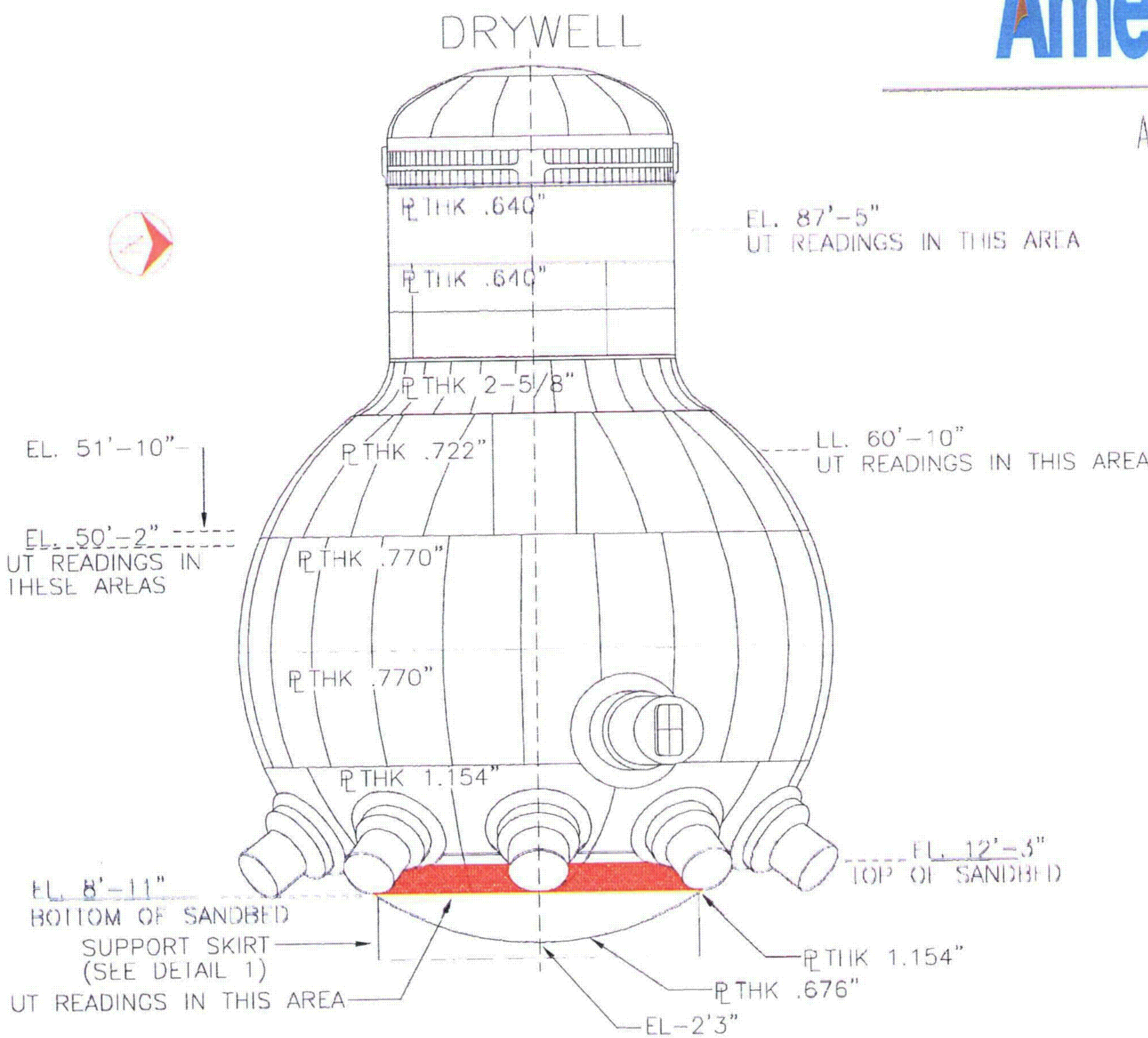
LOWER DRYWELL/SANDBED REGION
DETAIL C



REACTOR BUILDING, DRYWELL SUPPORT STRUCTURE





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Cause and Corrective Actions

- Water accumulation in the sand bed region resulted in corrosion of the exterior surface of the drywell shell
- Corrective actions were completed in 1992
  - Prevented water intrusion into the sand bed region
  - Eliminated corrosive environment by removing the sand
  - Coated the drywell shell with epoxy in the sand bed region

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Verification and Monitoring

- In 2006 refueling outage
  - Leakage from the reactor cavity liner, estimated at about 1 gpm, was captured by the drainage system
  - UT measurements of the drywell at 19 monitoring locations for the sand bed region showed no change in thickness
  - 100% visual inspection of the epoxy coating showed it to be in good condition
  - There was no water in the sand bed region

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Verification and Monitoring

- In 2006 refueling outage
  - 106 UT measurements at locations measured in 1992, before epoxy coating applied, showed the drywell shell exceeds design thickness requirements
  - UT measurements at 13 locations in the upper elevations of the drywell show only 1 location with minimal ongoing corrosion (meets minimum required through 2029 with margin)

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Drywell Shell Current Condition

Drywell Region	Nominal Design Thickness, mils	Minimum Measured Thickness, mils	Minimum Required Thickness, mils	Minimum Available Thickness Margin, mils
Cylindrical	640	604	452	152
Knuckle	2,625	2,530	2260	270
Upper Sphere	722	676	518	158
Middle Sphere	770	678	541	137
Lower Sphere	1154	1160	629	531
Sand Bed	1154	800	736	64

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Drywell Thickness Analysis

Hardayal S. Mehta, Ph.D., P.E.
General Electric

Drywell Analysis

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- Analysis completed in early 1990s
  - Without sand in the sand bed
- Modeling of the drywell
  - Loads and Load Combinations
- Buckling analysis
  - Controls the required drywell shell thickness in the sand bed region
  - Uniform drywell shell thickness of 736 mils over the entire sand bed region was used in the analysis
- ASME Section VIII stress analysis based on 62 psi
- Drywell pressure design basis change from 62 psi to 44 psi
  - Stress analysis of the drywell shell based on 44 psi

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Modeling of the Drywell

Drywell Configuration

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- Oyster Creek Drywell Geometry
  - It is 105'-6" high
  - Drywell head is 33' in diameter
  - Spherical section has an inside diameter of 70'
  - 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
  - Drywell interior filled with concrete to elevation 10'-3" to provide a level floor
  - Base of the drywell is supported on a concrete pedestal conforming to the curvature of the vessel
  - Shell thicknesses vary
- Drywell shell, i.e., the sphere, cylinder, dome and transitions, was constructed from SA-212, Grade B Steel ordered to SA-300 spec.

Finite Element Models Used

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- Axisymmetric, Beam and Pie Slice models used
- Axisymmetric drywell model used to evaluate
  - Unflooded and flooded seismic inertia loading
  - Thermal loading during postulated accident condition
- Beam drywell model used to evaluate stresses due to seismic relative support displacement
- Pie slice drywell model used for the Code and buckling evaluations
  - Vent lines included in the model
- No sand stiffness considered in any of the models

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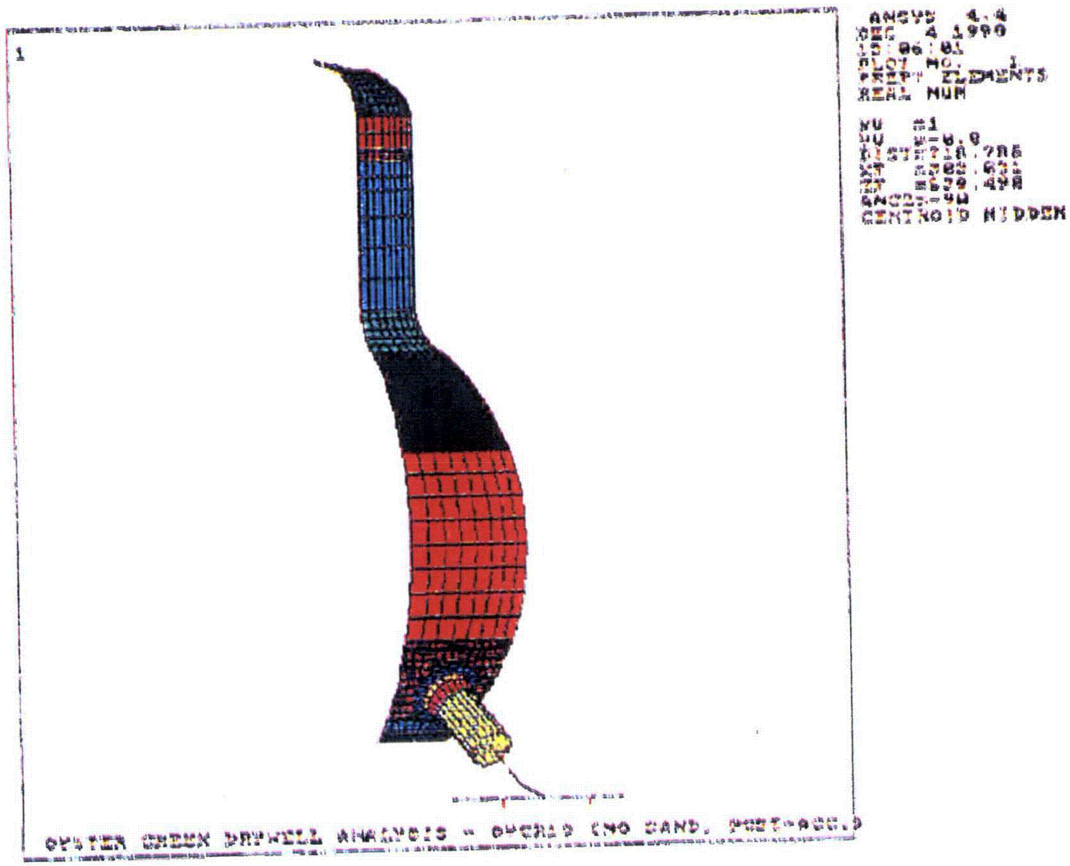
Pie Slice Model and Load Application

- Taking advantage of symmetry of the drywell with 10 vent lines, a 36 degree section was modeled
  - The model included the drywell shell from base of the sand bed region to the top of the elliptical head and the vent and vent header
  - Drywell shell thickness in the sand bed region: 736 mils uniform

Pie Slice model



Applied Loads

- Gravity loading consists of dead weight loads, penetration loads, live loads
- Design pressure of 62 psi pressure (at 175°F)
  - Note 62 psi criterion was later changed to 44 psi per Tech. Spec. Amendment #165 (SER dated September 13, 1993)
- Seismic Loads
  - Inertia loads
  - Relative support displacement (Drywell and Reactor Building)

Seismic Load Definition

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- Axisymmetric finite element model used to determine inertia loading
  - Drywell is constrained at the "reactor building/drywell/ star truss" interface at elevation 82'-6" and at its base
- Spectra at two locations: At the mat foundation and at the upper constraint
- Envelope spectrum used in ANSYS analysis

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Load Combinations and Constituent Loads

Load Combination	Constituent Loads
Normal Operating Condition	Gravity loads+ Pressure (2 psi external) + Seismic (2 x DBE)
Refueling Condition	Gravity loads + Pressure (2 psi external) + Water load +Seismic (2 x DBE)
Accident Condition	Gravity loads + Pressure (62 psi @ 175 deg. F or 35 psi @ 281 deg.F) + Seismic (2 x DBE)
Post-Accident Condition	Gravity loads + Water Load to El. 74' 6" + Seismic (2 x DBE)

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Buckling Analysis

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Buckling Analysis Conclusion

- The buckling analysis was conducted using a uniform drywell shell thickness in the sand bed region of 736 mils.
- Stress limits and safety factors are in accordance with the Code requirements.
- The analysis shows that the drywell shell meets ASME Code Case N-284 requirements considering all design basis loads and load combinations.
- A locally thinned 12"x 12" area down to 536 mils was evaluated and determined not to have significant impact on buckling.
- The drywell shell thickness will be monitored using 736 mils as acceptance criteria for the minimum required general thickness and 536 mils as the minimum required local thickness.

Buckling Analysis Details

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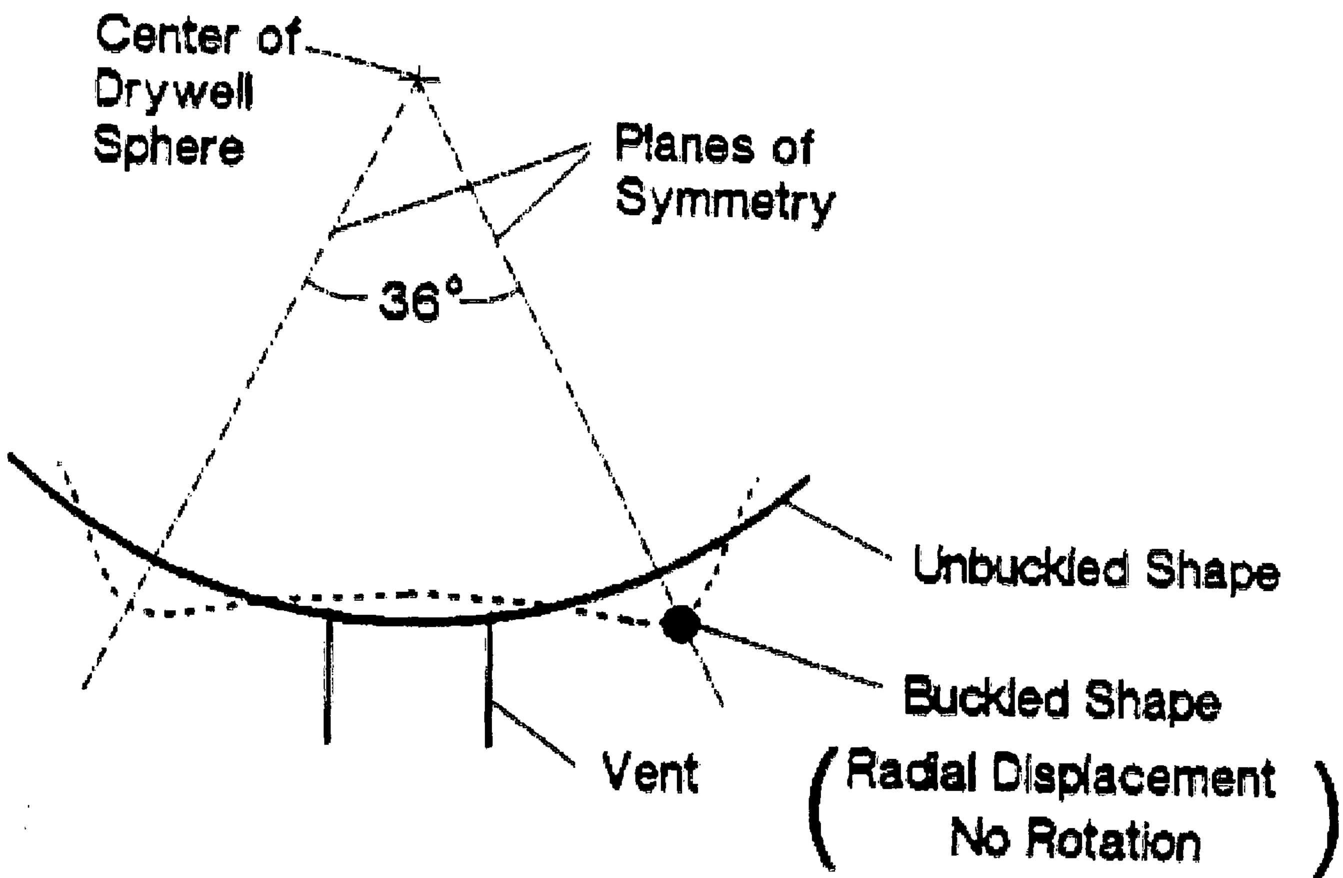
- Basic approach used in buckling evaluation followed the methodology outlined in ASME Code Case N-284

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

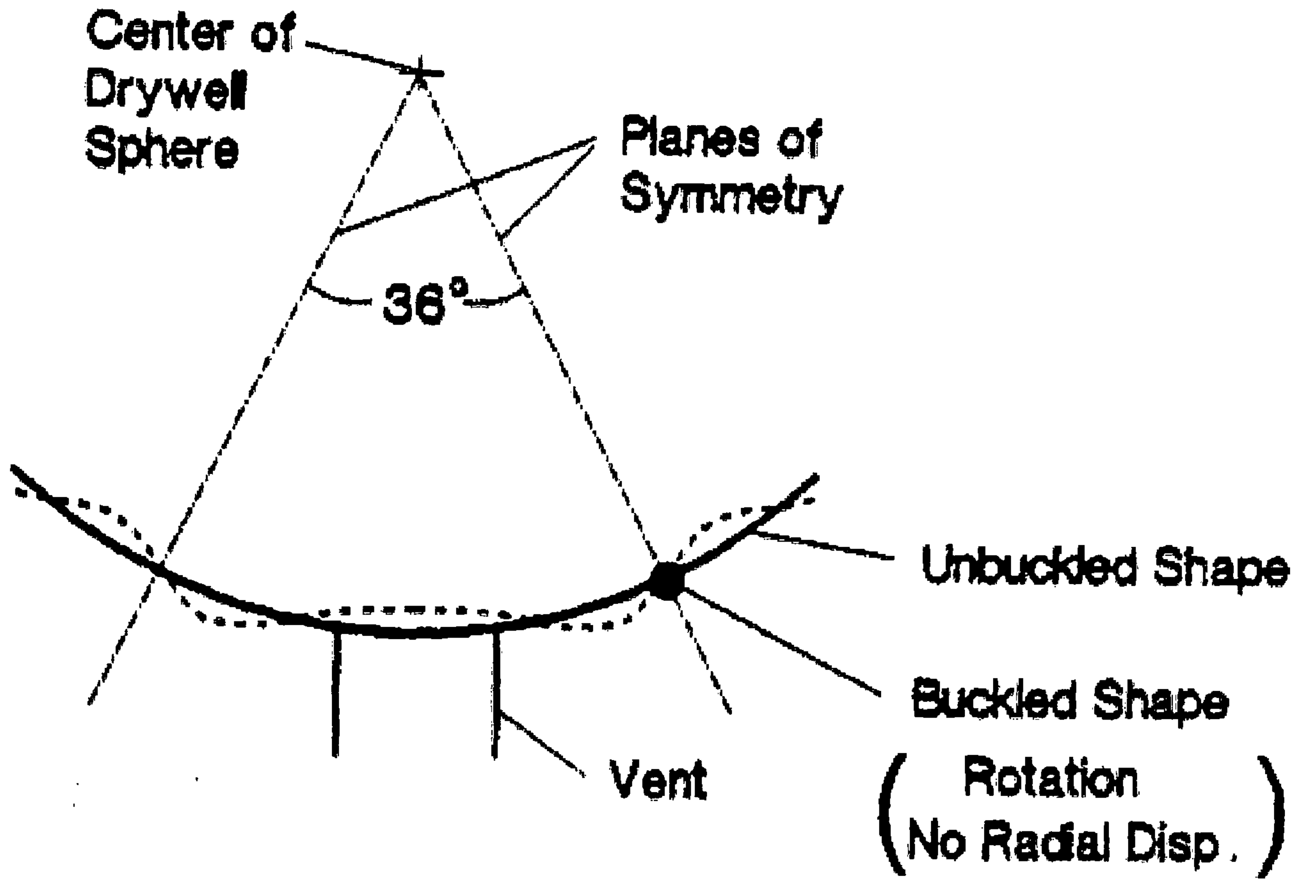
  - FS is factor of safety (equal to 2.0 for refueling condition and 1.67 for post accident condition)
- Boundary conditions for buckling analysis
  - Symmetric at both edges (sym-sym)
  - Symmetric at one edge and asymmetric at the other edge (sym-asym)
  - Asymmetric at both the edges (asym-asym)
  - This captures all possible buckling mode shapes
- A uniform drywell shell thickness in the sand bed region of 736 mils was used in the buckling analysis

Buckling Analysis Details



Symmetric Buckling of Drywell

Buckling Analysis Details



Asymmetric Buckling of Drywell

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Buckling Analysis Details

- Limiting load combination is the refueling condition
- Loads during refueling condition are
  - Gravity loads including weight of refueling water
  - External pressure of 2 psig
  - Seismic inertia and deflection loads for unflooded condition

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Buckling Analysis Details

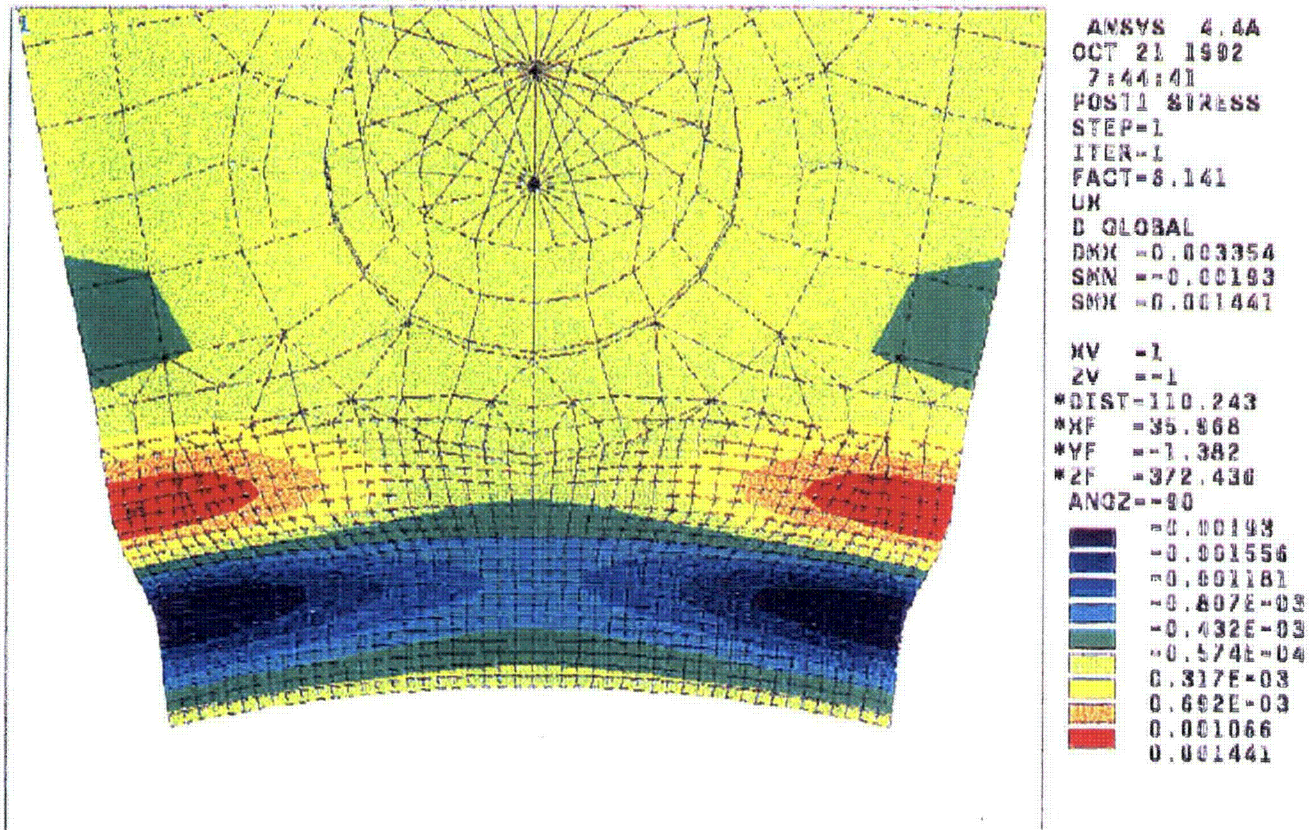

Figure 3-18 Sym-Sym Buckling Mode Shape - Refueling Case

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

Buckling Analysis Details

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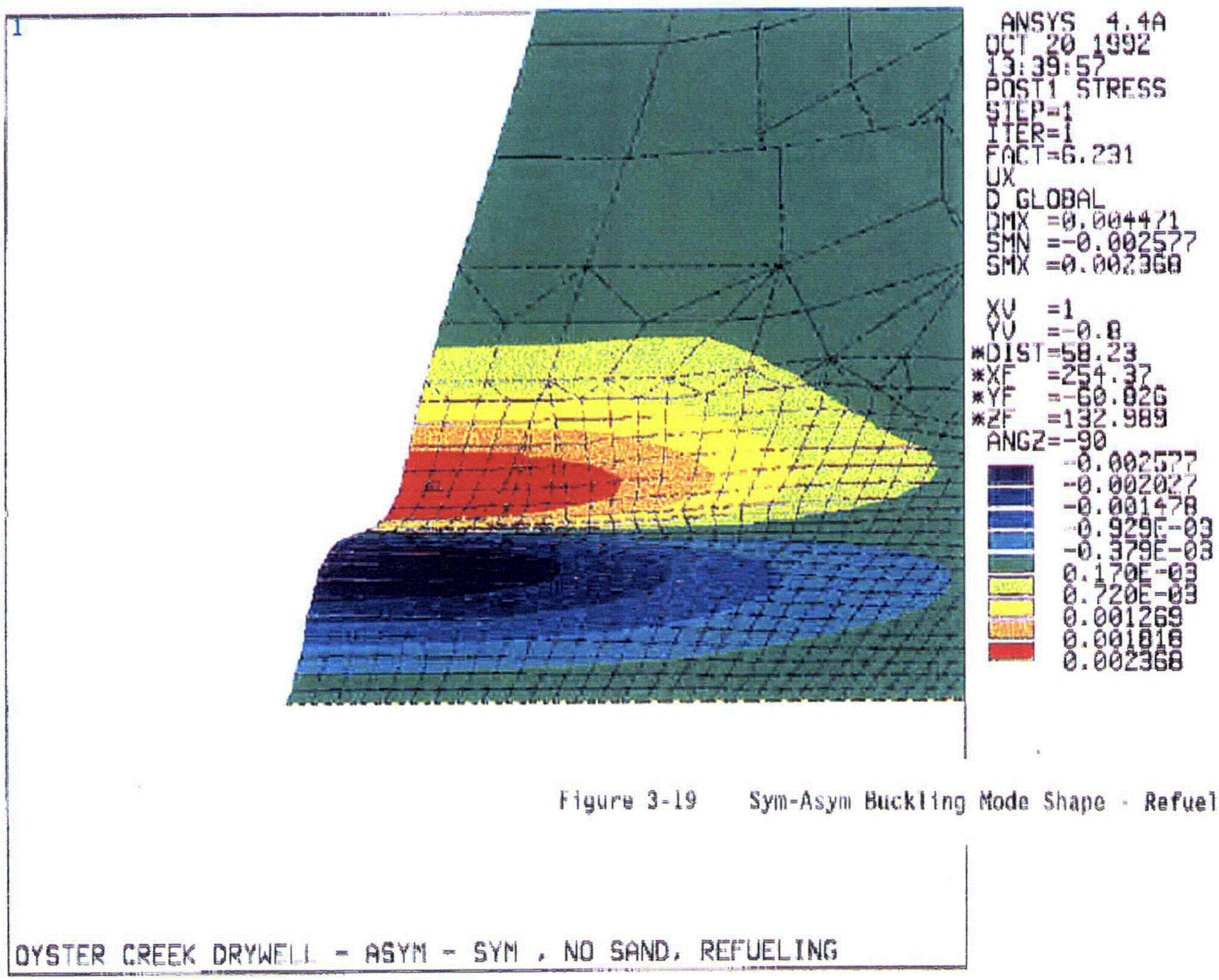

Figure 3-19 Sym-Asym Buckling Mode Shape - Refueling Case

Buckling Analysis Details

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Summary of Buckling Analysis Results – 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

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Evaluation of Local Thinning on Buckling Analysis - Sensitivity Study

- A locally 12"x12" thin area was modeled in the sand bed region drywell shell in the highest stress area, to determine the impact of local thinning on buckling stress
  - Establish minimum required local thickness down to 536 mils

Note: UT thickness measurements taken through 2006 show that locally thinned areas of the drywell shell are not coincident with high stress areas. The locally thinned areas are typically scattered below and near the vent headers. These areas are not highly stressed because of the additional stiffness provided by the vent header.

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Buckling Analysis Conclusion

- The buckling analysis was conducted using a uniform drywell shell thickness in the sand bed region of 736 mils.
- Stress limits and safety factors are in accordance with the Code requirements.
- The analysis shows that the drywell shell meets ASME Code Case N-284 requirements considering all design basis loads and load combinations.
- A locally thinned 12"x 12" area down to 536 mils was evaluated and determined not to have significant impact on buckling.
- The drywell shell thickness will be monitored using 736 mils as acceptance criteria for the minimum required general thickness and 536 mils as the minimum required local thickness.

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ASME Section VIII Stress Analysis

ASME Section VIII Stress Analysis Conclusion

- Stress analysis of the drywell shell was conducted in accordance with ASME Code and SRP 3.8.2 using reduced thicknesses due to corrosion.
- Stress limits and safety factors are in accordance with the ASME Code requirements.
- The analysis shows that the drywell shell meets ASME Code Stress requirements considering all design basis loads and load combinations.
- To regain margin, a plant specific analysis was conducted that reduced drywell design basis pressure from 62 psi to 44 psi (Tech Spec Amendment #165)
- The reduction in pressure resulted in a stress reduction of up to 5200 psi
- The minimum required general and local drywell shell thicknesses were calculated in accordance with ASME Code based on 44 psi pressure.
- The drywell shell thickness will be monitored for corrosion using the calculated minimum required general and local thicknesses as acceptance criteria.

Codes and Standards

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- 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
- Original Code of record and Code Cases do not provide specific guidance in two areas
- For the size of the region of increased membrane stress, guidance sought from Subsection NE of Section III
- For the Post-accident stress limits Standard Review Plan Section 3.8.2 was used as guidance

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Drywell – Section VIII Allowable Stresses

Drywell Allowable Stresses

Stress Category	Allowable Stress Values (psi)	
	All Conditions Except Post-Accident	Post-Accident Condition*
General Primary Membrane	19300	38000
General Primary Membrane Plus Bending	29000	57000
Primary Plus Secondary	52500	70000

* Allowable values based on Standard Review Plan Section 3.8.2, Steel Containment

Code Stress Evaluation Results

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(based on 62 psi, 1993)

Primary Stress Evaluation

Drywell Region	Stress Category	Calculated Stress Magnitude (psi)	Allowable Stress (psi)	Percent Margin
Cylinder (t=0.619 in.)	Primary Membrane	19850	21200*	6
	Primary Memb.+Bending	20970	29000	28
Upper Sphere (t=0.677 in.)	Primary Membrane	20360	21200*	4
	Primary Memb.+Bending	28100	29000	3
Middle Sphere (t=0.723 in.)	Primary Membrane	19660	21200*	7
	Primary Memb.+Bending	24610	29000	15
Lower Sphere (t=1.154 in.)	Primary Membrane	13940	21200*	34
	Primary Memb.+Bending	17640	29000	39
Sand Bed (t=0.736 in.)	Primary Membrane	16540	21200*	22
	Primary Memb.+Bending	23130	29000	20

* This is (1.1x19300) and is the threshold for local primary membrane stress per NE-3213.10

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Regain Margin through Licensing Basis Change

- The drywell pressure of 62 psi was very conservative
- Analysis was conducted in early 1990's to establish Oyster Creek specific drywell design pressure.
  - Design pressure changed from 62 psi to 44 psi.
    - 44 psi is based on conservatively calculated peak drywell pressure of 38.1 psi plus an added 15% allowance.
  - The change was approved by NRC per Technical Specification Amendment No. 165 (SER dated September 13, 1993).
  - The reduction in pressure resulted in a pressure stress reduction of up to 5200 psi
- Recalculated the required drywell shell thicknesses based on 44 psi to regain thickness margin.

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Primary Membrane Stress Comparison 62 psi vs. 44 psi

Drywell Region	Time Frame	As-analyzed Thickness (mils)	Stress Category	Calculated Stress (psi)	Allowable Stress (psi)	Stress Margin (%)
Cylinder	1993	619	Primary Membrane	19, 850	21,200	6
	2006	604	Primary Membrane	14,446	19,300	25
Upper Sphere	1993	677	Primary Membrane	20,360	21,200	4
	2006	676	Primary Membrane	14,796	19,300	23
Middle Sphere	1993	723	Primary Membrane	19,660	21,200	7
	2006	678	Primary Membrane	15,499	19,300	20
Lower Sphere	1993	1154	Primary Membrane	13,940	21,200	34
	2006	1154	Primary Membrane	10,660	19,300	45
Sand Bed	1993	736	Primary Membrane	16,540	21,200	22
	2006	736	Primary Membrane	11,404	19,300	41

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Minimum Required Drywell Shell Thickness

- Minimum required general thickness for 44 psi
  - Calculated based on primary membrane stresses for 62 psi, adjusted for pressure reduction (62 psi to 44 psi)
- Minimum required local thickness for 44 psi
  - Calculated based on ASME Section III provisions which allow increase in allowable local primary membrane stress from 1.0 Smc to 1.5 Smc
  - Local thickness criteria is applicable to an area of 2.5" in diameter and less consistent with ASME Section III, Subsection NE-3332.1
  - Extent of Locally thinned areas is evaluated per ASME Section III, Subsection NE-3213.10, NE-3332.2, and NE-3335.1

Minimum Required Thicknesses Based on 44 psi pressure

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Drywell Region	Design Nominal Thickness, mils	Minimum Measured General Thickness Thru 2006, mils	Minimum Required General Thickness, mils	Minimum Required Local Thickness, mils
Cylinder	640	604	452	301
Upper Sphere	722	676	518	345
Middle Sphere	770	678	541	360
Lower Sphere	1154	1160	629	419
Sand Bed	1154	800	479(1)	319(2)

(1) The minimum required general drywell shell thickness in the sand bed region is 736 mils, controlled by buckling.

(2) Acceptance criteria for evaluating locally thinned areas of the drywell shell in the sand bed region is conservatively based on 490 mils instead of 319 mils

ASME Section VIII Stress Analysis Conclusion

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- Stress analysis of the drywell shell was conducted in accordance with ASME Code and SRP 3.8.2 using reduced thicknesses due to corrosion.
- Stress limits and safety factors are in accordance with the ASME Code requirements.
- The analysis shows that the drywell shell meets ASME Code Stress requirements considering all design basis loads and load combinations.
- To regain margin, a plant specific analysis was conducted that reduced drywell design basis pressure from 62 psi to 44 psi (Tech Spec Amendment #165)
- The reduction in pressure resulted in a stress reduction of up to 5200 psi
- The minimum required general and local drywell shell thicknesses were calculated in accordance with ASME Code based on 44 psi pressure.
- The drywell shell thickness will be monitored for corrosion using the calculated minimum required general and local thicknesses as acceptance criteria.

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Sand Bed Region

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Sand Bed Region Conclusions

- Corrosion on the outside of the drywell shell in the sand bed region has been arrested
- The coating shows no degradation
- There is sufficient margin to the minimum thickness requirement (64 mils margin above code required average thickness of 736 mils)

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Background and History

Sand Bed Internal UTs

- 1983 to 1986 corrosion data 360° at elev. 11'3"
  - When thin locations were identified, UT measurements were taken horizontally and vertically to locate the thinnest locations
  - UT grid measurements were taken at the thinnest locations
  - 19 locations were selected for corrosion monitoring based on over 500 initial data points measured
  - At least one grid is located in each of the 10 bays

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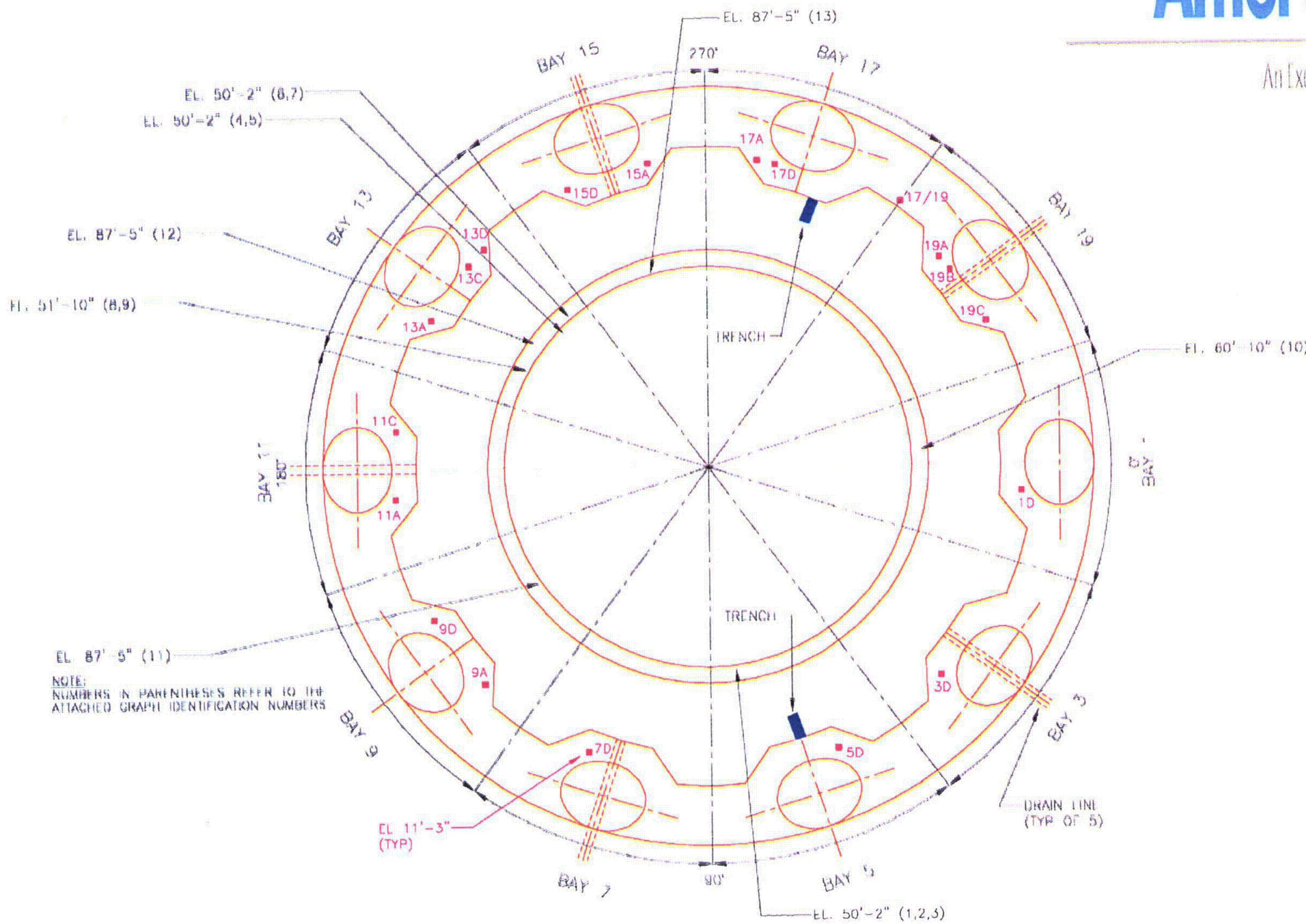

KEY PLAN

VIEW FROM INSIDE DRYWELL

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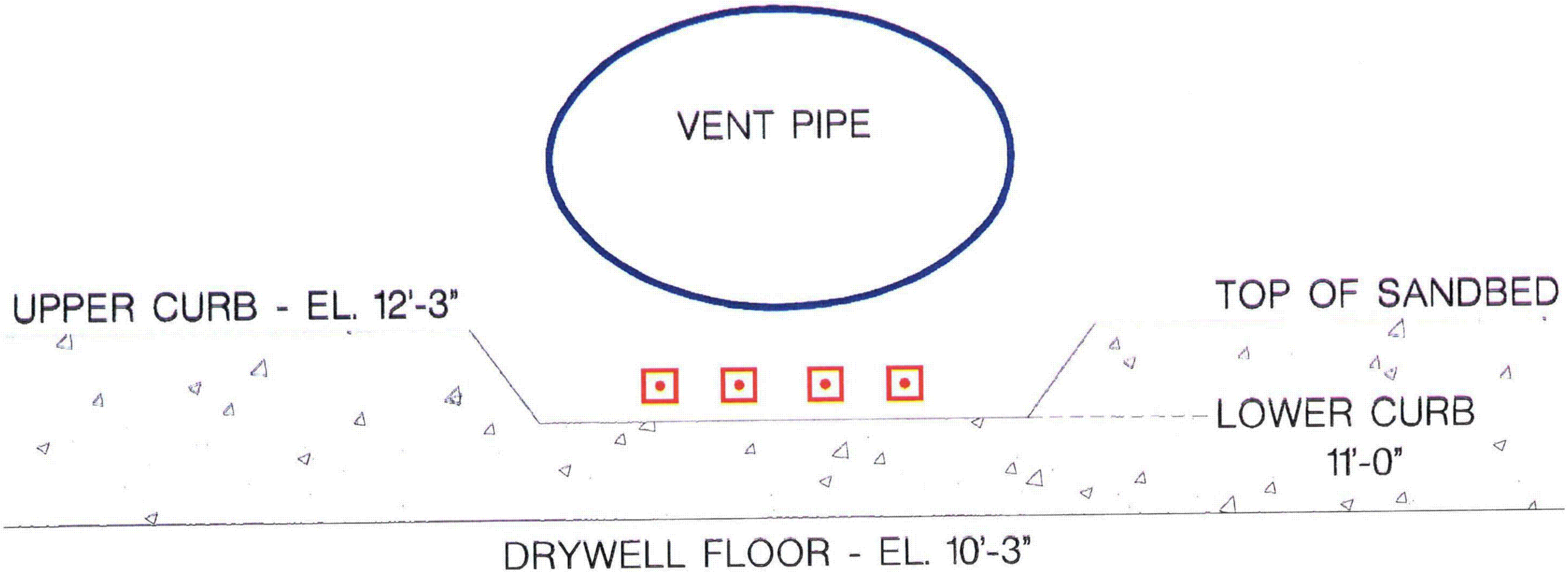
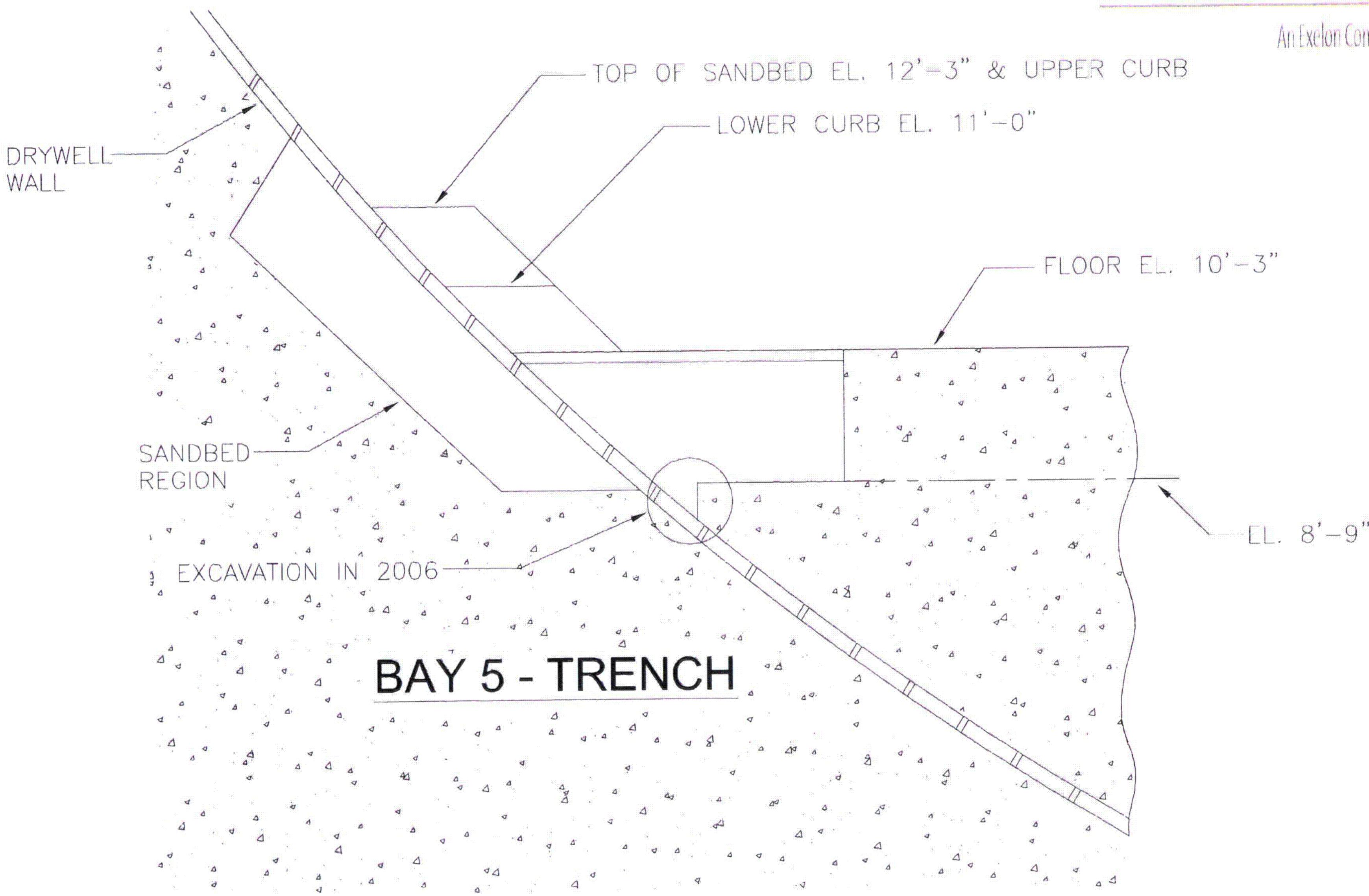
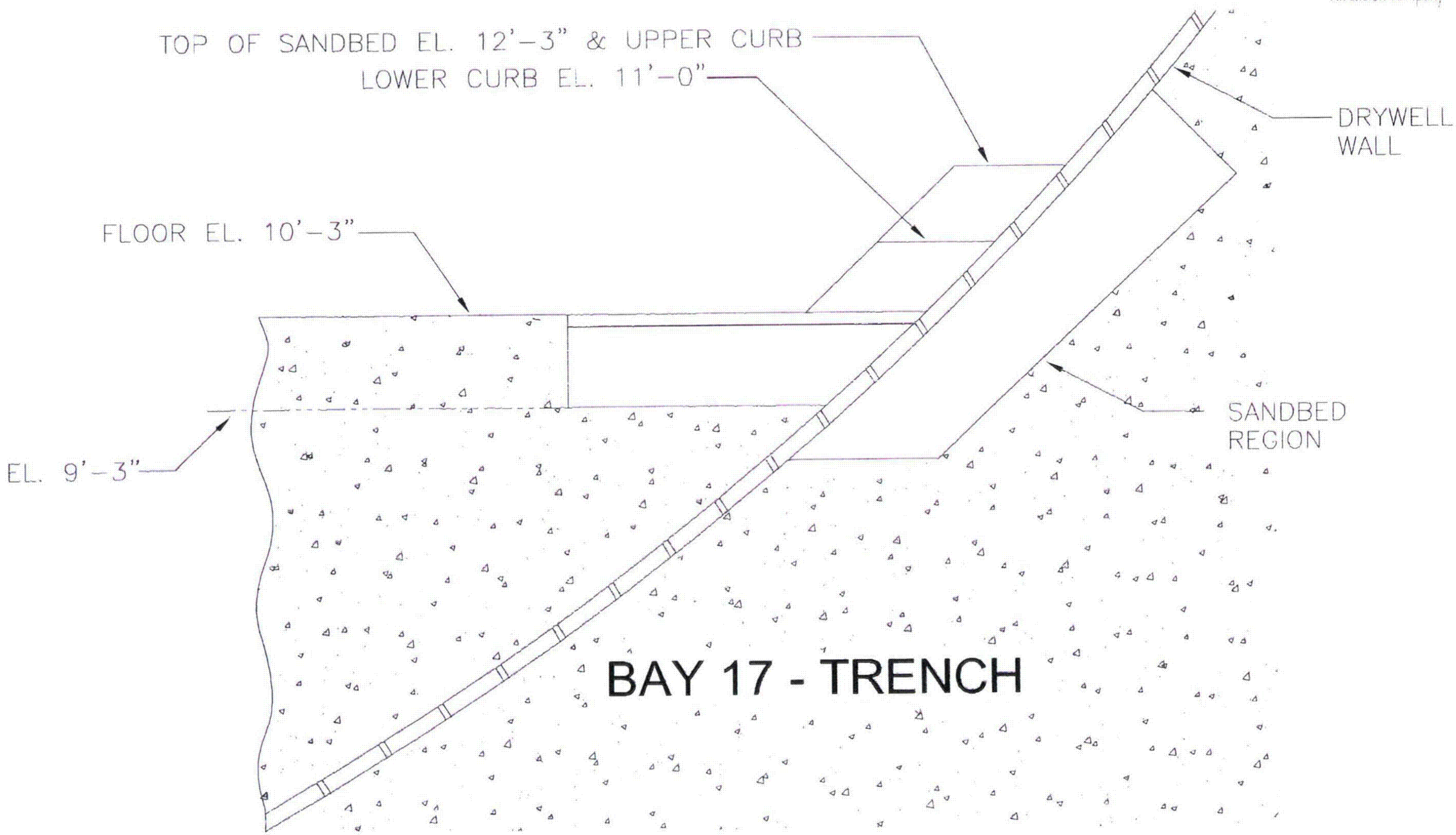




TOP OF SANDBED EL. 12'-3" & UPPER CURB
LOWER CURB EL. 11'-0"
DRYWELL WALL
FLOOR EL. 10'-3"
SANDBED REGION
EL. 8'-9"
EXCAVATION IN 2006
BAY 5 - TRENCH


TOP OF SANDBED EL. 12'-3" & UPPER CURB
LOWER CURB EL. 11'-0"
DRYWELL WALL
FLOOR EL. 10'-3"
SANDBED REGION
EL. 9'-3"
BAY 17 - TRENCH

Sand Bed Region Background and History

- Trenches in bays 5 and 17 were excavated in 1986 to determine corrosion in sand bed at elevations below the drywell interior floor
  - Bays 5 and 17 were selected because UT measurements indicated these bays had the least and the most corrosion, respectively
  - The trenches extend to about the elevation of the bottom of the sand bed
  - UT measurements taken in the trenches confirmed that the corrosion below elev. 11' 3" was bounded by the monitoring at elev. 11' 3"

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2006 Inspection Data

General Thickness (mils)

	Bay 5	Bay 17				
Grid	**5D**	**17A Top**	**17A Bottom**	**17D**	**17/19 Top**	**17/19 Bottom**
Grid Elev. 11'3" Above Lower Curb	1185	1122	935	818	964	972
Trench Lower Curb to Sand Bed Floor	1074	986				
Trench Below Sand Bed Floor	1113	N/A				

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Sand Bed Region Background and History

- Sand was removed in 1992 and the shell was cleaned
- External UT measurements were taken in all bays at thinned local areas (as determined by visual inspection)
- The shell was coated with epoxy coating
- UT grid measurements were taken at the 19 monitored locations at elev. 11'3" as a baseline for the new condition

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Condition of the Drywell Shell in the Sand Bed Region After Sand Removal

Sand Bed Region 1992

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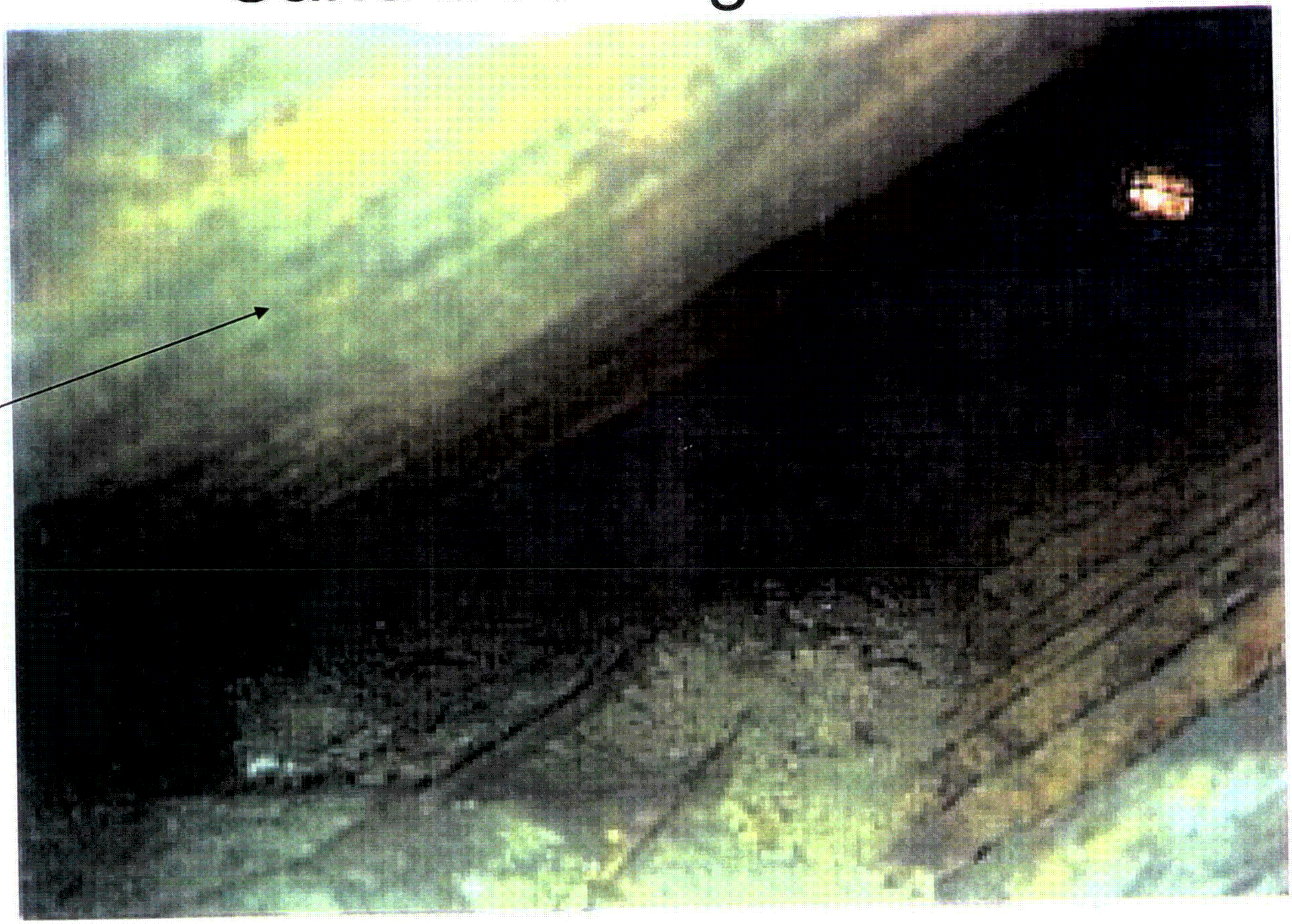
Drywell Shell

Corrosion product on drywell vessel

Sand Bed Region 1992



As found condition of floor bed

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Condition of the Drywell Shell in the Sand Bed Region After Application of Epoxy Coating

Sand Bed Region 1992

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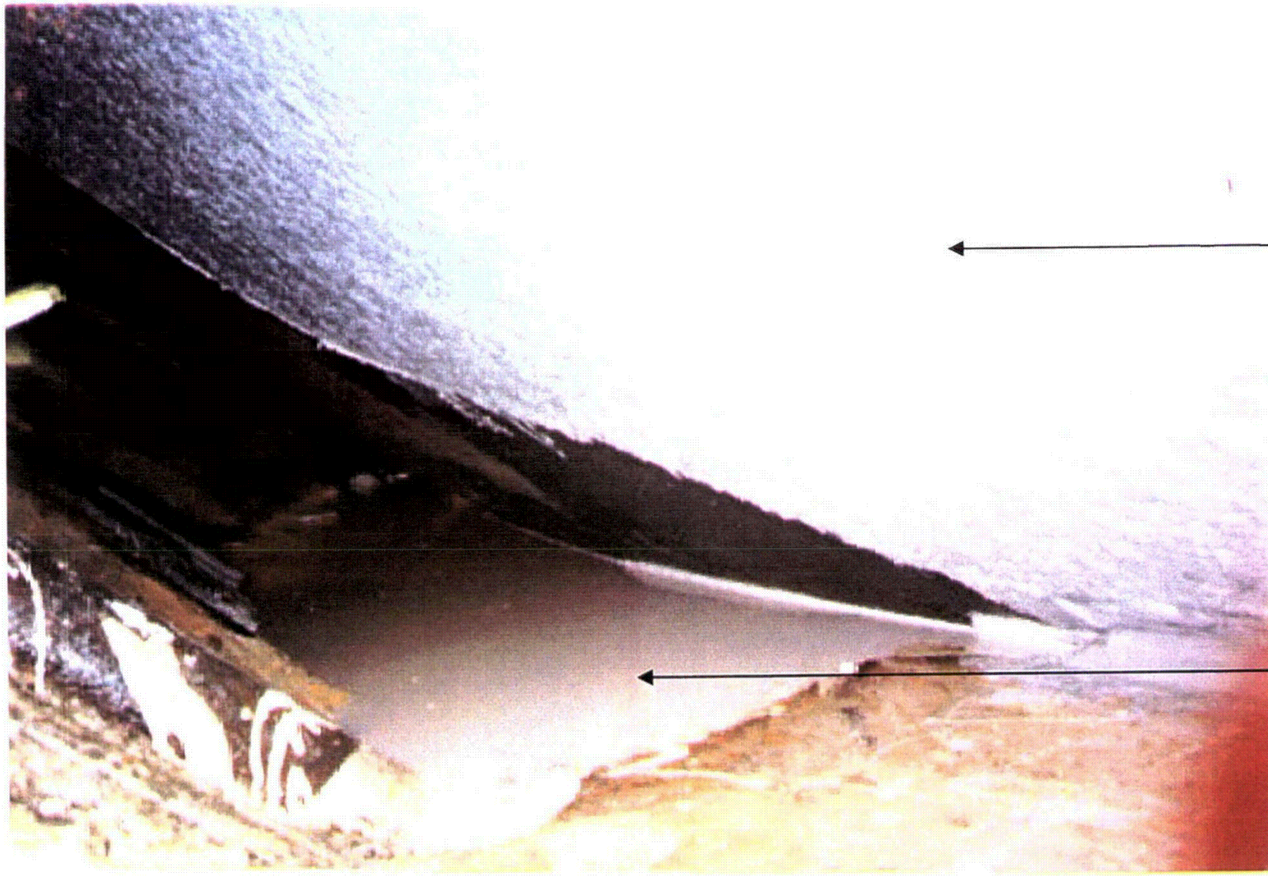
Bay 5 before shell coating

Sand Bed Region 1992



Shell and floor undergoing coating and repairs

Sand Bed Region 1992

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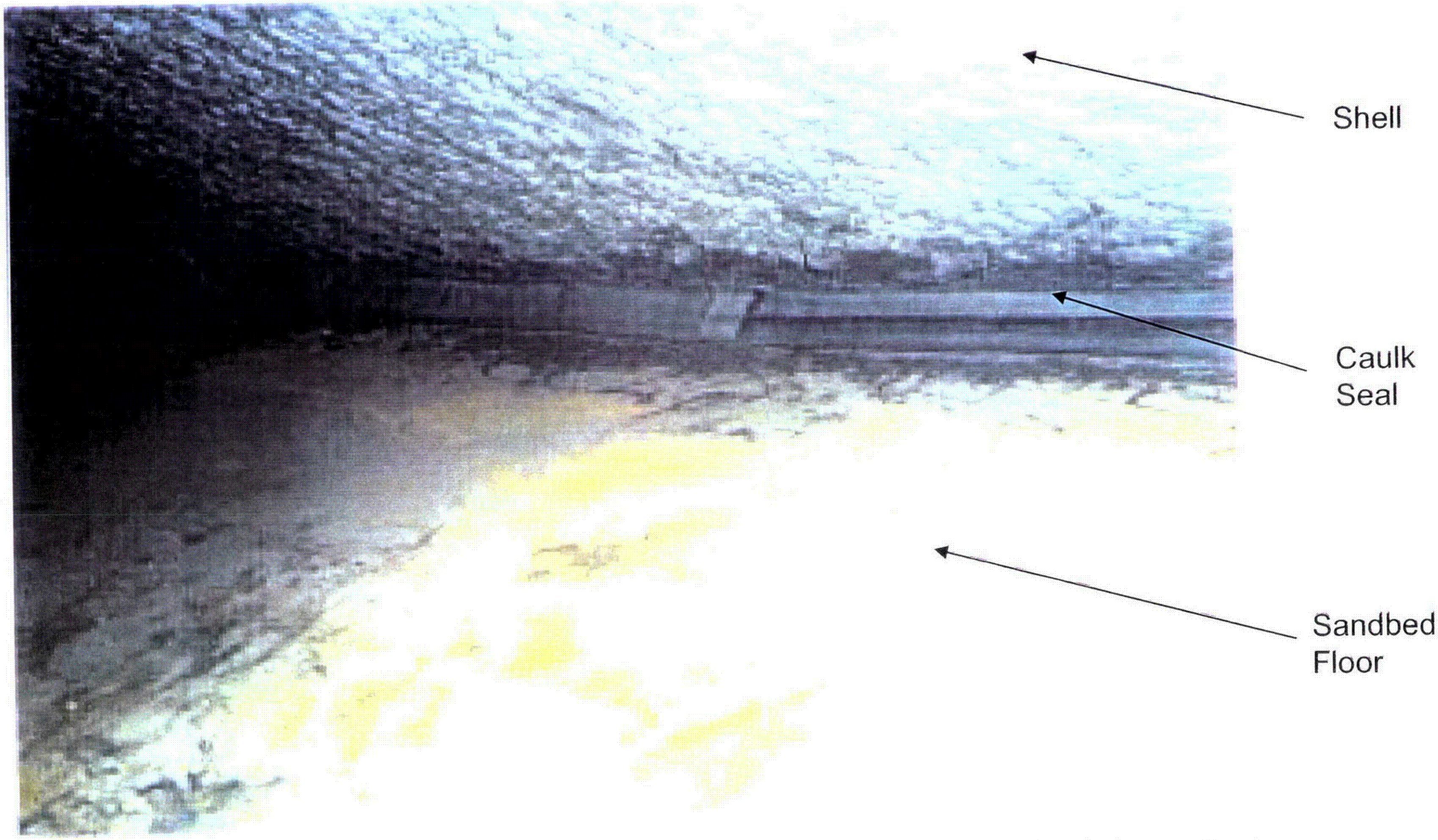

Finished floor, vessel with two top coats – caulking material applied

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Sand Bed Region Background and History

- DEVOE Epoxy coating system (3 part)
  - Designed for application on corroded surfaces
  - One coat DEVOE 167 Rust Penetrating Sealer
    - Penetrates rusty surfaces
    - Reinforces rusty steel substrates
    - Ensures adhesion of Devran 184 epoxy coating

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Sand Bed Region Background and History

- DEVOE Epoxy coating system
  - Two coats Devran 184 epoxy coating
    - Designed for tank bottoms, including water tanks, fuel tanks, selected chemical tanks
    - Coating application was tested in a mock-up for coating thickness and absence of holidays or pinholes
    - Two coats used to minimize any chance of pinholes or holidays
    - The two coats are different colors

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Use of Coatings to Prevent Corrosion

Jon R. Cavallo, PE, PCS

Vice President

Corrosion Control Consultants and Labs, Inc.

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Background and History

- The OCNGS Protective Coatings Monitoring and Maintenance Program aging management program is consistent with NUREG 1801, Rev. 1 (the GALL Report), Appendix XI.S8
  - NUREG 1801, Appendix XI.S8 only covers Coating Service Level I coatings
- In addition, the OCNGS Coating Monitoring and Maintenance Program includes the Coating Service Level II coatings applied to exterior of drywell in Sand Bed region

Background and History

- Inspection and evaluation of OCNGS external coated drywell Sand Bed region surfaces (Coating Service Level II Coatings) is conducted in accordance with ASME Section XI, Subsection IWE by qualified VT inspectors.
  - Areas shall be examined (as a minimum) for flaking, blistering, peeling, discoloration and other signs of distress.
- The premise of ASME Section XI, Subsection IWE is that degradation of a steel substrate will be indicated by the presence of visual anomalies in the attendant protective coatings

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How Barrier Coating Systems Prevent Corrosion

- Barrier coating systems separate the electrolyte from the anodes, cathodes and conductors
- A barrier coating system has been applied to the steel substrate in the OCGS Sand Bed region

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Technical Review of OCGS Sand Bed Region Coating System

- The OCGS Sand Bed region barrier coating system consists of:
  - Devoe Pre-Prime 167 penetrating sealer
  - Devoe Devran 184 mid- and top-coat
  - Devoe Devmat 124S caulk

  and is appropriate for the intended service

Technical Review of OCGS Sand Bed Region Coating System

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- With periodic condition assessment and maintenance (if required), the OCNGS Sand Bed region coating system will continue to prevent corrosion of the steel substrate for the period of extended operation
- Oyster Creek inspected 100% of the Sand Bed region coating in 2006 and will inspect at least three bays every other outage, with all 10 inspected every 10 years
- The 10 year inspection periodicity cycle is appropriate and commensurate with the Sand Bed Region environment and industry experience
  - EPRI 1003102, "Guideline on Nuclear Safety-Related Coatings"

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UT Thickness Measurements In the Sand Bed

Pete Tamburro

Oyster Creek Engineering

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Background and History

Sand Bed Region

- UT grid measurements were taken at the 19 monitored locations at elev. 11'3" as a baseline for the new condition in 1992
- In 1992, thinnest grid average thickness 800 mils vs. criterion of 736 mils
- In 1992, thinnest local reading 618 mils vs. criterion of 490 mils

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Background and History

Sand Bed Region

- 19 grids repeated in 1994 and 1996
  - Statistically, no changes in thickness were observed
  - Basis for corrosion "arrested" in the sand bed region, on outer surface of the drywell
  - Basis for NRC SER concluding that further UT measurements are not needed and visual inspection of the coating is sufficient
- The 2006 UT measurements confirmed that corrosion has been arrested

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UT Measurements of 6"x6" Grid

Sand Bed Region

- Measurement locations are marked on the inside of the drywell shell
- Use a stainless steel template with 49 holes to align the UT probe
- UT probe placed perpendicular to the surface to consistently obtain lowest reading
- A protective grease is applied to the 6"x6" grid during operation, and removed to take UT measurements

Statistical Methodology

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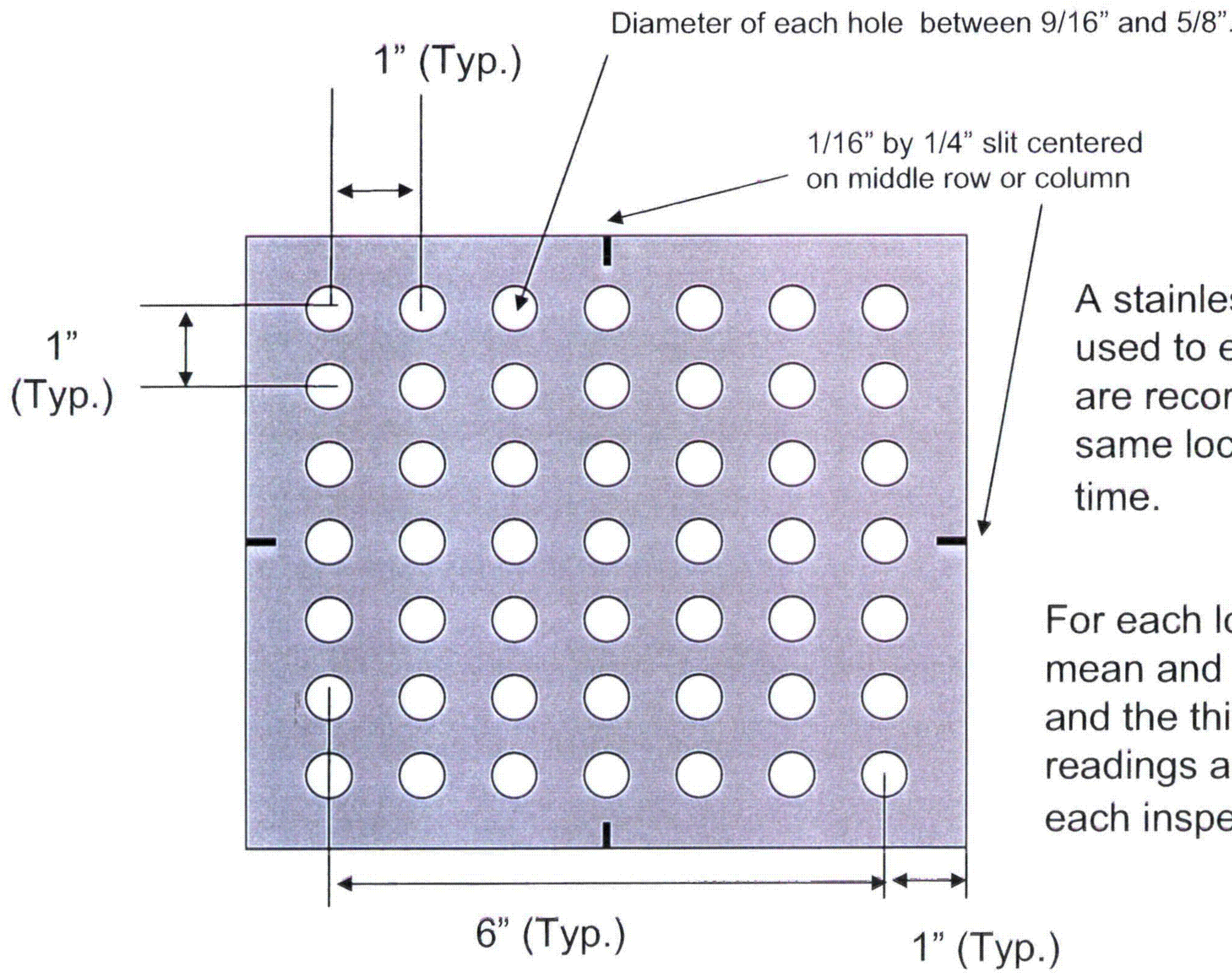
49 UT readings are recorded over a 6" by 6" area.



A stainless steel template is used to ensure that the readings are recorded consistently and in same location (+/- 1/16") every time.

For each location, the mean and standard error and the thinnest of the 49 readings are calculated after each inspection.

Statistical Methodology

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- Because of roughness of the exterior surface of the drywell shell in the sand bed, there is uncertainty in the mean thickness calculated for each grid location
- The major contributor to the uncertainty in the means is the variance from point to point due to the rough surface and not inaccuracy or repeatability of the UT Instrumentation

Statistical Methodology

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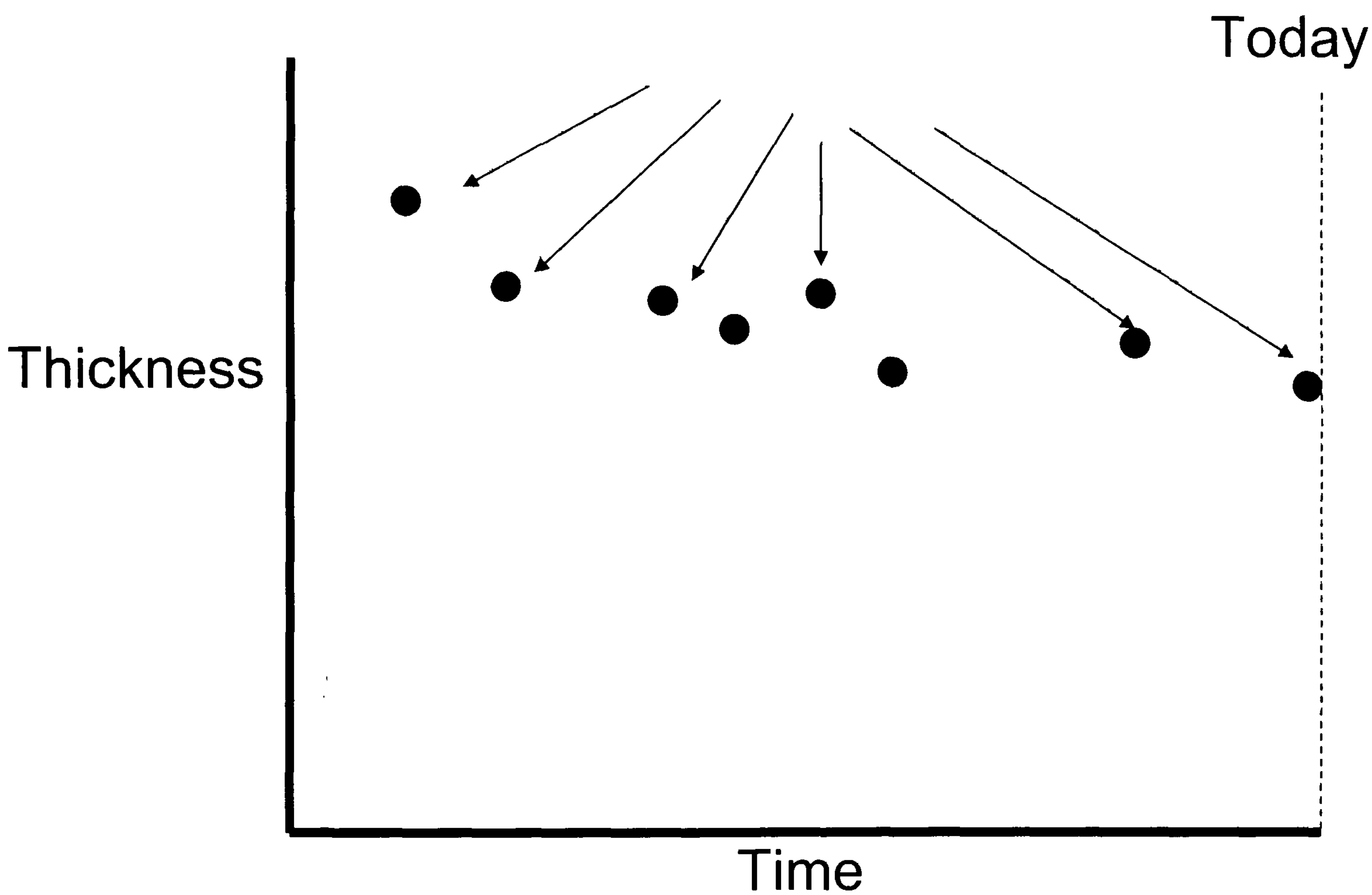
For each location the means and thinnest points are trended over time



Statistical Methodology

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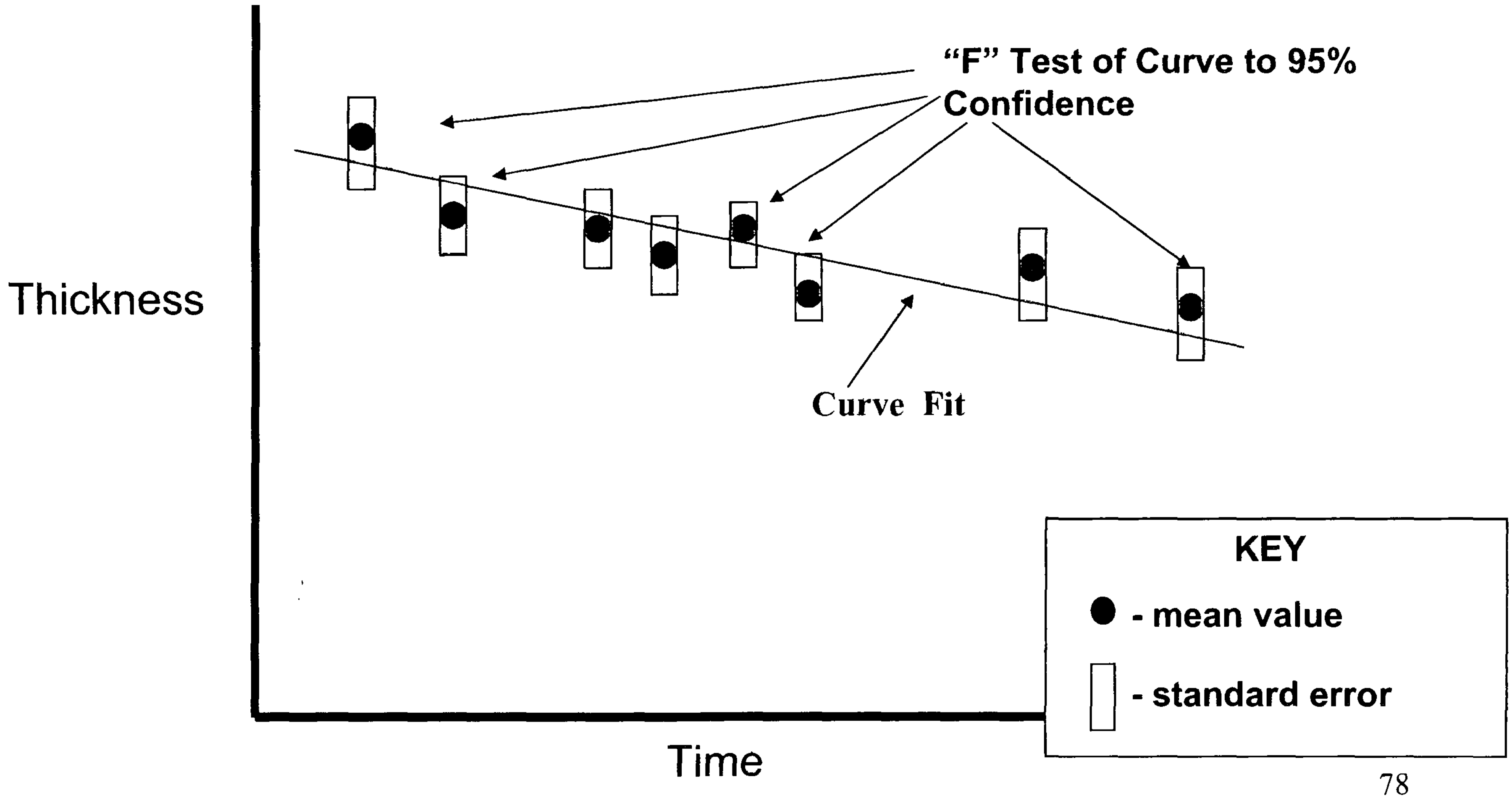
1) A curve fit based on the regression model is then developed.

2) The Corrosion "F" Test is performed to determine if the data meet the curve fit with 95% confidence.



Projection Based on Successful Corrosion F tests

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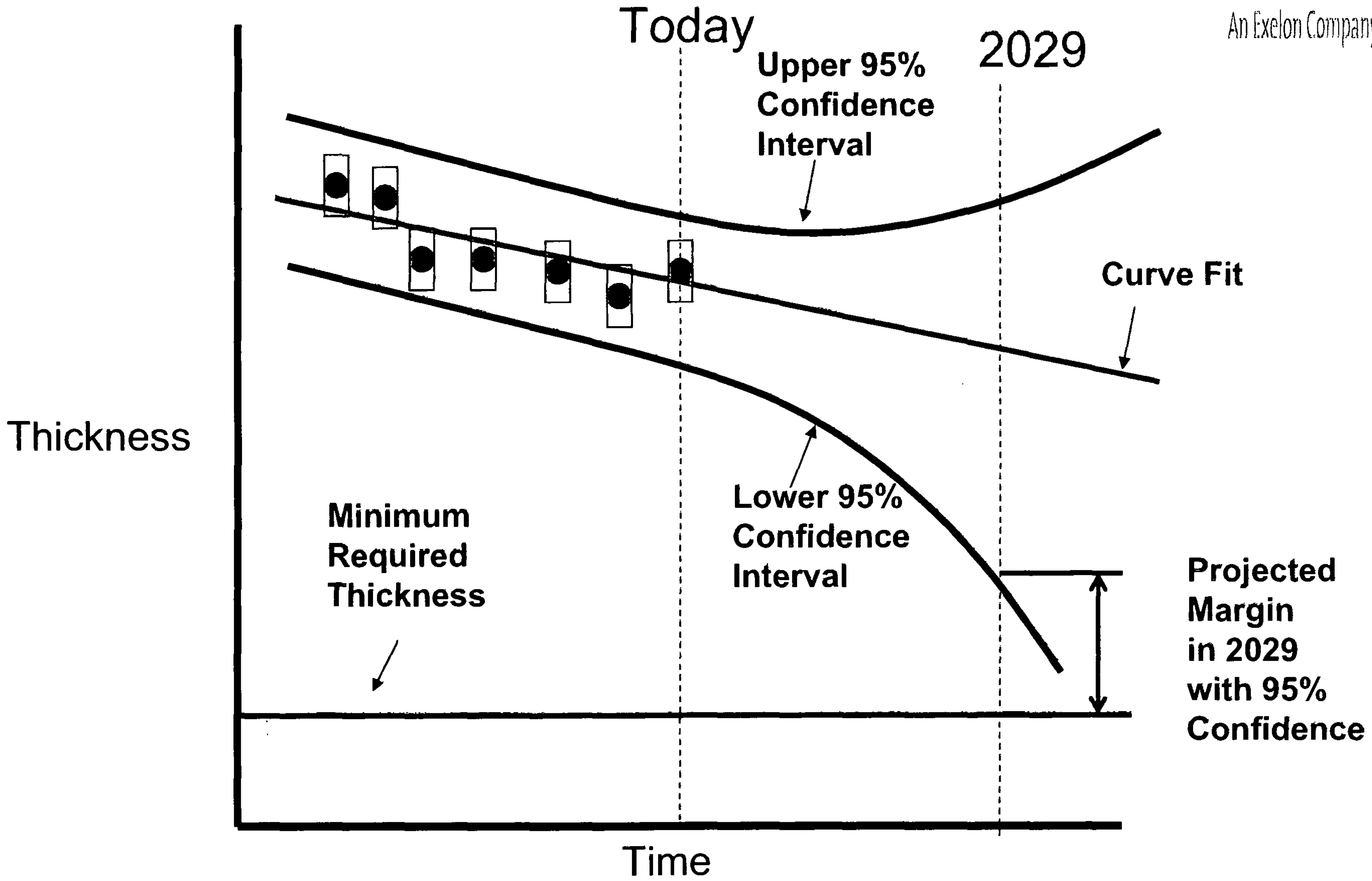

2006 Sand Bed Data Summary

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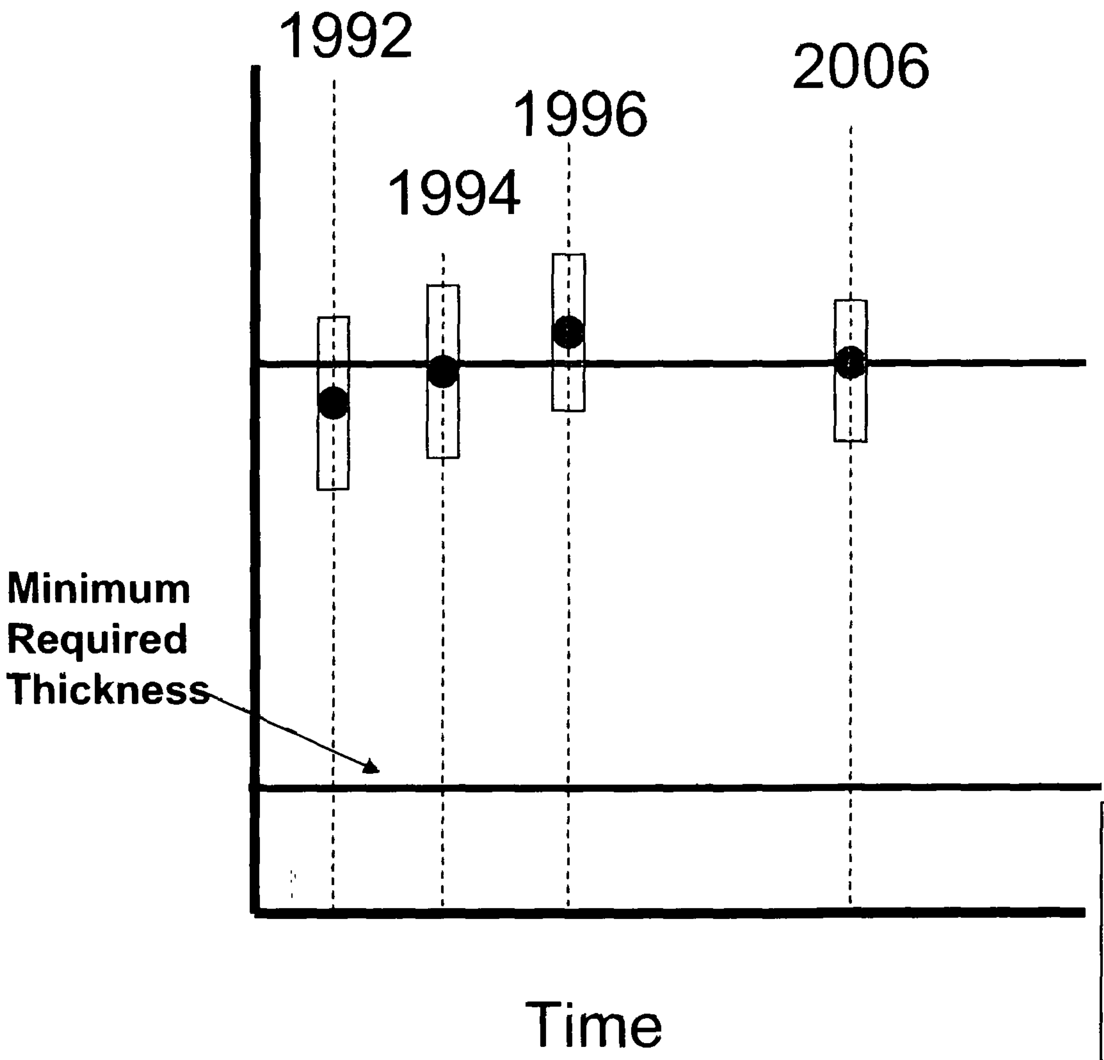

In the case of the 2006 sand bed inspections, there are only 4 inspections per location with most standard errors between +/- 8 and +/-16 mils

There are not enough inspections to satisfy the Corrosion Test F test with 95% confidence.

KEY

● - mean value

▯ - standard error

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Statistical Methodology

- We then employed a conservative statistical analysis based on a "Monte Carlo" type simulation to determine a minimum statistically observable corrosion rate for the purpose of ensuring adequate inspection frequency

Given only 4 inspections and the standard errors, simulation was required to determine the minimum observable rate with 95% confidence. <u>This is not an actual rate!</u>

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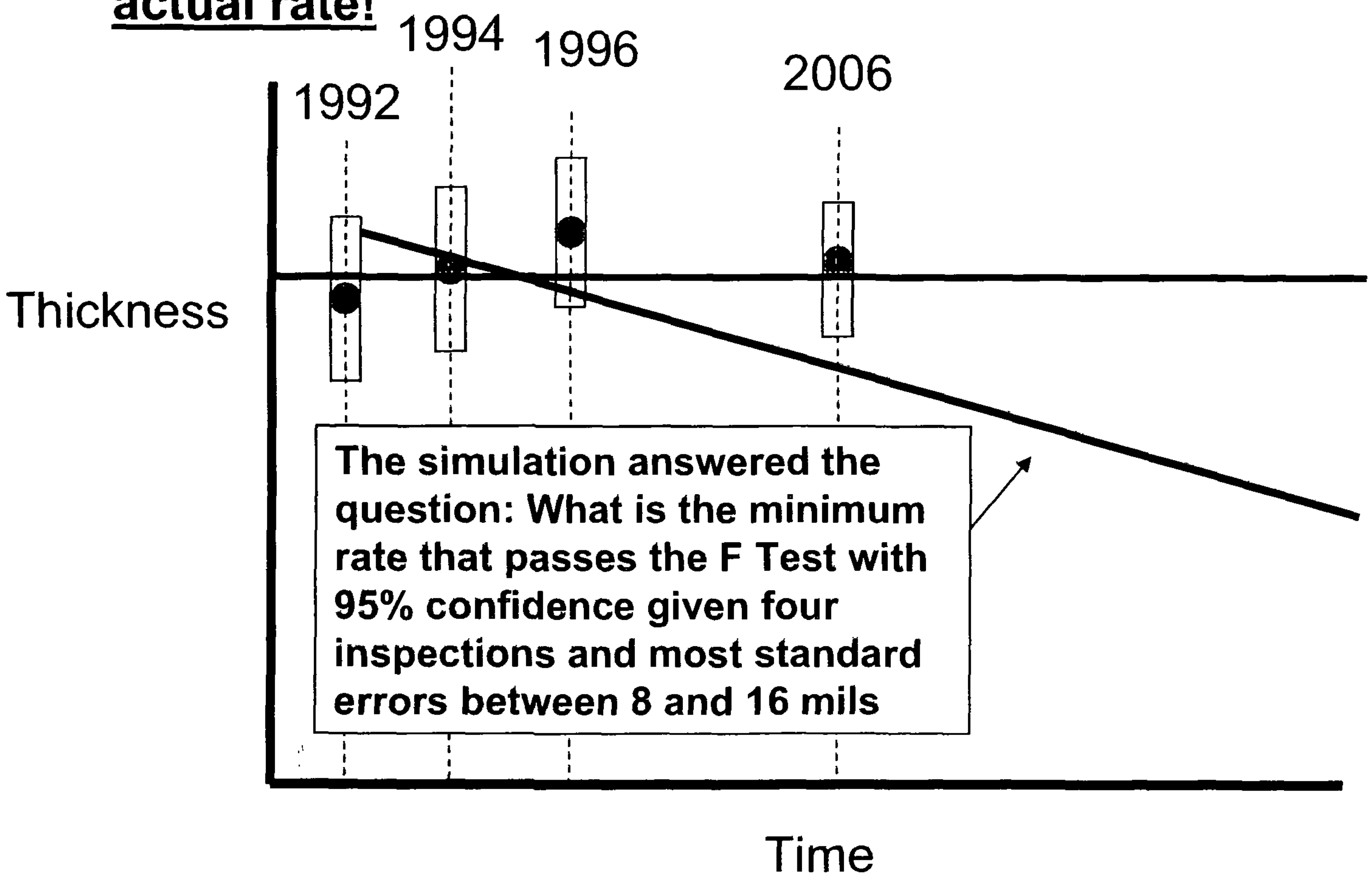
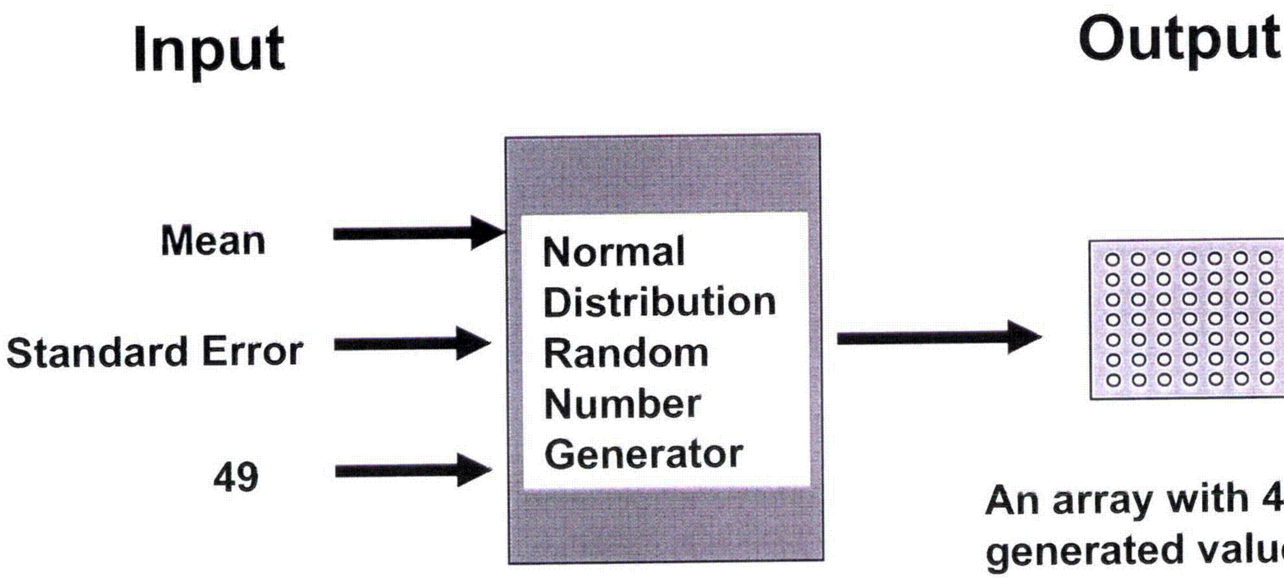


The simulation answered the question: What is the minimum rate that passes the F Test with 95% confidence given four inspections and most standard errors between 8 and 16 mils

The simulation used a random number generator based on the normal distribution



An array with 49 randomly generated values. The array is normally distributed with a resulting simulated mean and a resulting simulated standard error.

Simulation – Minimum Observable Corrosion Rate

Chose a rate and performed 100 Iterations (Steps 1 through 6)

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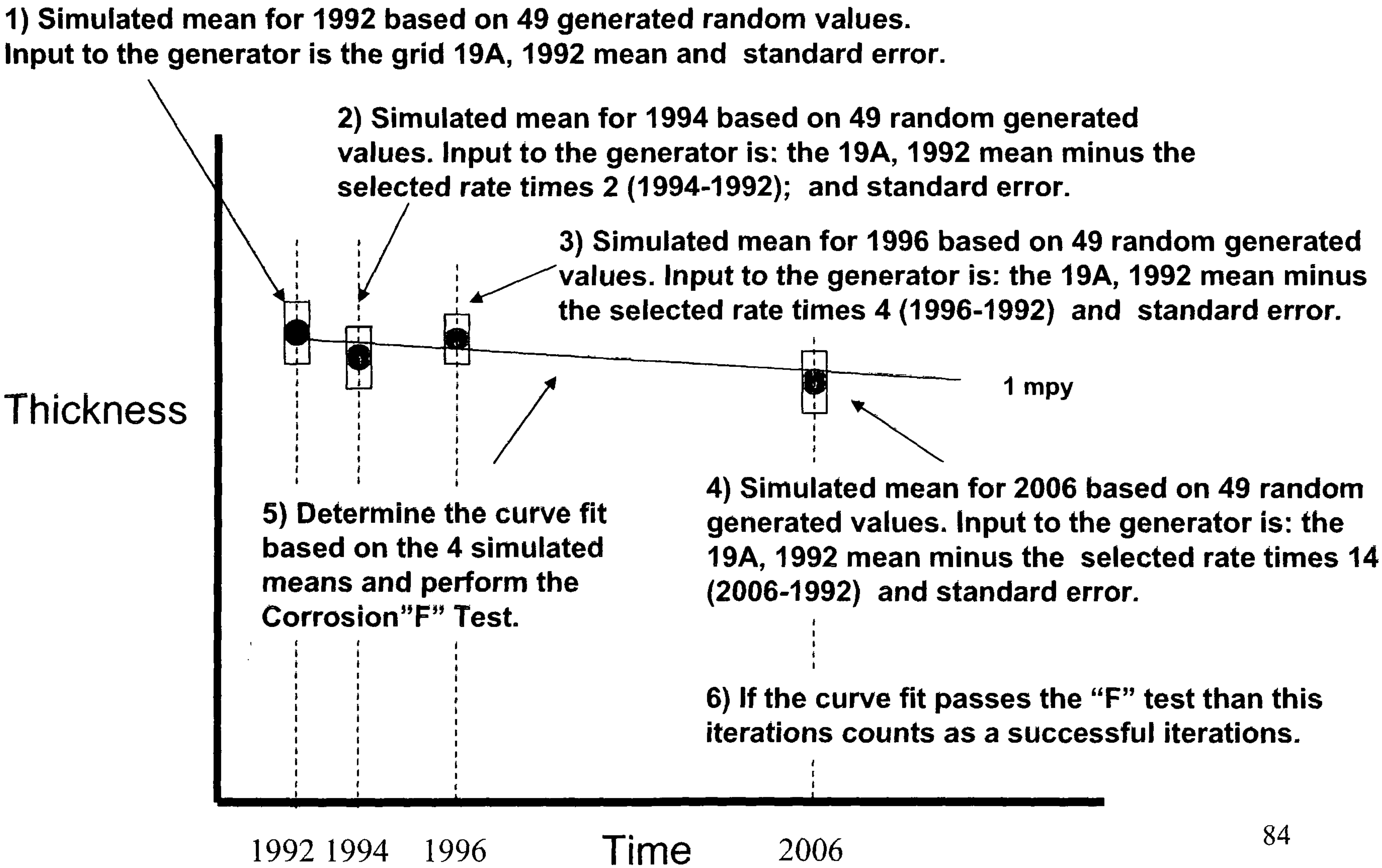

Simulation – Minimum Observable Corrosion Rate

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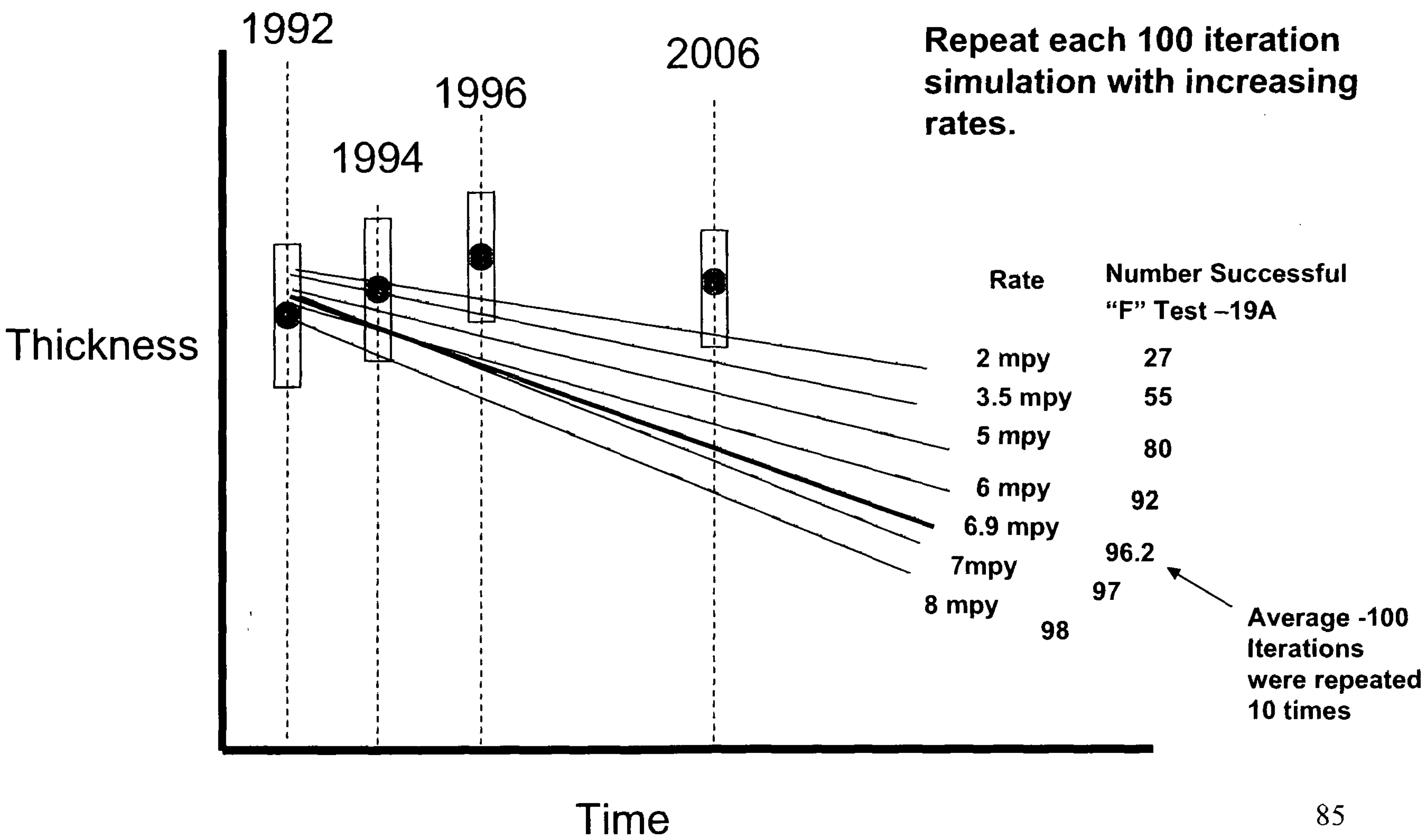
The minimum rate which consistently passes the Corrosion "F" Tests 95 out of 100 times is the Minimum Observable Corrosion Rate.



Repeat each 100 iteration simulation with increasing rates.

Next Required Inspection Based on the Minimum Observable Rate

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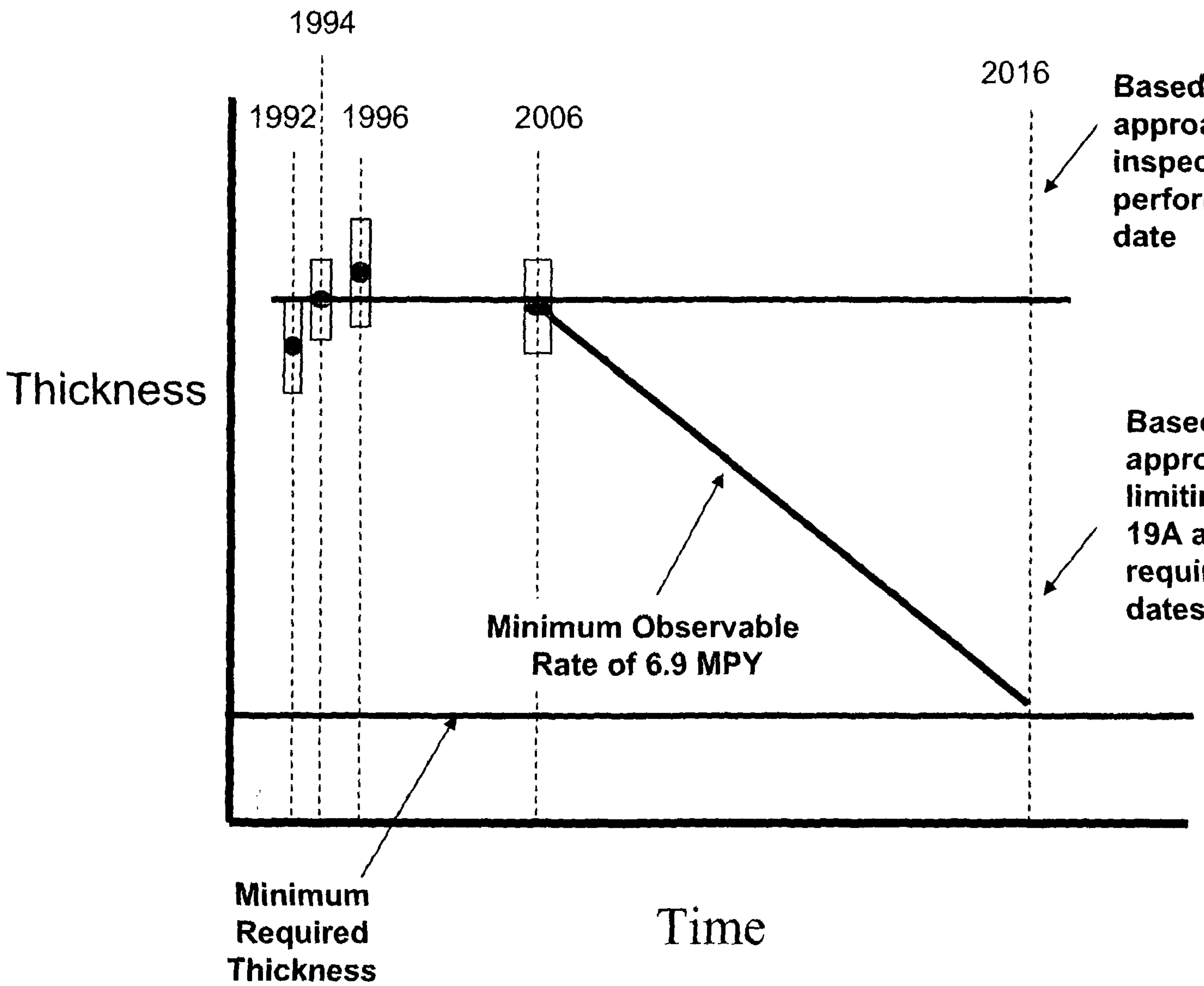

Based on this statistical approach, the next inspection shall be performed prior to this date

Based on this statistical approach the most limiting locations are 19A and 17D with required inspection dates prior to 2016.

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Results of the Statistical Simulation

- The most limiting locations are 19A and 17D, with required inspections prior to 2016
- Therefore, the next inspection scheduled for 2010 is appropriate
- Analysis after future inspections will be used to determine the appropriate inspection frequency

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2006 Inspections
Sand Bed Region

- Visual inspection of coating in all 10 bays (external)
- UT measurements of 19 grids at elev. 11'3" (internal)
- UT measurements 106 locally thinned single point locations (external)

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2006 Inspection Results
Sand Bed Region

- Visual inspection of External Shell Coating – no degradation

Sand Bed Region 2006

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Bay 7 – Drywell shell, caulking, sand bed floor

Sand Bed Region 2006

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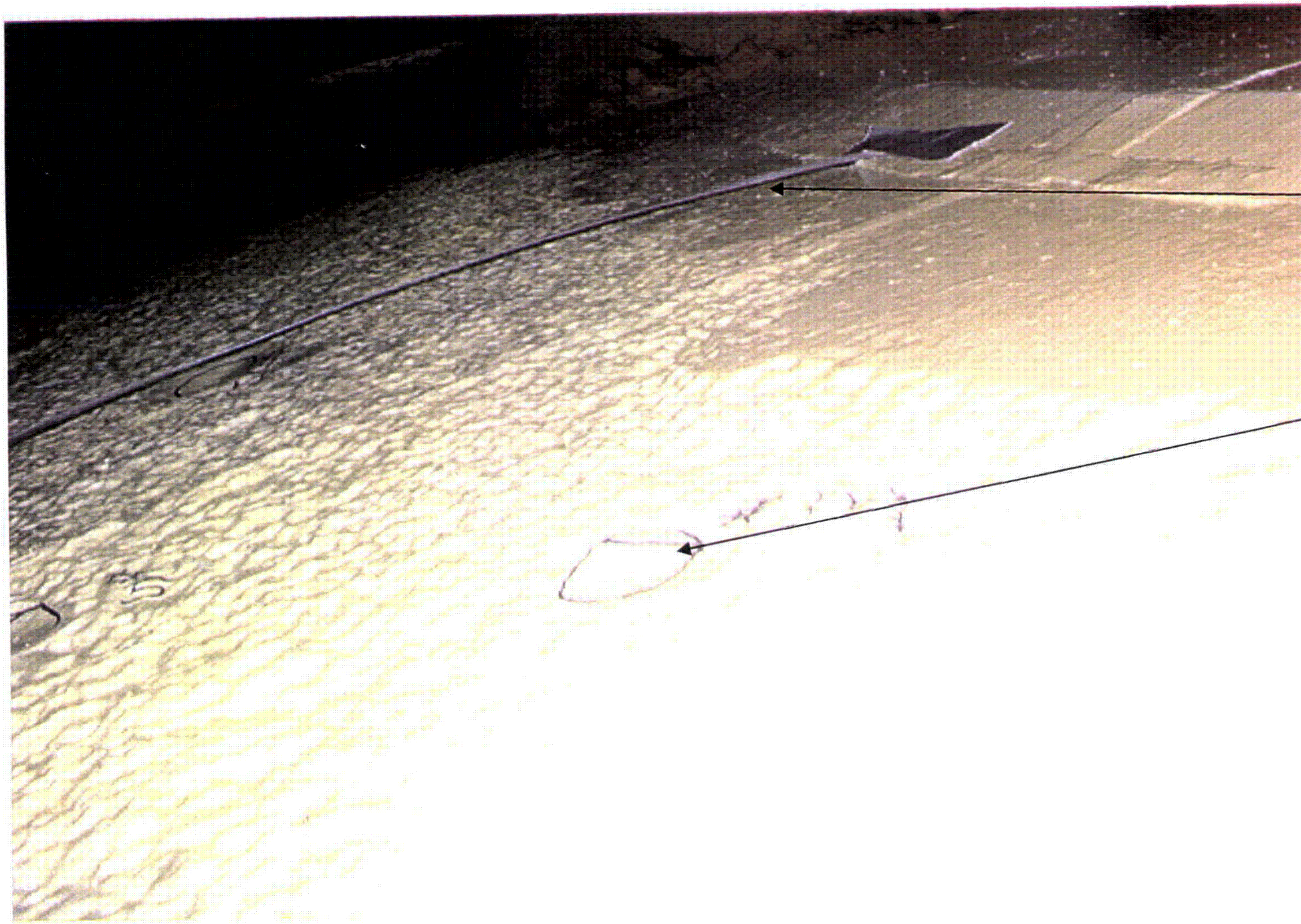

Bay 13 Drywell shell

Sand Bed Region 2006

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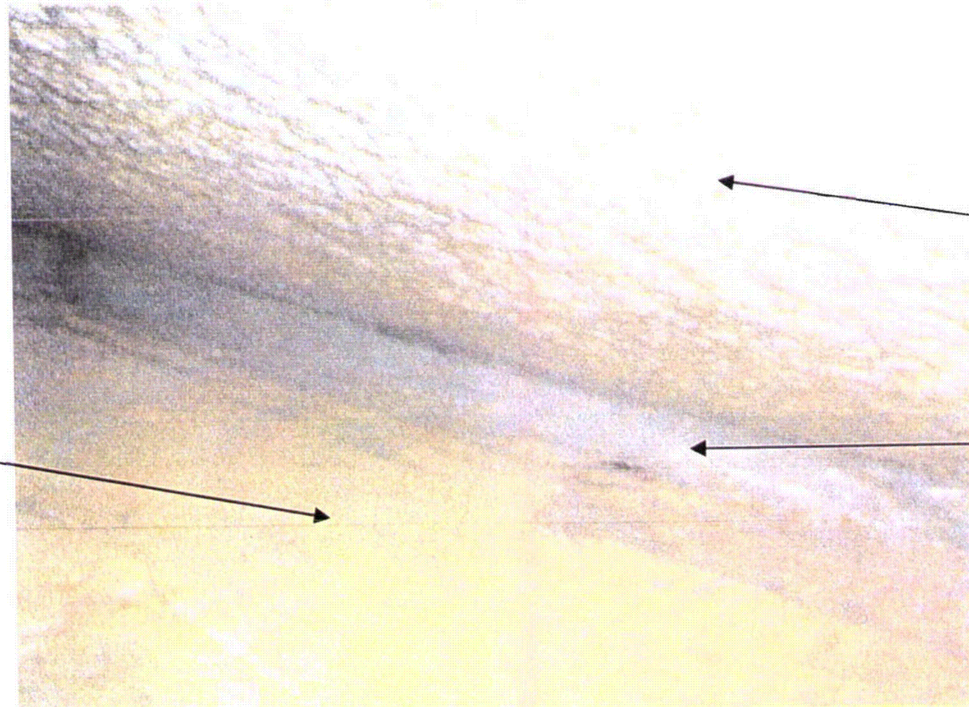

Floor

Shell

Caulk

Bay 19 caulking

Drywell Shell Bay 19

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2006 Inspection Results

Sand Bed Region

- UT measurements at 19 internal grid locations
  - No ongoing corrosion

General Thickness at 19 Grid Locations

AmerGen

Location		Pre-1992	May 1992	Sept. 1992		1994		1996		2006		Min. Req'd	Nominal Thick.	Margin
				Thick	Std Error	Thick	Std Error	Thick	Std Error	Thick	Std Error			
1D		1115				1101	±10.0	1151	±13.6	1122	±8.4			365
3D		1178				1184	±4.9	1175	±7.5	1180	±5.7			439
5D		1174				1168	±2.6	1173	±2.2	1185	±2			432
7D		1135				1136	±4.3	1138	±5.9	1133	±6.5			397
9A		1155				1157	±4.5	1155	±4.8	1154	±4.2			418
9D		992	1000	1004	±10.0	992	±10.4	1008	±10.6	993	±11.2			256
11A		833	842	825	±8.2	820	±7.7	830	±8.7	822	±8.0			84
11C	Bot	856	882	859	±6.4	850	±4.5	883	±7.4	855	±4.5			114
	Top	952	1010	970	±23.8	982	±23.4	1042	±21.4	958	±24.7			216
13A		849	865	858	±9.6	837	±7.8	853	±8.8	846	±8.2			101
13D	Bot	900	931	906	±9.0	895	±8.2	933	±9.6	904	±8.9			159
	Top	1048	1088	1055	±14.1	1037	±13.6	1059	±11.2	1047	±13.7	736	1154	301
13C				1149	±1.9	1140	±3.8	1154	±3.2	1142	±3.1			404
15A		1120				1114	±16.3	1127	±10.8	1121	±16.6			378
15D		1042	1065	1058	±8.7	1053	±9.0	1066	±8.5	1053	±8.9			306
17A	Bot	933	948	941	±11.8	934	±10.7	997	±10.7	935	±10.5			197
	Top	999	1125	1125	±7.2	1129	±6.8	1144	±11.1	1122	±7.2			263
17D		822	823	817	±9.2	810	±9.5	848	±8.9	818	±9.5			74
17/19	Top	954	972	976	±4.8	963	±4.9	967	±6.0	964	±4.8			218
Frame	Bot	955	990	989	±6.3	975	±7.8	991	±6.2	972	±5.9			219
19A		803	809	800	±8.4	806	±9.9	815	±9.6	807	±8.9			64
19B		826	847	840	±8.7	824	±7.8	837	±9.5	848	±8.6			88
19C		822	832	819	±11.0	820	±10.5	854	±11.8	824	±11.3			83

Note: Shaded cells indicate thickness value used to conservatively calculate the margin

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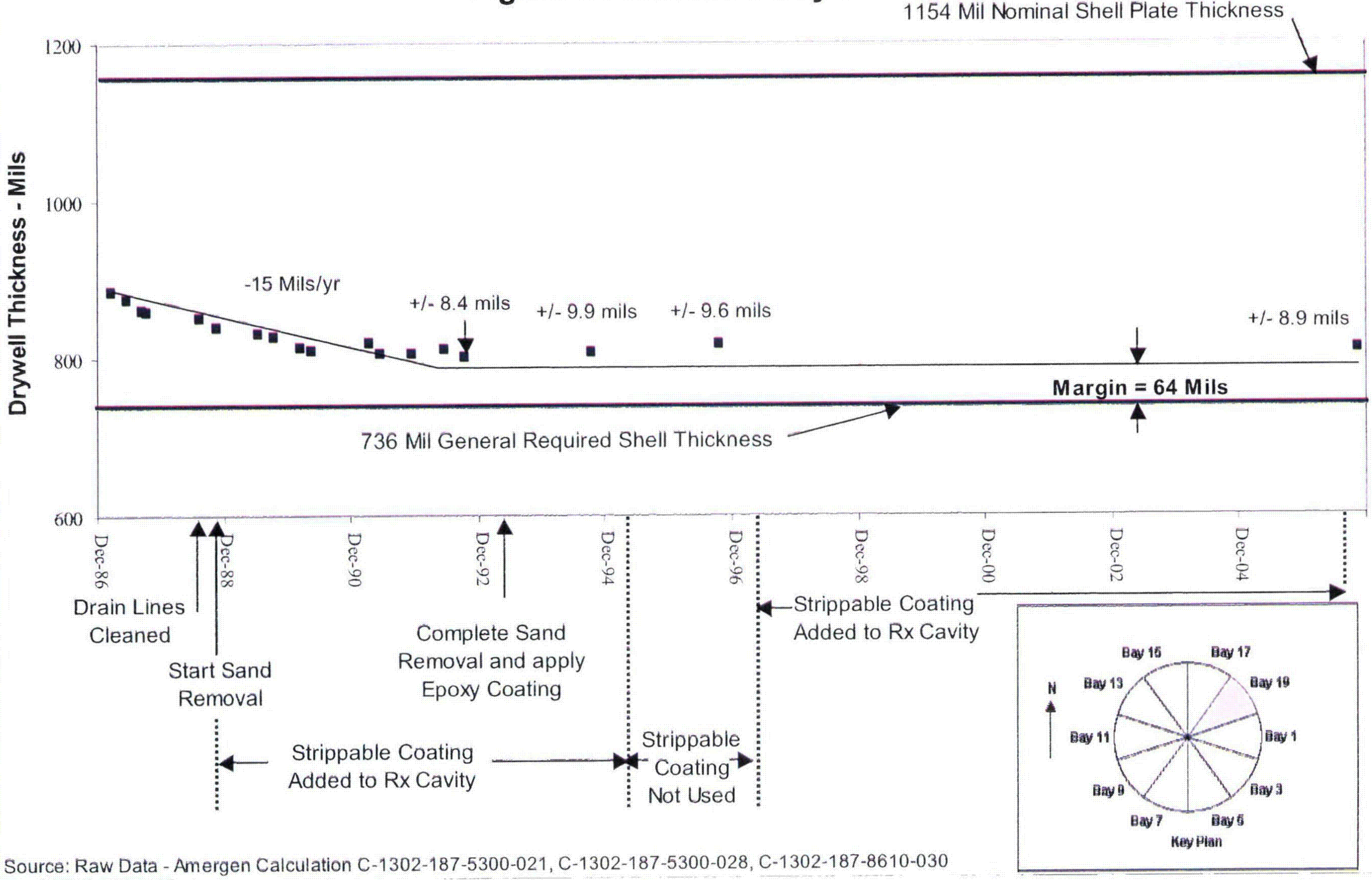
Minimum Available Thickness Margins

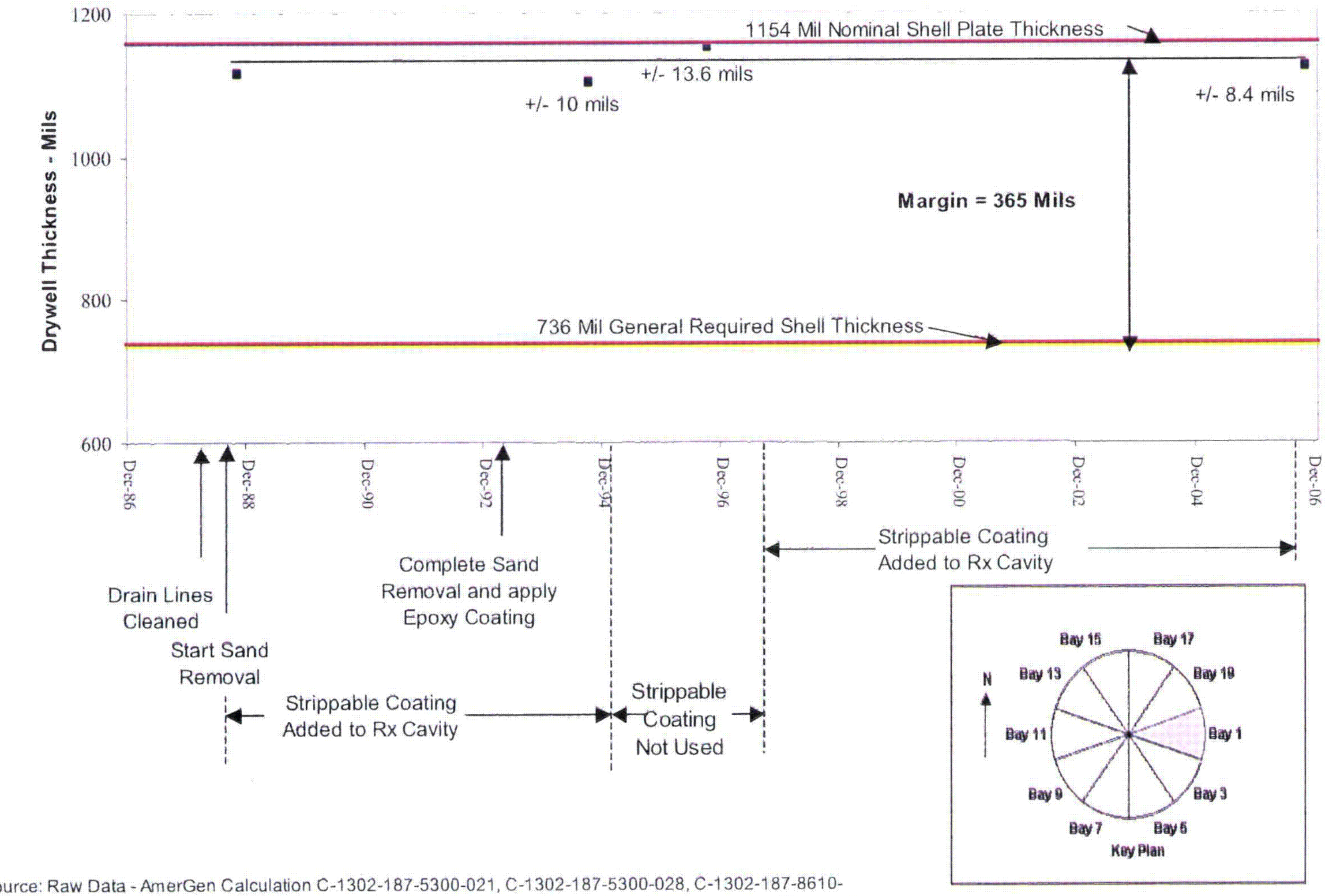
Bay No.	1	3	5	7	9	11	13	15	17	19
Minimum Available Margin, mils	365	439	432	397	256	84	101	306	74	64

Figure 21 Sandbed Bay # 19A



Source: Raw Data - Amergen Calculation C-1302-187-5300-021, C-1302-187-5300-028, C-1302-187-8610-030

Figure 1. Sandbed Bay # 1D



Source: Raw Data - AmerGen Calculation C-1302-187-5300-021, C-1302-187-5300-028, C-1302-187-8610-

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2006 Inspection Results External Sand Bed UTs

- 106 individual UT measurements were taken externally in the sand bed region
- It was verified that all 106 measurements meet the local thickness requirements (both buckling and membrane stresses)
- The 2006 measurements are not directly comparable to the 1992 results because of differences in measurement techniques

Concave Curvature Effects 1992 vs. 2006 External UT Data (106) Sand Bed Readings

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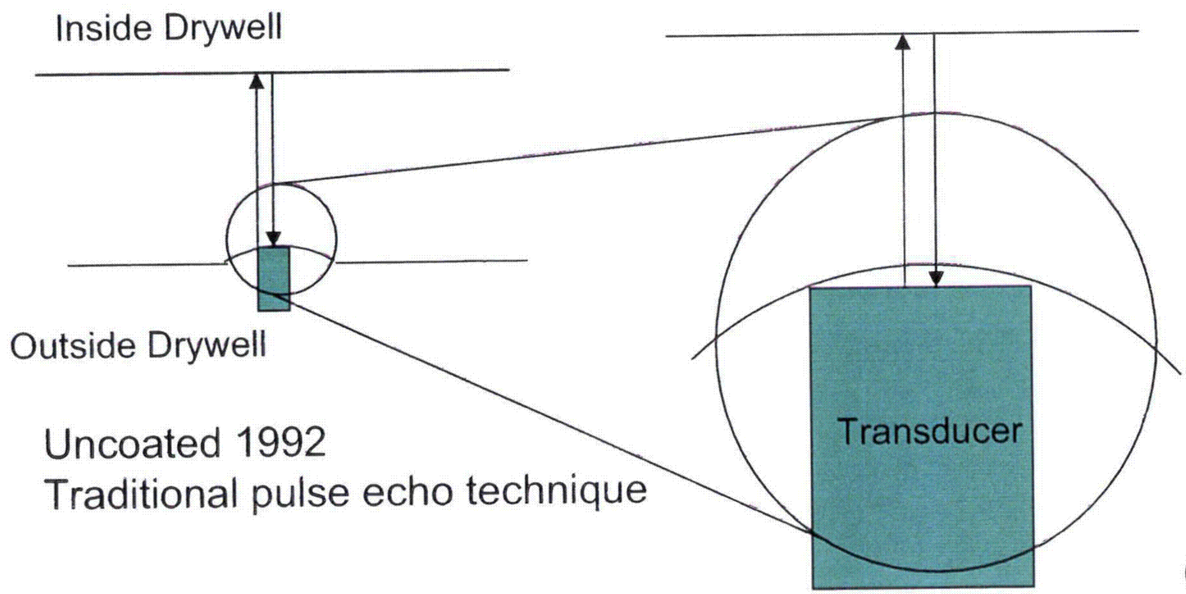

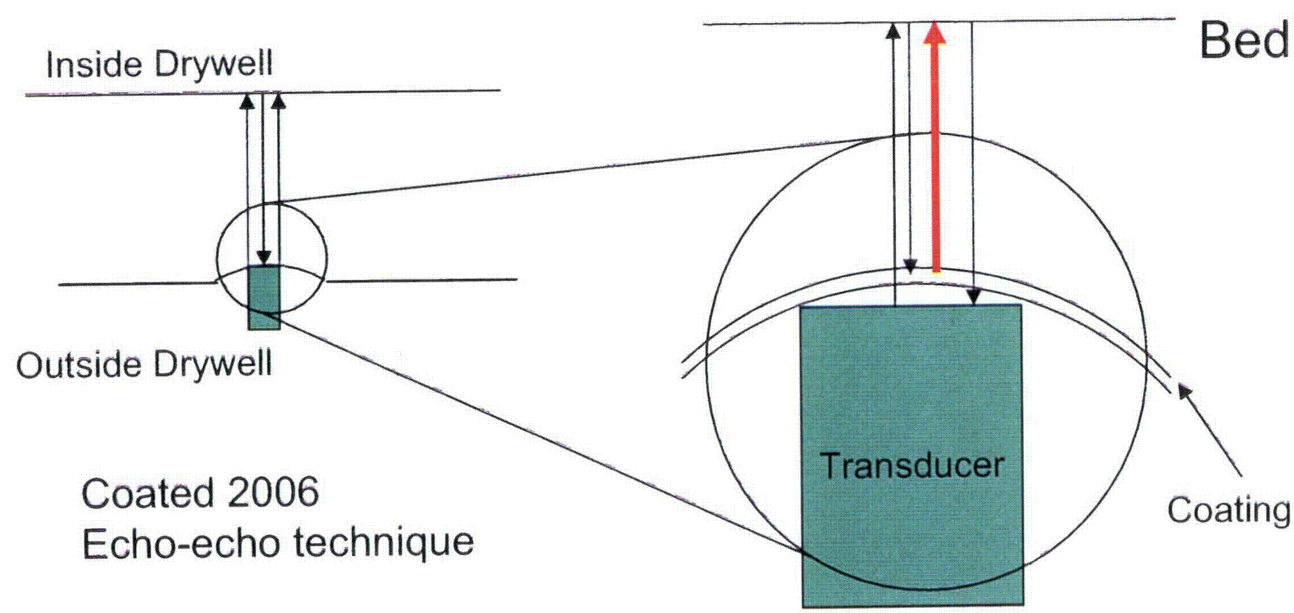

External UT Inspection Results

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Location	1992 UT Measurements				2006 UT Measurements			
	No. of UTs	No. of UTs <736 mils	Thickness in mils <736	Thickness in mils >736	No. of UTs	No. of UTs <736 mils	Thickness in mils <736	Thickness in mils >736
Bay 1	23	9	680 to 726	760 to 1156	23	10	665 to 731	738 to 1160
Bay 3	8	0		780 to 1000	8	0		764 to 999
Bay 5	8	0		890 to 1060	7	0		880 to 1007
Bay 7	7	0		920 to 1045	5	0		964 to 1040
Bay 9	10	0		791 to 1020	10	0		781 to 1016
Bay 11	8	1	705	755 to 850	8	1	700	751 to 830
Bay 13	29	9	618 to 728	807 to 941	15	6	602 to 708	741 to 923
Bay 15	11	1	722	770 to 932	11	0		749 to 935
Bay 17	11	1	720	760 to 1150	10	1	681	822 to 970
Bay 19	10	0		776 to 969	9	0		738 to 932
Total	125	21			106[1]	18		

[1]The locally thinned areas prepared for UT measurements in 1992 were measured in 2006. However, the inspection team was able to locate only 106 points instead of 125.

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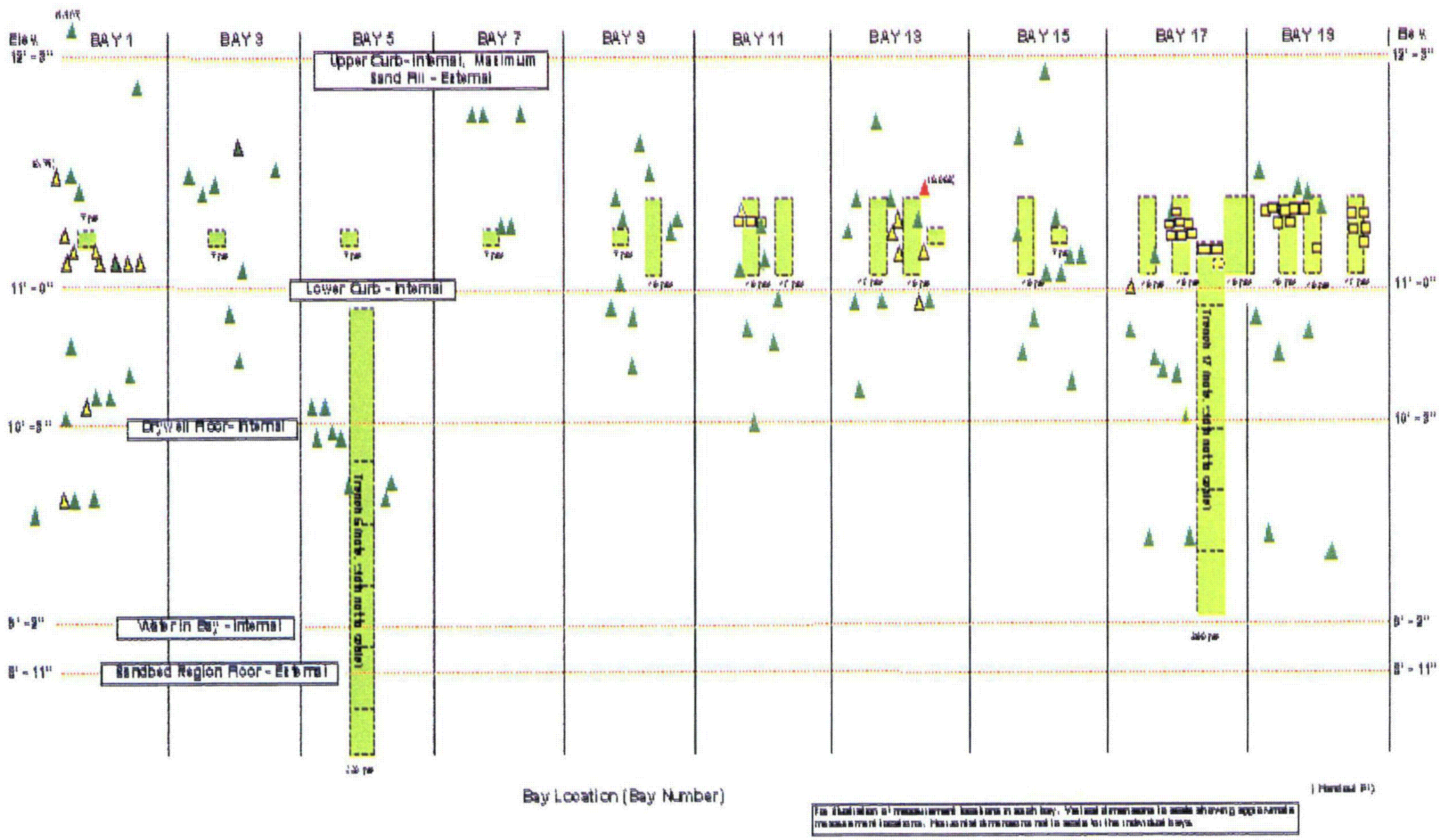
2006 Measurement Locations in the Sandbed Region

Color Code for thickness:

Green = UT Measurements > 736 Mils
Yellow = UT Measurements Between 636 and 736 Mils
Red = UT Measurements Between 536 and 636 Mils

Location / Type of UT Measurement

△ External Point UT Measurements
[ ] Internal Grid UT Measurements
□ Internal Point UT Measurements



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Sand Bed Region Conclusions

- Corrosion on the outside of the drywell shell in the sand bed region has been arrested
- The coating shows no degradation
- There is sufficient margin to the minimum thickness requirement (maintain 64 mils margin above code required average thickness of 736 mils)

Future Inspections in the Sand Bed Region

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- Visual inspection of exterior coating in three bays every other outage, inspecting all 10 bays once every 10 years
- UT measurements at 19 grid locations at elev. 11'3" in 2010, then every 10 years thereafter
- Repeat UT at 106 locally thinned locations from the exterior in 2008 outage
  - In future outages, perform UT in 2 bays every outage

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Embedded Portions of the Drywell Shell

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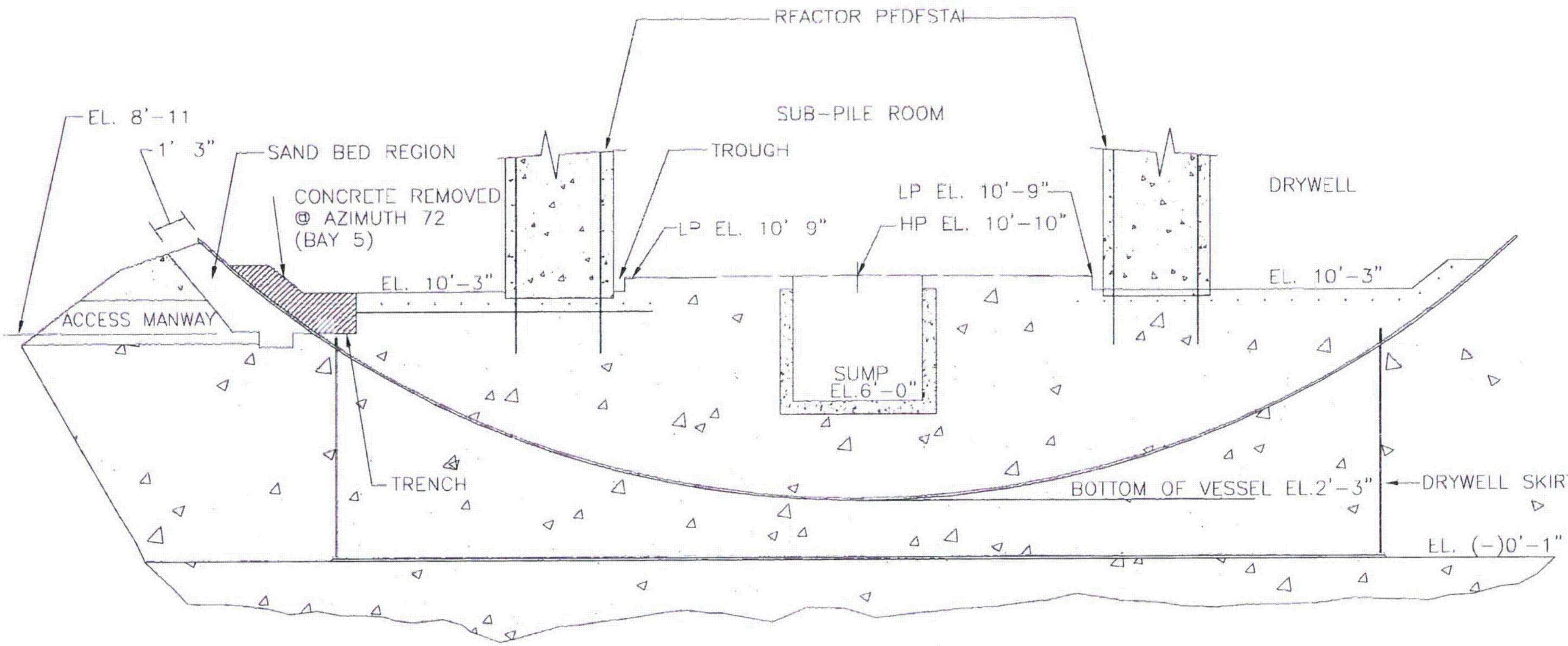
Embedded Shell Conclusions

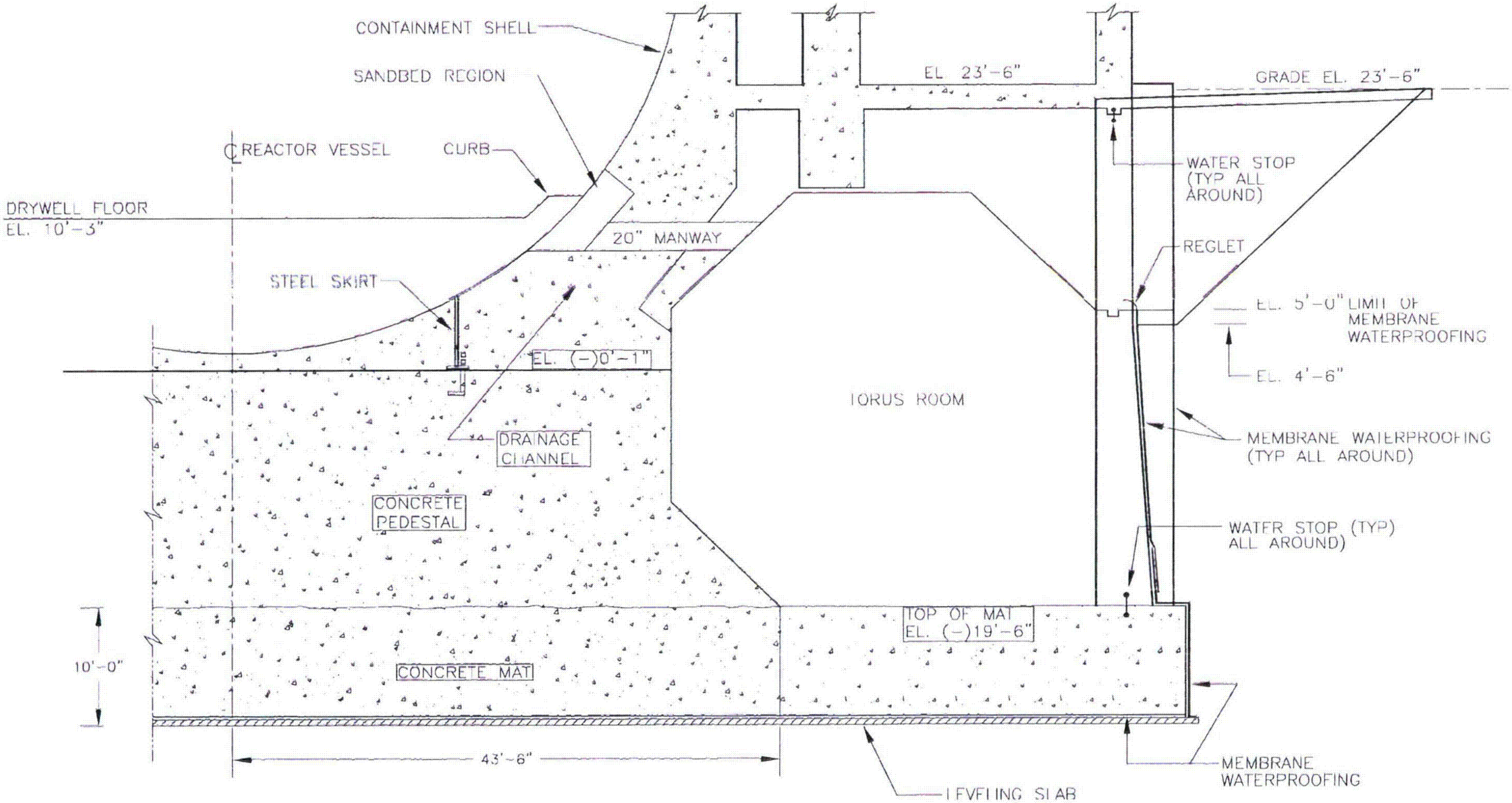
- Corrosion on the embedded surfaces of the drywell shell, both interior and exterior, is not significant
  - The environment of embedded steel in concrete prevents significant corrosion
- Estimated at <1 mil / year
- Drywell shell meets design basis requirements, with margin to 2029

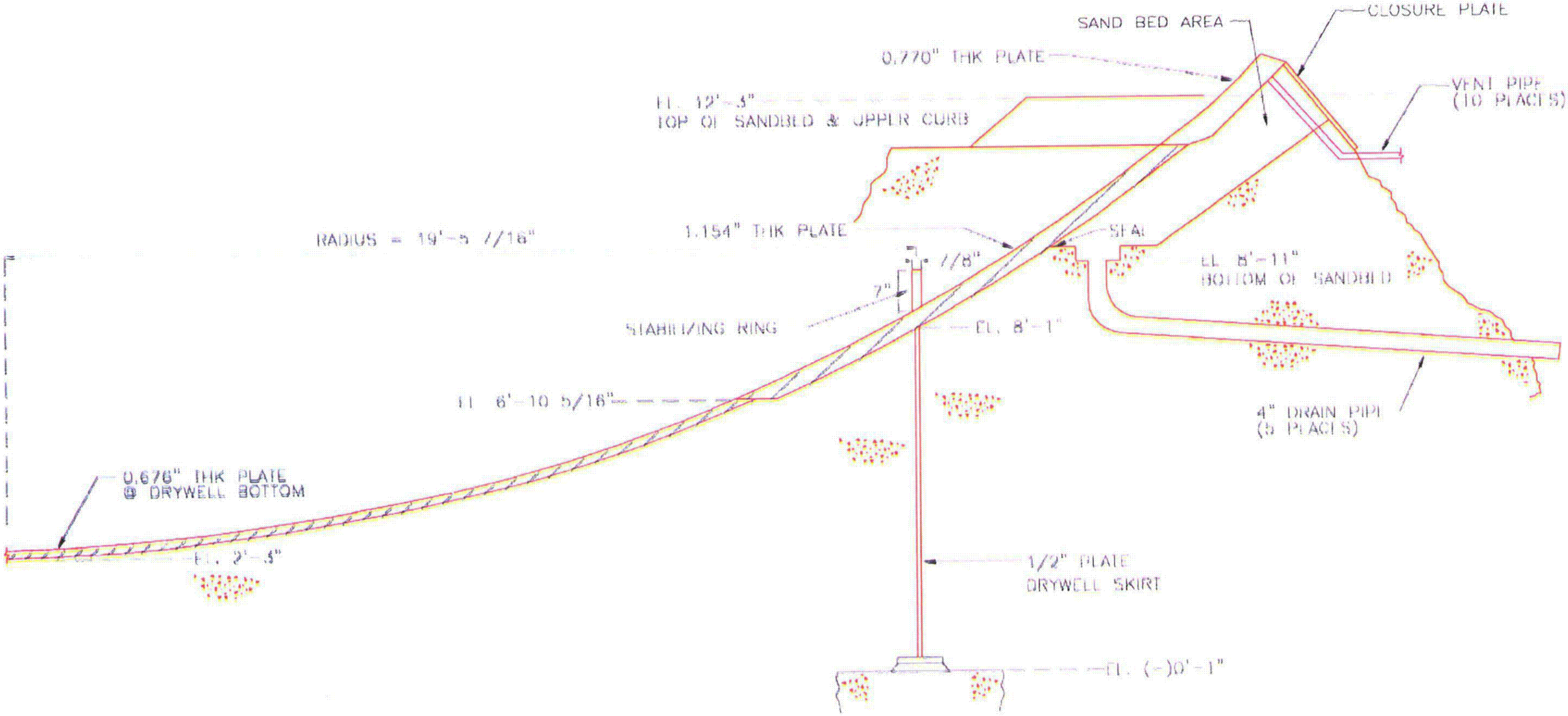
LOWER DRYWELL-
SANDBED, TRENCH & SUMP



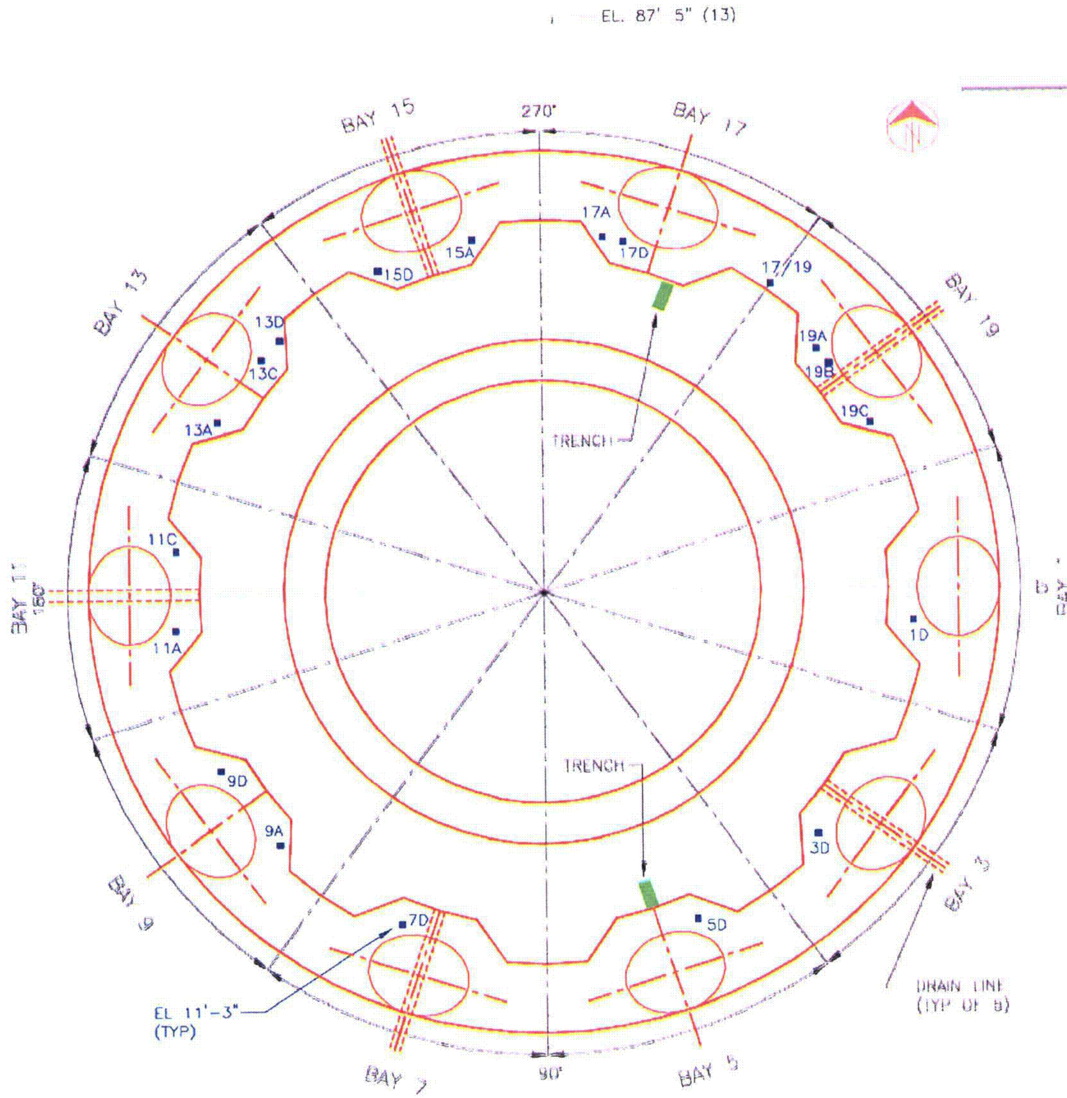
ELEVATION LOOKING WEST

REACTOR BUILDING, DRYWELL SUPPORT STRUCTURE





SECTIONAL VIEW OF SAND BED AREA AT VENT PIPE


EL. 87' 5" (13)
270°
BAY 15
BAY 17
BAY 13
BAY 19
17A
17D
15A
15D
17/19
13D
13C
13A
19A
19B
19C
TRENCH
11C
11A
BAY 11
180°
1D
9D
9A
3D
7D
5D
BAY 9
BAY 3
EL 11'-3"
(TYP)
BAY 7
90°
BAY 5

KEY PLAN

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Embedded Shell – Exterior Surface

- Any corrosion of the drywell exterior embedded surface occurred because of water leakage into the sand bed region
- Corrective actions for the sand bed region arrested corrosion of the drywell exterior embedded shell
  - Water leakage into the sand bed region was prevented
  - The joint between the drywell shell and floor of the sand bed region was sealed to prevent water from contacting the exterior shell

Embedded Shell – Interior Surface

- Water that was identified in the trenches in bays 5 and 17 inside the drywell when the foam filling was removed during the 2006 refueling outage was determined to have originated from equipment leakage inside the drywell (Not from external sources)

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Embedded Shell - Interior Surface

- Investigations into the source of the water indicate that there could have been water below the drywell interior floor for an extended period
- Additional concrete was removed from the bottom of the bay 5 trench to expose 6 inches of drywell shell that was embedded on both sides for UT thickness measurements of the drywell shell

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Embedded Shell – Interior Surface

- Corrective actions during the 2006 refueling outage included
  - Caulking the joint between the drywell interior floor and the drywell shell
  - Repairs to the collection trough in the sub-pile room

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Corrosion of Steel Embedded in Concrete

Barry Gordon

Structural Integrity Associates, Inc.

Corrosion of Steel Embedded in Concrete

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- Drywell shell was constructed first, followed by pouring of concrete both on the inside and the outside of the shell
- The high pH (e.g., 12.5 to 14) environment created during hydration of the cement in the concrete results in the formation of a passive, protective film [$Fe(OH)_2$ + $Ca(OH)_2$] on the carbon steel surface that mitigates corrosion in the absence of an aggressive environment

Exterior Embedded Steel Environment

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- The reactor cavity water that flowed into the embedded region outside the drywell was affected by the sand bed
- However, the chemistry of the water leachate from moist sand from the sand bed region was measured in 1986 revealed high purity water:
  - pH >7, <0.045 ppm Cl^- <0.032 ppm $SO_4^=$
    (US Water: 59 ppm Cl^-, 81 ppm $SO_4^=$)
  - This water is not aggressive to the embedded steel in concrete per GALL/EPRI

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Exterior Embedded Steel Environment

- The water in the embedded region would have been the same quality as in the sand bed region, except the pH would have been greater because of the interaction with high pH concrete pore water
- Per GALL NUREG-1801 Vol. 2, Rev.1 and EPRI 1002950, no aging effects are expected since pH>5.5, <500 ppm Cl^- and <1500 ppm $SO_4^=$ (GALL II.B1.2-2, II.B1.2-8)

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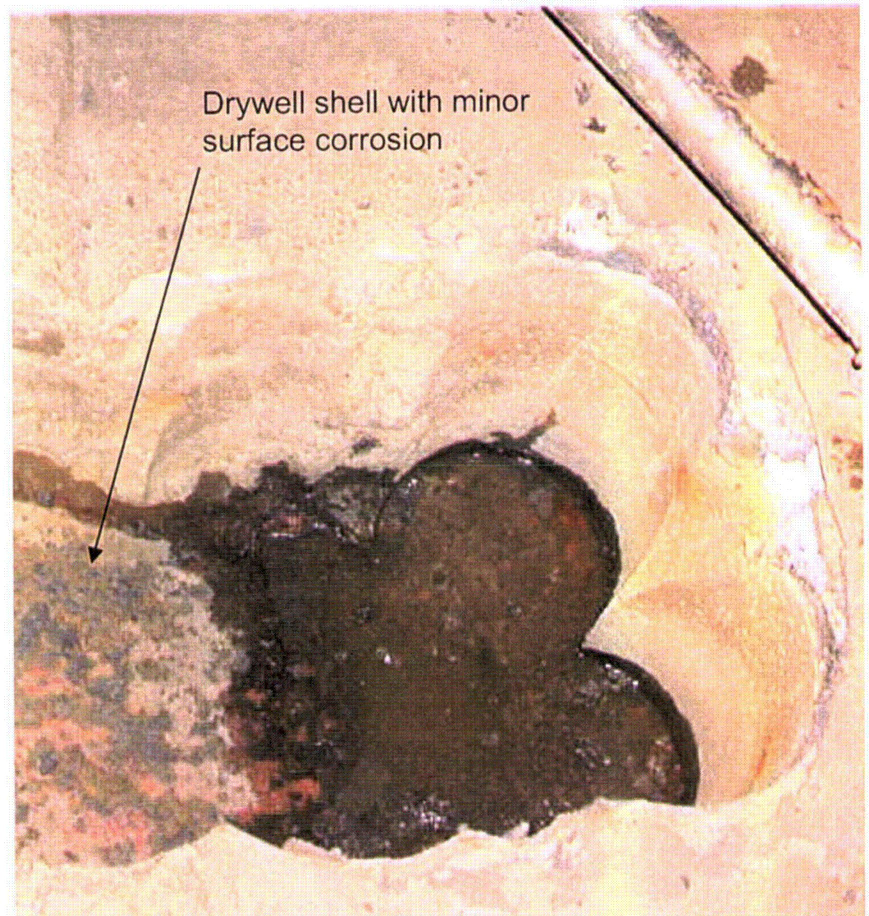
Interior Embedded Steel Environment

- Chemistry of the drywell Trench #5 water (from equipment leakage) shows high pH, low Cl^-, low $SO_4^=$ and high Ca:
  - pH 8.4 to 10.2 (despite CO_2) (> GALL/EPRI limit)
  - Cl^-: 13.6 – 14.6 ppm (<< 500 ppm GALL/EPRI limit)
  - $SO_4^=$: 228 - 230 ppm (<<1500 ppm GALL/EPRI limit)
  - Ca: 83.5 – 96.6 ppm (No GALL/EPRI limit)
- Water is characterized as good quality "concrete pore water" that mitigates steel corrosion
- Trench #5 water complies with GALL/EPRI embedded steel guidelines

Interior Embedded Steel Environment

- Trench #5 water's high Ca indicates that the water slowly migrated through the alkaline concrete
- Any subsequent water ingress into the concrete floor will also become high pH concrete pore water



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Interior Embedded Steel Environment

- Corrosion of the steel shell not wetted by high pH concrete pore water is mitigated by subsequent inerting of the drywell during operation
- Any possible subsequent steel corrosion could occur only during brief outages when fresh oxygenated water can contact with the shell
- Finally, transport of any oxygenated water through the concrete to the steel is slow, will increase in pH and must displace oxygen depleted water before any possible corrosion can occur

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2006 Outage Inspections

Embedded Shell

- Visual inspection of the surface in the trenches showed minor corrosion which was easily removed with no visible loss of material or degradation of the surface

2006 Outage Inspections

Embedded Shell

- UT measurements in the trenches measure total corrosion on the inside and outside between 1986 and 2006
  - Corrosion was occurring on the exterior surface that was not embedded until 1992 when sand was removed
  - Material loss was consistent with the corrosion rates on the outside of the drywell before the sand was removed

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2006 Inspection Results Embedded Shell

UT measurements in trenches 5 and 17

	1986 Thickness	1986 Std. Error	2006 Thickness	2006 Std. Error	Difference
Trench 5	1112 mils	±2.59 mils	1074 mils	±2.66 mils	38 mils
Trench 17	1024 mils	±2.85 mils	986 mils	±4.18 mils	38 mils

2006 Inspection Results Embedded Shell

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- UT measurements of the 6 inch surface excavated in the bottom of the trench in bay 5 were performed to determine total corrosion, both interior and exterior
- Measured thickness is 1113 mils, as compared to a nominal of 1154 mils
  - A change of 41 mils, approximately 1 mil/yr

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2006 Outage Inspections Embedded Shell

- The 106 individual UT measurements made from the exterior of the sand bed region are a baseline for monitoring corrosion of the interior embedded surface of the drywell in future outages

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2006 Inspection Results Embedded Shell

- The joint sealant between the sand bed floor and the exterior drywell shell was inspected and found to be in good condition
- No water was identified in the sand bed region in any of the 10 bays

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Embedded Shell Conclusions

- Corrosion on the embedded surfaces of the drywell shell, both interior and exterior, is not significant
  - The environment of embedded steel in concrete prevents significant corrosion
- Estimated at <1 mil / year
- Drywell shell meets code thickness requirements, with margin to 2029

Future Inspections on the Embedded Shell

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- Repeat UT measurements in both trenches, including the newly excavated 6 inches in 2008
  - If results indicate no significant changes, then fill the trenches with concrete and restore the curb to original configuration
- Repeat UT measurements at 106 external points in 2008
  - Perform external UT measurements in 2 bays every refuel outage starting in 2010
  - All bays will be inspected every 10 years

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Upper Drywell Shell

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Upper Drywell Shell Conclusions

- These measurements are the lead indicators of corrosion on the outside of the shell
- Corrosion of the upper shell is <1 mil / yr
- Upper Drywell shell has a minimum of 137 mils margin
- Based on current rates, will have margin through the period of extended operation

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Upper Drywell Shell

- Starting in 1983, over 1,000 UT measurements were taken to locate areas of corrosion on the exterior surface of the drywell shell
- 13 grid locations have been selected for monitoring
- These locations are measured every other refueling outage

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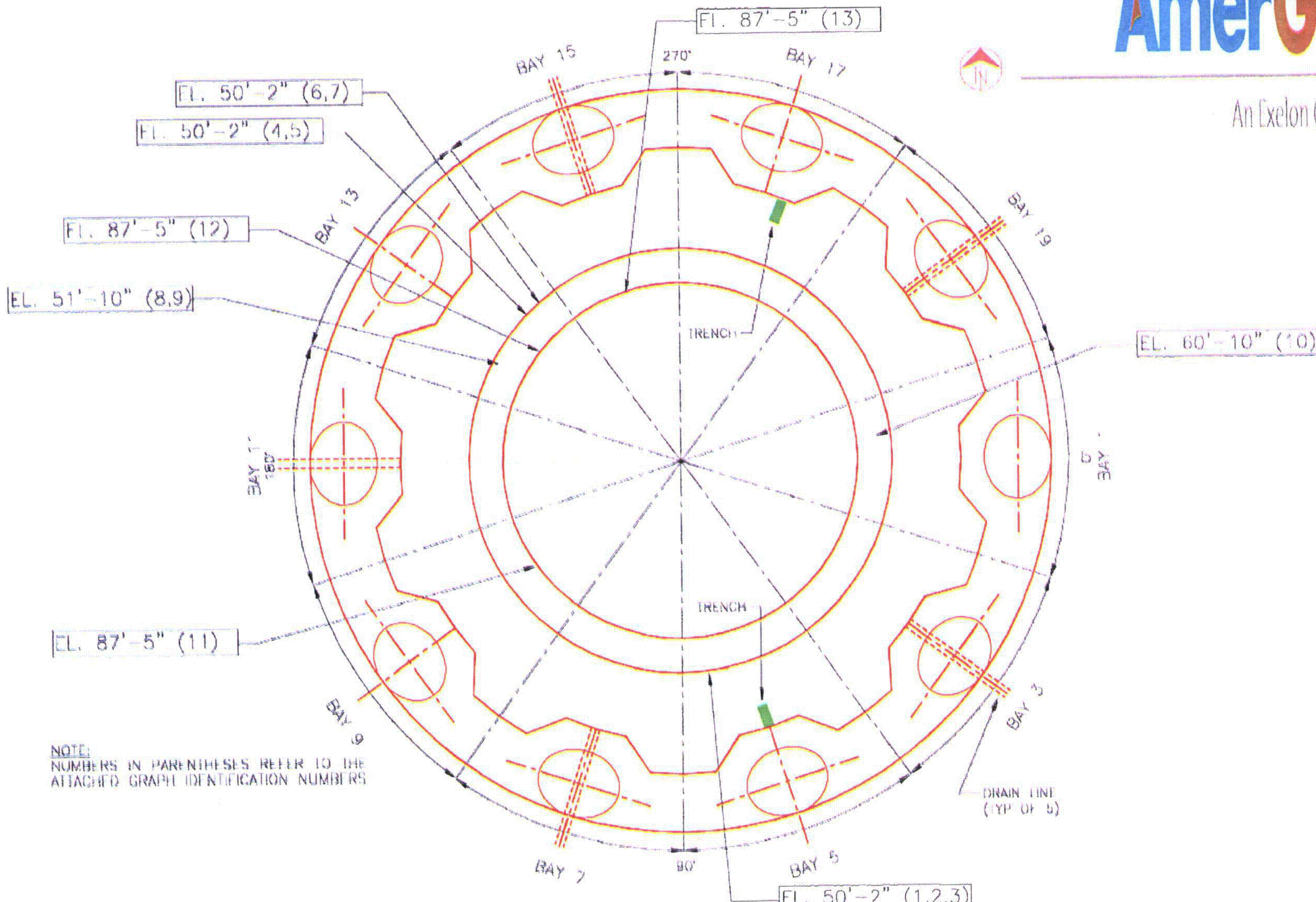

NOTE:
NUMBERS IN PARENTHESES REFER TO THE ATTACHED GRAPH IDENTIFICATION NUMBERS

KEY PLAN

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Upper Drywell UT Measurements

Monitored Elevation	Location	Minimum Required Thickness mils	Average Measured Thickness [1,2] mils												Projected Thickness in 2029 mils
			1987	1988	1989	1990	1991	1992	1993[3]	1994	1996	2000	2004	2006	
Elevation		541													
50' 2"	Bay 5-D12					743 745 746	742 745 748	747 747		741	748	741	743	747	No Observable Ongoing Corrosion
	Bay 5-5H					761 761	755 758 760	759 759		754	757	754	756	760	No Observable Ongoing Corrosion
	Bay 5-5L					706 703	703 705 706	703 702		702	705	706	701	705	No Observable Ongoing Corrosion
	Bay 13-31H					762 779	760 758 765	765 763		759	766	762	758	762	No Observable Ongoing Corrosion
	Bay 13-31L					687 684	689 678 688	685 688		683	690	682	693	678	No Observable Ongoing Corrosion
	Bay 15-23H					758 764	762 762 765	767 763		758	760	758	757		
	Bay 15-23L					726 728	726 729 725	726 724		728	724	729	727	749	720

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Upper Drywell UT Measurements

Monitored Elevation	Location	Minimum Required Thickness mils[3]	Average Measured Thickness [1,2] mils												Projected Thickness in 2029 mils
			1987	1988	1989	1990	1991	1992	1993[3]	1994	1996	2000	2004	2006	
Elevation 51' 10"		518													
	Bay 13-32H					716	715 715 720	717 717		714	715	715	713	715	No Observable Ongoing Corrosion
	Bay 13-32L					686	683 683 682	683 676		680	684	679	687	685	No Observable Ongoing Corrosion
Elevation 60' 10"	Bay 1-50-22	518							693	711	693	689	693	691	No Observable Ongoing Corrosion
Elevation 87' 5"	Bay 9-20	452	619	622 620	619	620	614 612	629 614		613	613	604	612	617	No Observable Ongoing Corrosion
	Bay 13-28		643	641 642	645	643	635 629	641 637		640	636	635	640	642	No Observable Ongoing Corrosion
	Bay 15-31		638	636 636	638	642	628 627	631 630		633	632	628	630	633	No Observable Ongoing Corrosion

Notes:

1. The average thickness is based on 49 Ultrasonic Testing (UT) measurements performed at each location.
2. Multiple inspections were performed in the years 1988, 1990, 1991, and 1992.
3. The 1993 elevation 60' 10" Bay 5-22 inspections was performed on January 6, 1993. All other locations were inspected in December 1992.

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Upper Drywell Shell 2006 Inspection Results

- 12 of the 13 locations show no statistically observable corrosion
- The location with the minimum margin (137 mils) has no ongoing corrosion
- 1 location shows a corrosion rate of 0.66 mils/year
  - Projected thickness in 2029 is 720 mils, compared to a minimum required thickness of 541 mils

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Upper Drywell Shell Conclusions

- These measurements are the lead indicators of corrosion on the outside of the shell
- Corrosion of the upper shell is <1 mil / yr
- Upper Drywell shell has a minimum of 137 mils margin
- Based on current rates, will have margin through the period of extended operation

Overall Conclusions

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- The corrective actions to mitigate drywell shell corrosion have been effective
- The drywell shell corrosion has been arrested in the sand bed region and continues to be very low in the upper drywell elevations
- The corrosion on the embedded portion of the drywell shell is not significant
- The drywell shell meets code safety margins
- We have an effective aging management program to ensure continued safe operation