Crystal River Unit #3
Containment Delamination
Briefing to PNSC for De-Tensioning

March 8, 2010

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Progress Energy

0/56

Agenda

- De-tensioning Scope and Sequence
- De-tensioning Analysis Results
- Uncertainty Analysis
- Dome Assessment
- PII Document Reviews
- De-tensioning Phase Monitoring
- Engineering Logistics
- Questions

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SGR Opening
Showing Delamination Boundary

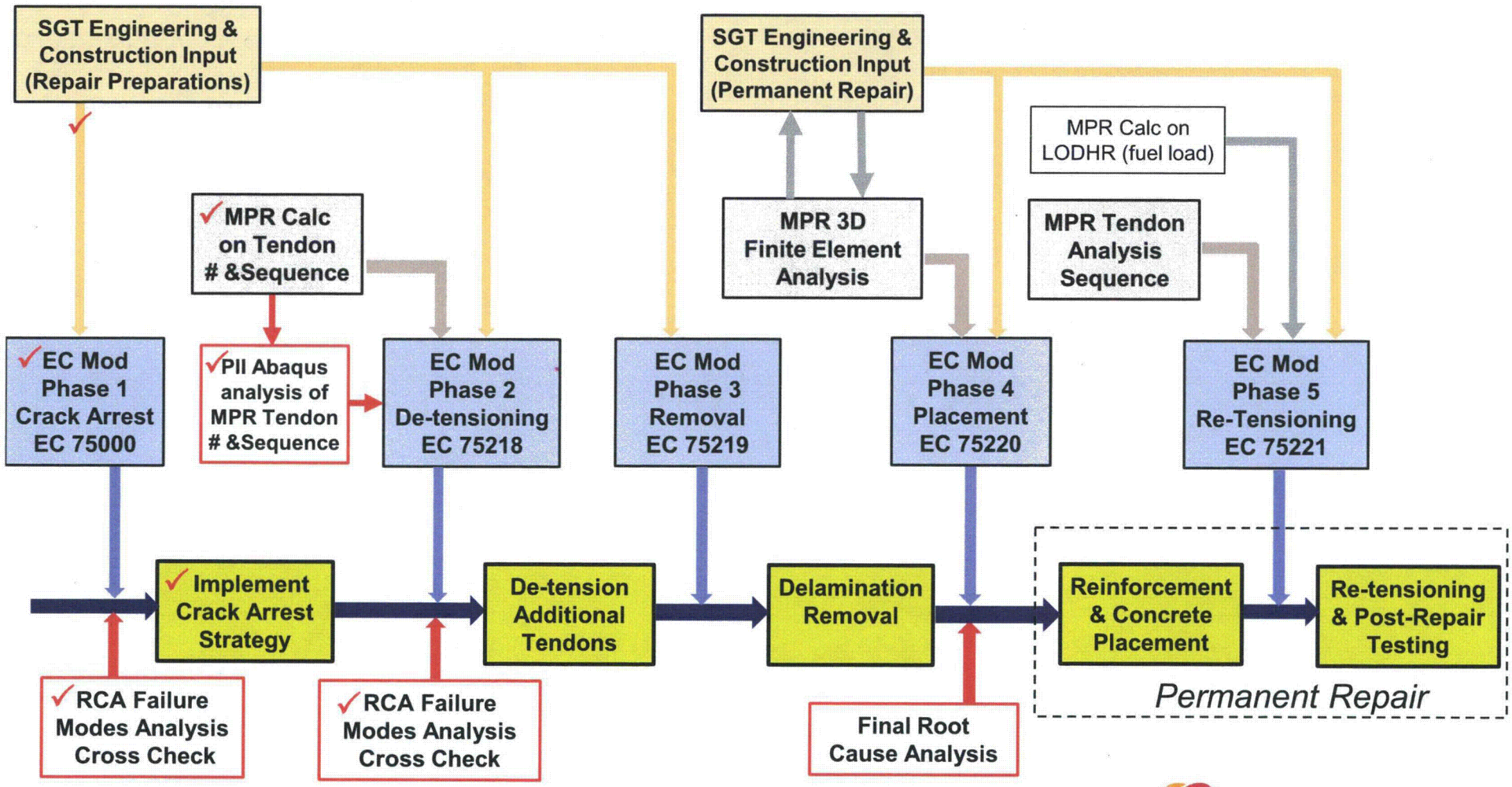
SGR Opening Dimensions

@ Liner
23' 6" x 24' 9"

@ Concrete Opening
25' 0" x 27" 0"

Engineering & Repair Work Flow

✓ Indicates Completed Task



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De-tensioning Scope and Sequence

- Scope and Sequence specified as Option 10F in EC 75218 Rev. 2
  - 155 Horizontal (of those,17 already de-tensioned as part of SGR)
  - 64 Verticals (of those,10 already de-tensioned as part of SGR)

- 11 Passes(3 vertical and 8 horizontal)= V, H, V, H, H, H, H, H, V, H, H
  - 1V (5 Sequences, 10 tendons)
  - 1H (7 Sequences, 20 tendons)
  - 2V (6 Sequences, 24 tendons)
  - 2H (8 Sequences, 18 tendons)
  - 3H (14 Sequences, 32 tendons)
  - 4H (14 Sequences, 35 tendons)
  - 5H (3 Sequences, 7 tendons)
  - 6H (4 Sequences, 10 tendons)
  - 3V (5 Sequences, 20 tendons)
  - 7H (4 Sequences, 10 tendons)
  - 8H (3 Sequences, 6 tendons)

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De-tensioning Scope and Sequence

Option 10F Tendon Scope and Sequence

	Seq.	Option 10-F Tendon	Tendon	Tendon	Tendon
Pass 1	V-1	61V11	61V14		
	V-2	61V09	61V16		
	V-3	61V12	61V13		
	V-4	61V10	61V15		
	V-5	61V08	61V17		
Pass 2	1	13H18	35H18	51H18	
	2	13H20	35H20	51H19	
	3	13H22	35H22		
	4	13H24	35H24	51H24	
	5	13H38	35H38	51H38	
	6	13H42	35H42	51H42	
	7	13H44	35H44	51H44	
Pass 3	V-6	61V07	61V18	34V18	34V07
	V-7	61V05	61V20	34V20	34V05
	V-8	61V03	61V22	34V22	34V03
	V-9	61V01	61V24	34V24	34V01
	V-10	12V23	56V02	23V02	45V23
	V-11	12V21	56V04	23V04	45V21
Pass 4	8	42H17			
	9	42H19			
	10	42H21	62H21	64H21	
	11	42H23	62H23	64H23	
	12	42H25	62H25	64H25	
	13	42H35			
	14	42H41	62H41	64H41	
	15	42H43	62H43	64H43	

	Seq.	Option 10-F Tendon	Tendon	Tendon	Tendon
Pass 5	16	35H17			
	17	35H19			
	18	13H21	35H21		
	19	13H23	35H23	51H23	
	20	13H25	35H25	51H25	
	21	13H27	35H27	51H27	
	22	13H29	35H29	51H29	
	23	13H31	35H31	51H31	
	24	13H33	35H33	51H33	
	25	13H35	35H35	51H35	
	26	13H37	35H37	51H37	
	27	13H39	35H39	51H39	
	28	13H41	35H41	51H41	
	29	13H43	35H43	51H43	
Pass 6	30	42H18			
	31	42H20	64H20		
	32	42H22	64H22	62H22	
	33	42H24	64H24	62H24	
	34	42H26	64H26	62H26	
	35	62H28	42H28	64H28	
	36	62H30	42H30	64H30	
	37	62H32	42H32	64H32	
	38	62H34	42H34	64H34	
	39	42H36	62H36	64H36	
	40	42H38	62H38	64H38	
	41	42H40	62H40	64H40	
	42	42H42	62H42	64H42	
	43	42H44	62H44	64H44	

	Seq.	Option 10-F Tendon	Tendon	Tendon	Tendon
Pass 7	44	13H28	35H28	51H28	
	45	13H32	35H32	51H32	
	46	13H36	35H36	51H36	
Pass 8	47	62H29	42H29	64H29	
	48	62H33	42H33	64H33	
	49	42H37	62H37	64H37	
	50	42H39	62H39	64H39	
Pass 9	V-12	61V06	61V19	34V19	34V06
	V-13	61V04	61V21	34V21	34V04
	V-14	61V02	61V23	34V23	34V02
	V-15	12V24	56V01	23V01	45V24
	V-16	12V22	56V03	23V03	45V22
Pass 10	51	13H26	35H26	51H26	
	52	13H30	35H30	51H30	
	53	13H34	35H34	51H34	
	54	13H40	35H40	51H40	
Pass 11	55	62H27	42H27	64H27	
	56	62H31	42H31	64H31	
	57	62H35	64H35		

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Indicates tendons already de-tensioned as part of SGR

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De-tensioning Analysis Results

Panel	Critical Pass	Max Principal Stress	Margin (% below 200 psi Strength)	Location of Peak Stress
Panel 12	Pass 11	90 psi	55%	H29
Panel 23	Pass 10	121 psi	40%	H26
Panel 45	Pass 11	82 psi	59%	H27
Panel 56	Pass 11	78 psi	61%	H30
Panel 61	Pass 11	94 psi	53%	H30

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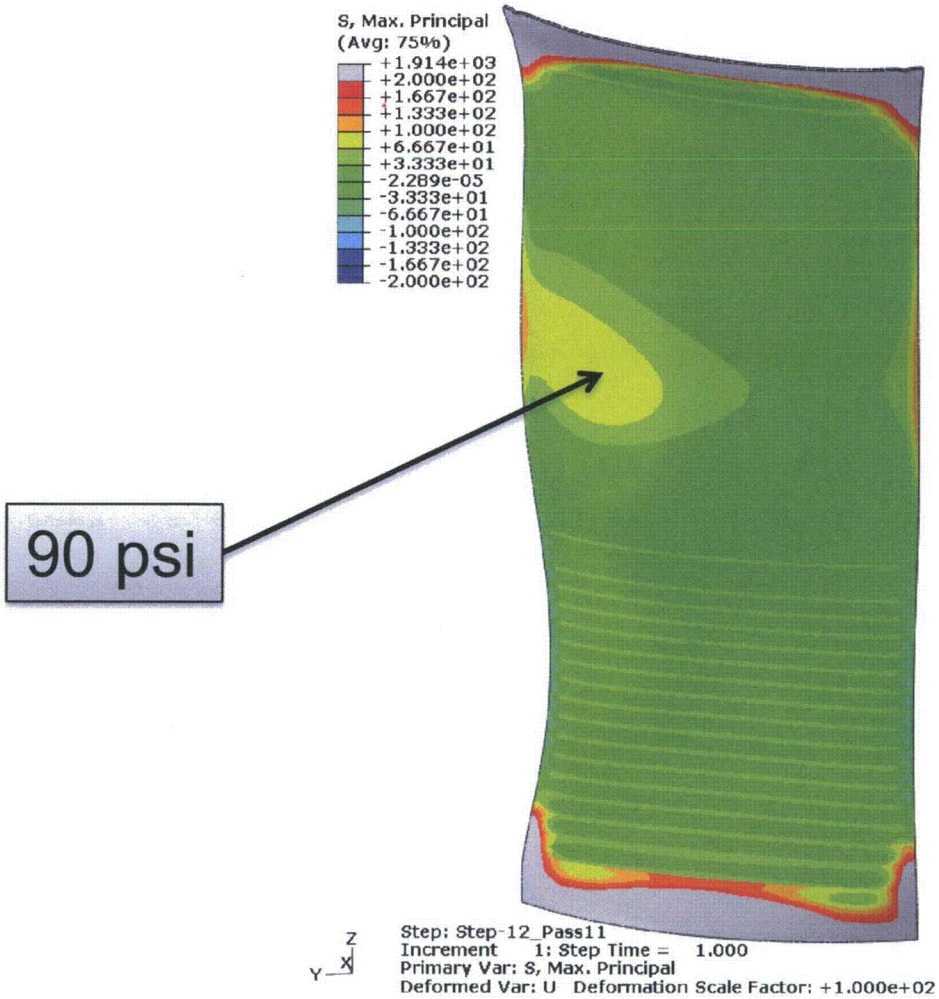
Option 10F Results
Panel 12 Maximum Stress – Pass 11



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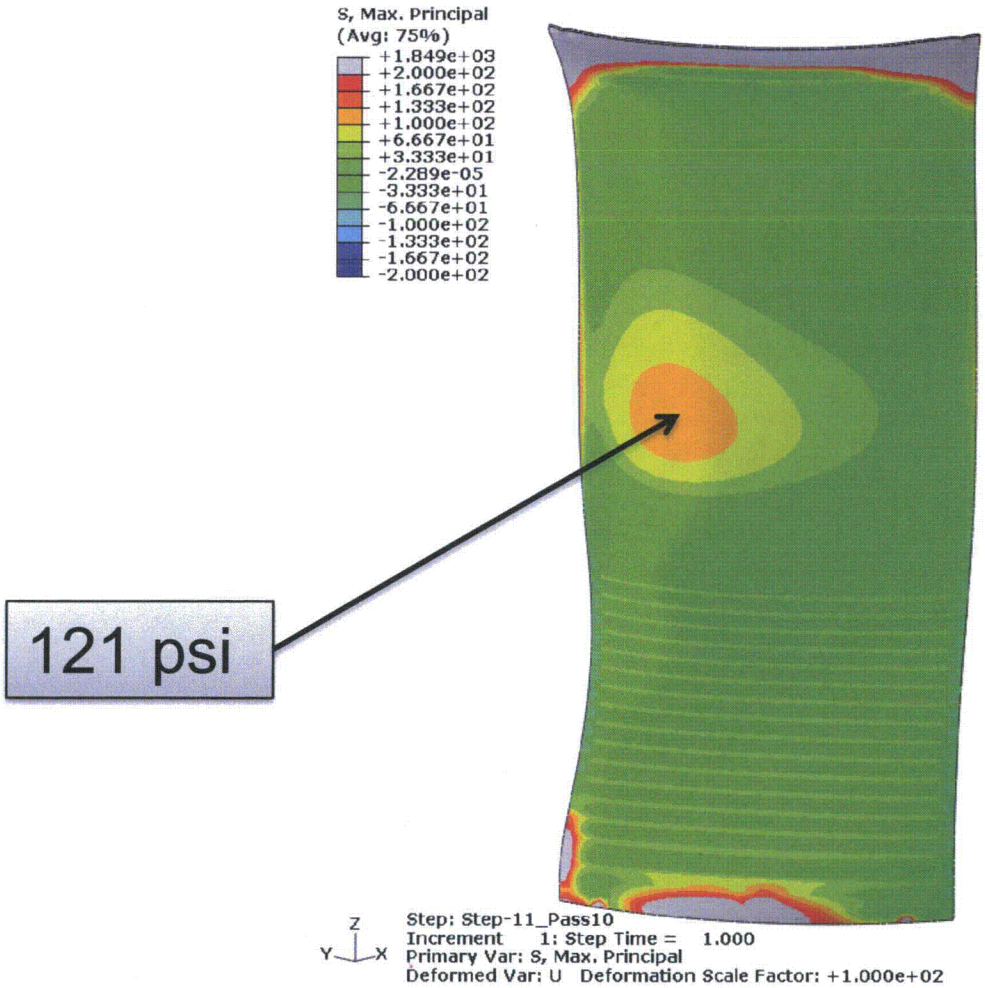
Option 10F Results
Panel 23 Maximum Stress – Pass 10



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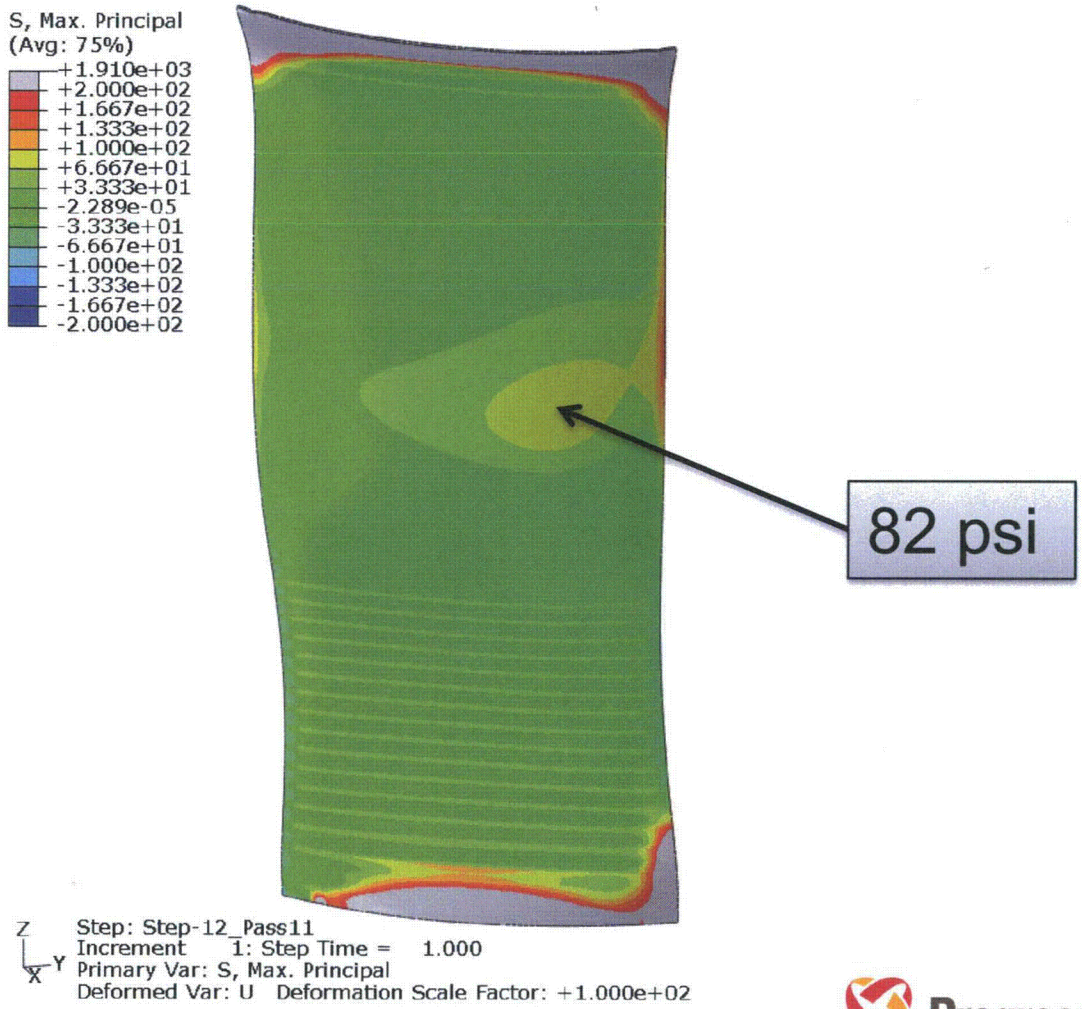
Option 10F Results
Panel 45 Maximum Stress – Pass 11



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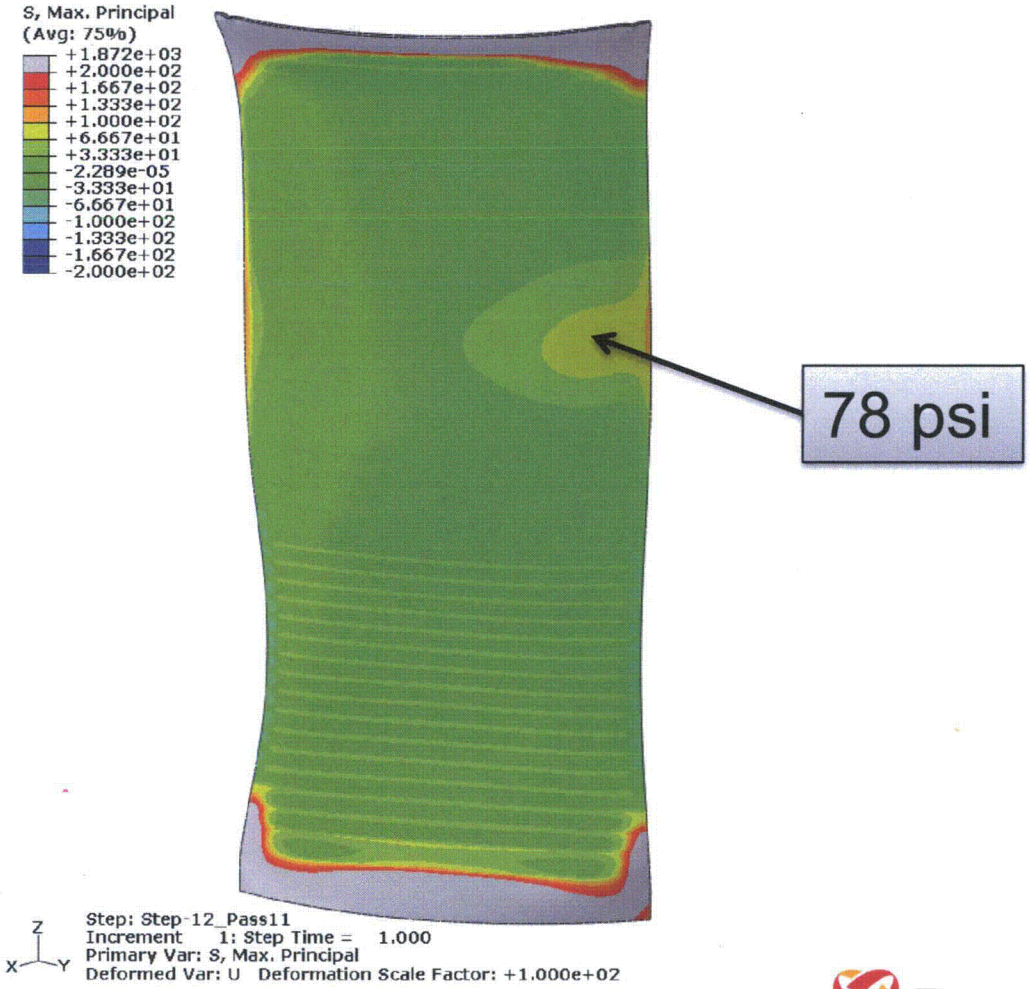
Option 10F Results
Panel 56 Maximum Stress – Pass 11



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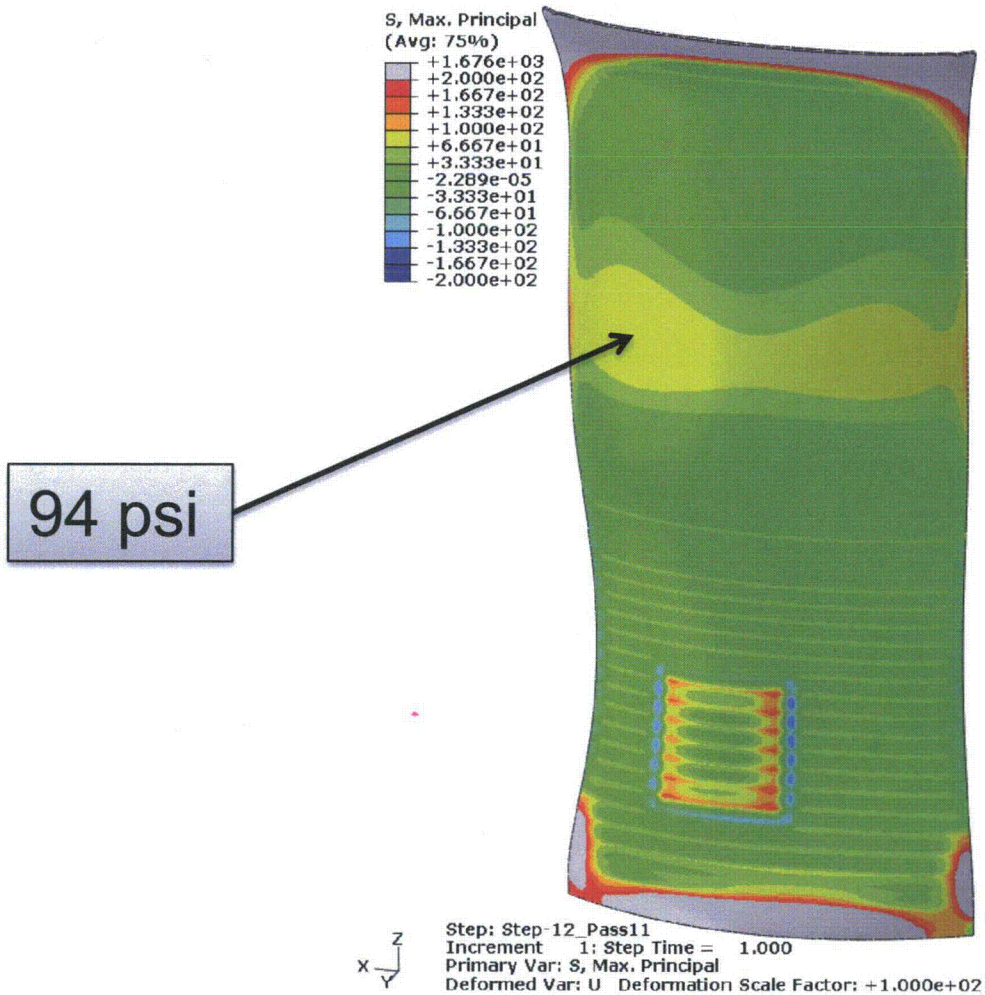
Option 10F Results
Panel 61 Maximum Stress – Pass 11



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Option 10F Results
Granular Check

Pass 10 and 11 Steps	Panel 23 Maximum Stress	Panel 23 Margin(% below 200 psi Strength)	Panel 61 Maximum Stress	Panel 61 Margin(% below 200 psi Strength)
Step 51	97 psi	51.5%	35 psi	82.5%
Step 52	123 psi	38.5%	< 25 psi	> 87.5%
Step 53	**125** psi	**37.5**%	< 25 psi	> 87.5%
Step 54	121 psi	39.5%	< 25 psi	> 87.5%
Step 55	107 psi	46.5%	34, 19 psi	83%, 90.5%
Step 56	80 psi	60%	81, 69 psi	59.5, 65.5%
Step 57	97 psi	51.5%	**94**, 84 psi	**53**, 58%

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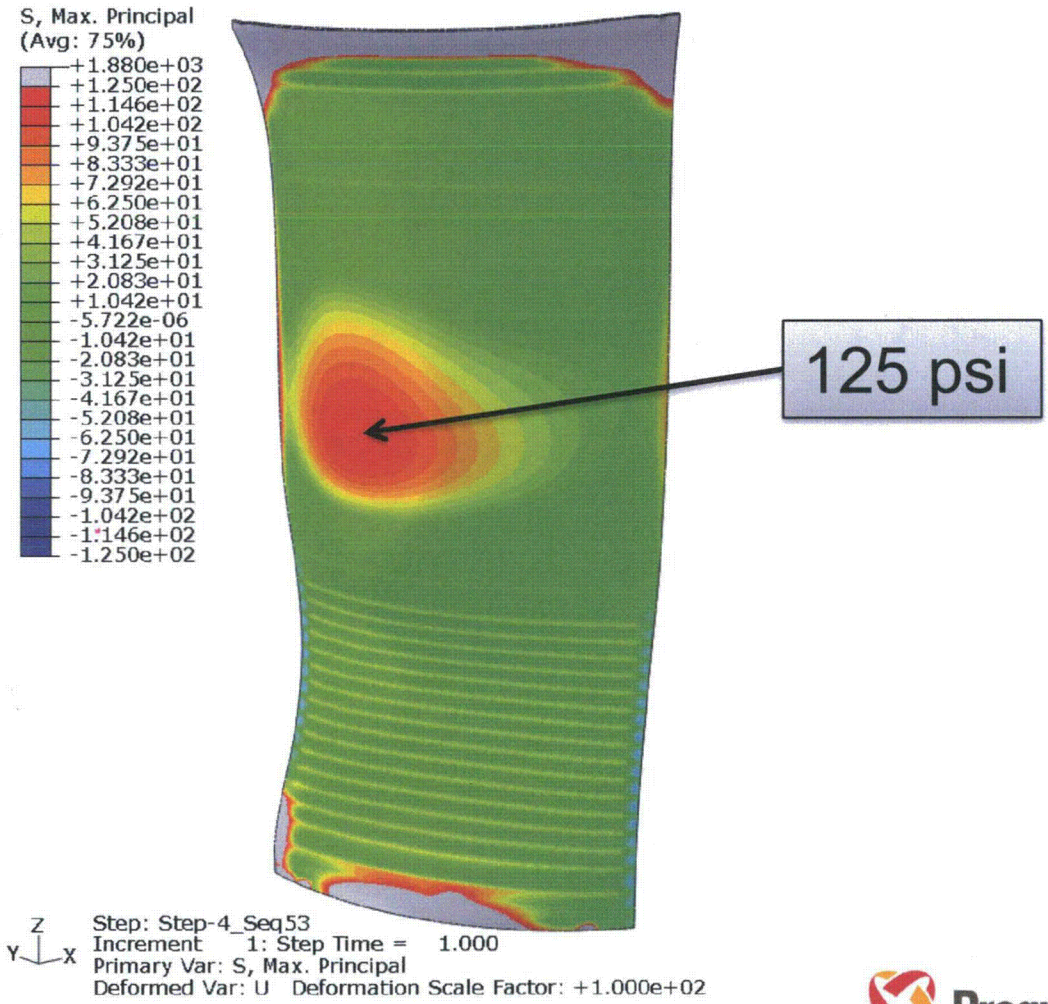
Option 10F Results
Granular Check - Panel 23 Step 53



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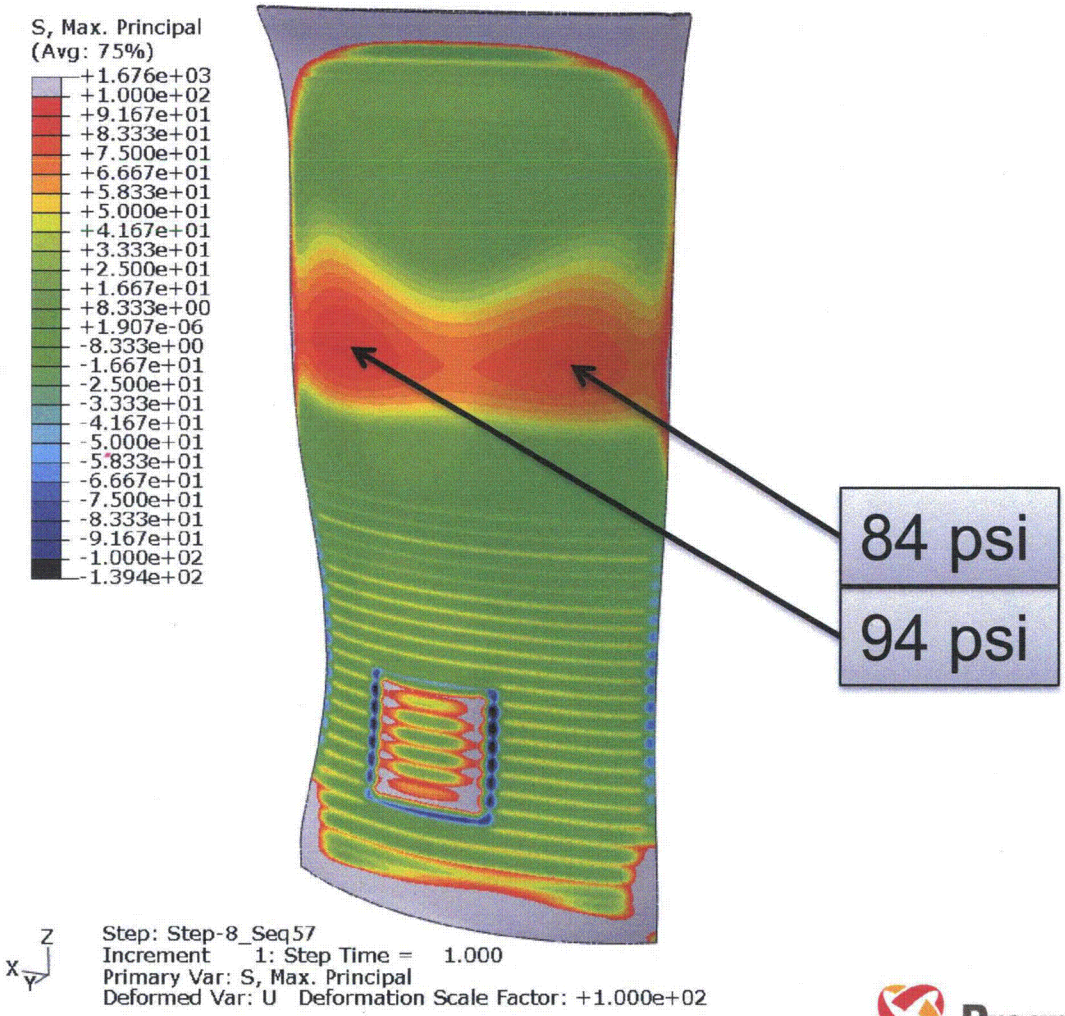
Option 10F Results
Granular Check - Panel 61 Step 57



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Uncertainty Analysis Results

- Summation of Bias and Uncertainty – **30.1**%
- Bias – Peak Energy for Delamination 200 psi versus 225 psi - 11.1%
- Uncertainty – 19.0%
  - Computer Modeling – 13.3%
  - Temperature Effects – 5.0%
  - Pre-existing Crack Size – 13.3%
  - Tendon Forces – 11.0%
  - Square root sum of squares
  - Uncertainty based on 95% probability

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Dome Assessment

- Dome has radial reinforcement throughout (unlike wall section that delaminated)
  - Dome repair area -1800 #6 reinforcement radial anchors
  - Non-repair area (from ring girder transition area to repair area)- 2006 #8 reinforcement hooks
  - Ring girder heavily reinforced in transition area to dome
- MPR calculation assessed the dome as acceptable
- Dome assessment included in EC 75218

- Conclusion – Dome not susceptible to delamination due to de-tensioning wall tendons within option 10F

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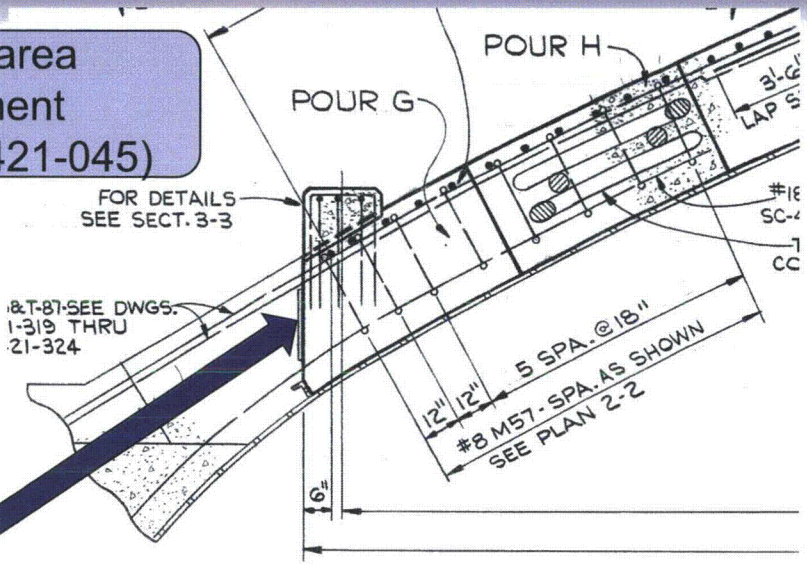
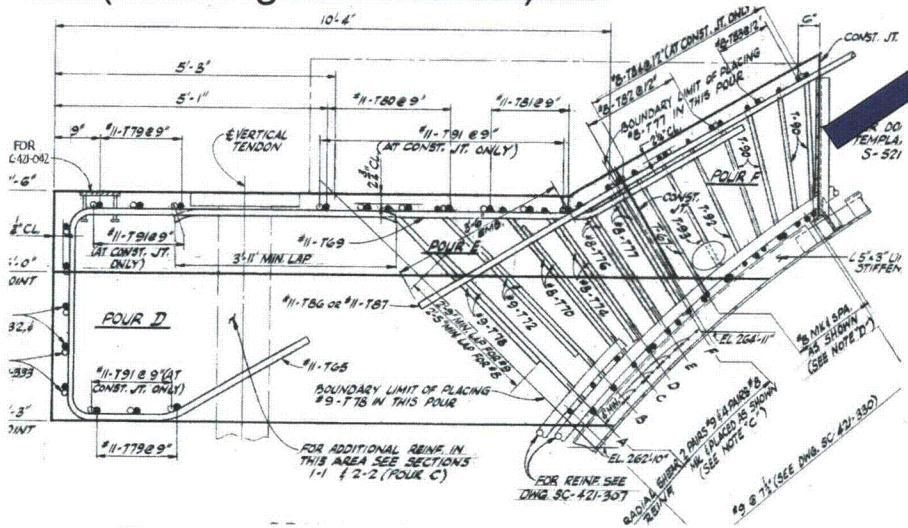
Dome Assessment
Reinforcement Sections

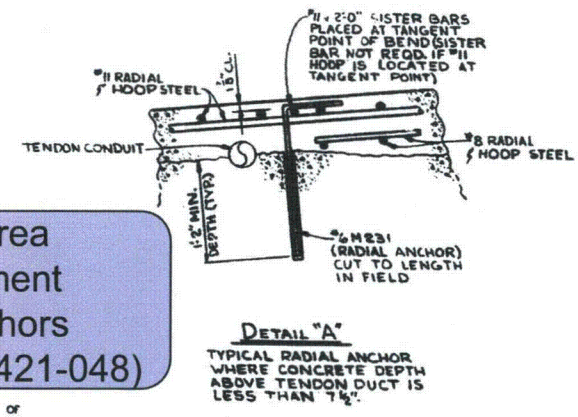
Non-repair area reinforcement (ref. drwg SC-421-045)



Ring girder to dome reinforcement transition (ref. drwg SC-421-328)



Repair area reinforcement radial anchors (ref. drwg SC-421-048)



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PII Documents and Owner's Review

- PII Summary Letter
- Supporting Document Examples
  - Methodology
  - SGR Shape and Delamination Correlation
  - Option 10F Results for Passes and Steps
  - Margin to Delamination (Uncertainty and Bias)
- Progress Energy Owner Reviewed and Accepted Using EGR-NGGC-0003
- Attachments to EC 75218

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De-tensioning Phase Monitoring

- Strain Gauges
- Acoustic Emissions
- Containment Wall Concrete Temperatures
- Contingency and Post De-tensioning IR Scans

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De-tensioning Phase Monitoring

- Strain Gauge Monitoring
  - Vendor-Sensing Systems (24 hr coverage)
  - Two locations - Panel 4-5
  - One location near 1st set of tendons to be de-tensioned
  - Second location near first tendon, next to an SGR de-tensioned tendon

- Criteria established in Engineering Change
  - Localized monitoring capabilities
  - Measures relative strain changes in radial direction
  - Strain changes towards reduction in tension strain
  - Maximum compressive strain

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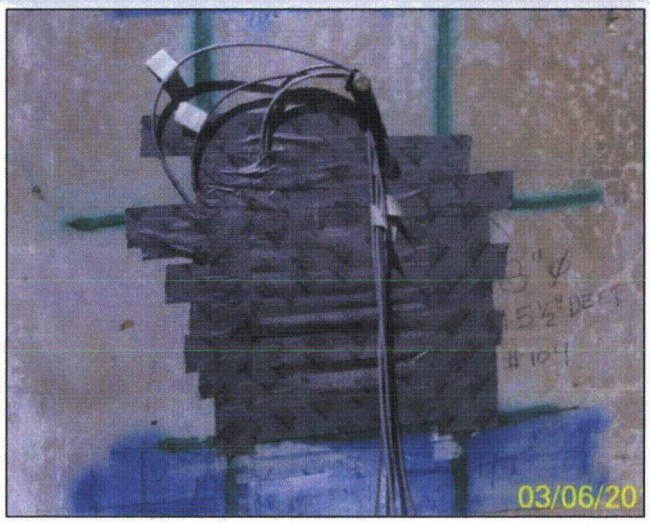
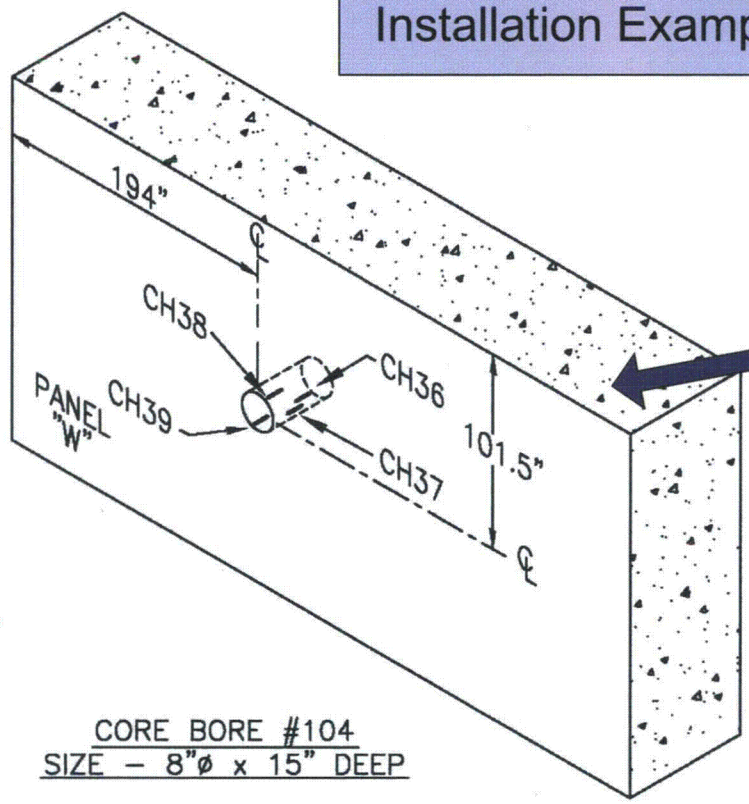
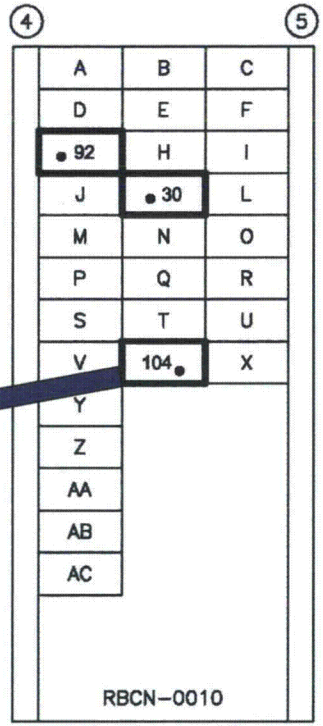
De-tensioning Phase Monitoring



Strain gage field installation

Radial Strain Gage Installation Example





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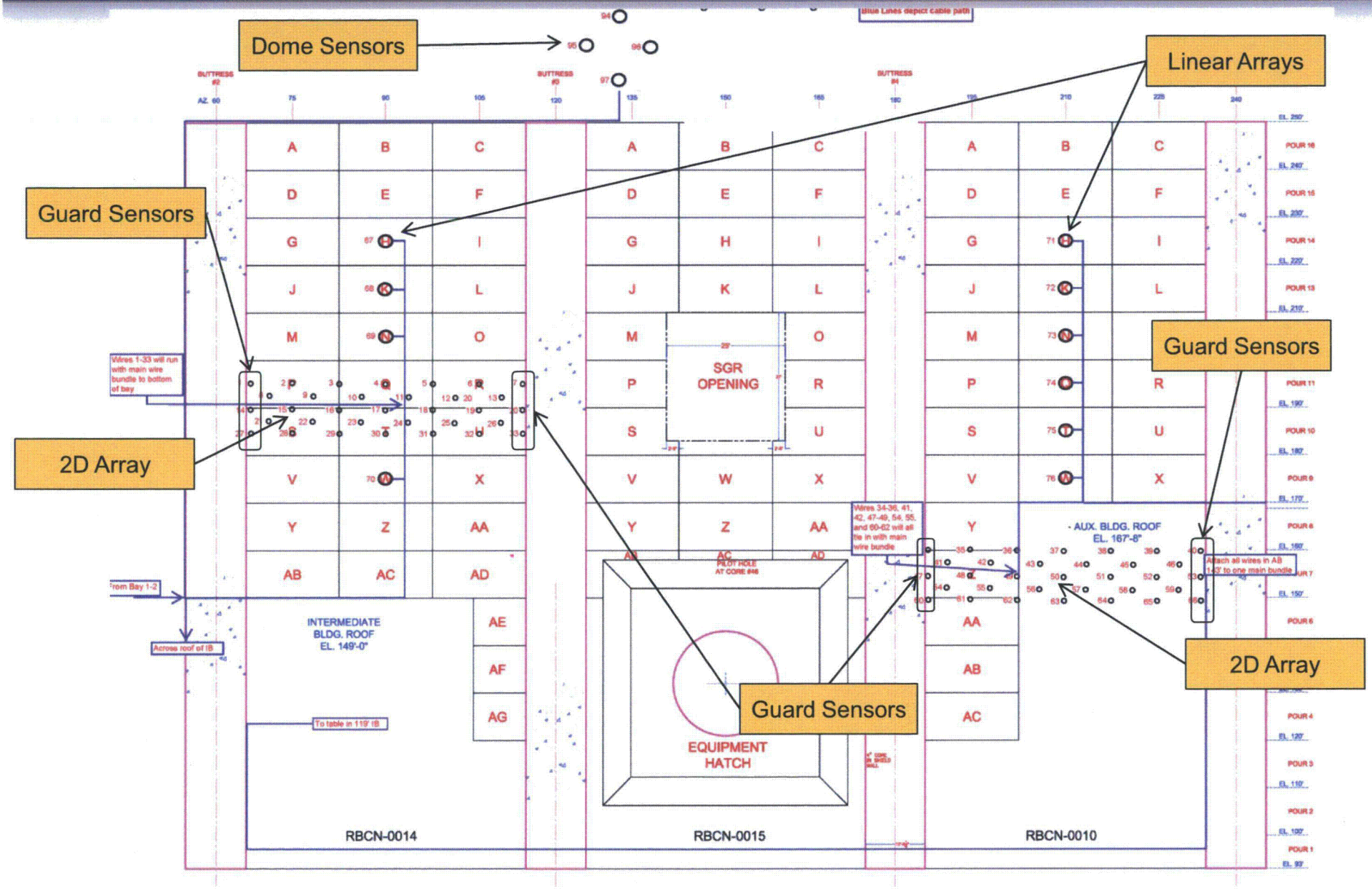
De-tensioning Phase Monitoring

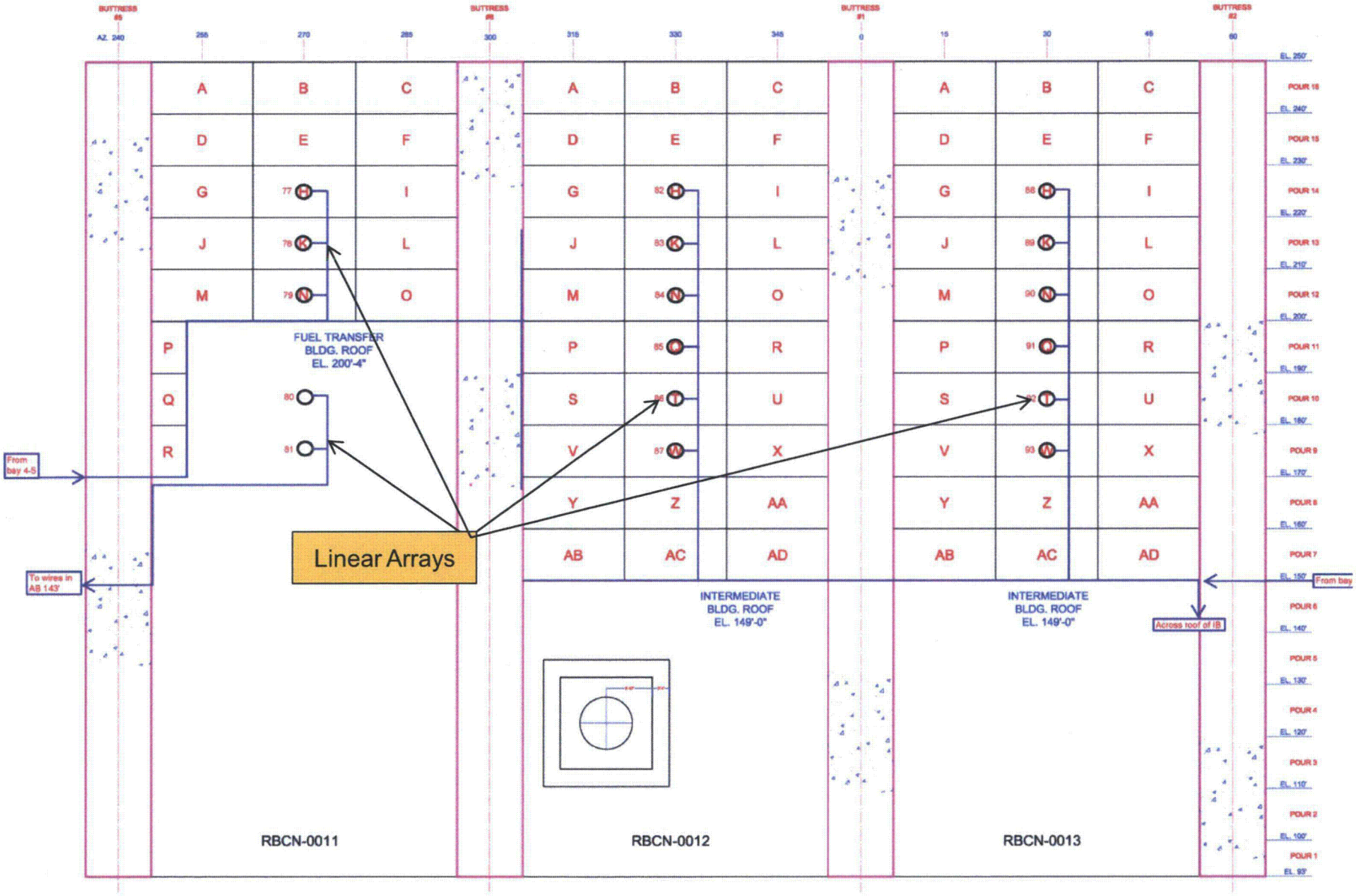
- Acoustic Emissions
  - Vendor - MISTRAS (24-hour coverage)
  - NDT method to detect transient elastic stress waves (i.e. cracking)
  - Two - 10 ft x 60 ft 2D arrays (panel 2-3 and 4-5)
  - 27 additional sensors on other panels (linear arrays)
  - 4 sensors on the dome
  - One 2D array provided in location of first tendon to be de-tensioned
  - Second location near first tendon next to an SGR de-tensioned tendon and at critical stress location of panel 2-3

- Monitoring Criteria Basis
  - CR3 concrete cores tested to optimize the detection algorithms
  - Testing provided wave velocities, and acoustic signatures from micro cracking and crack propagation to establish baseline criteria
  - System will filter out background noise and panel 3-4 noise using guard sensors.
  - Criteria includes; energy magnitude, duration, amplitude and others

De-tensioning Phase Monitoring Sensor Layout

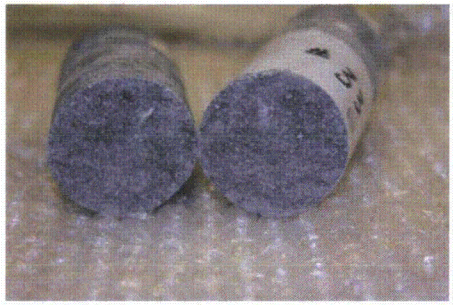


De-tensioning Phase Monitoring
Sensor Layout (continued)



De-tensioning Phase Monitoring

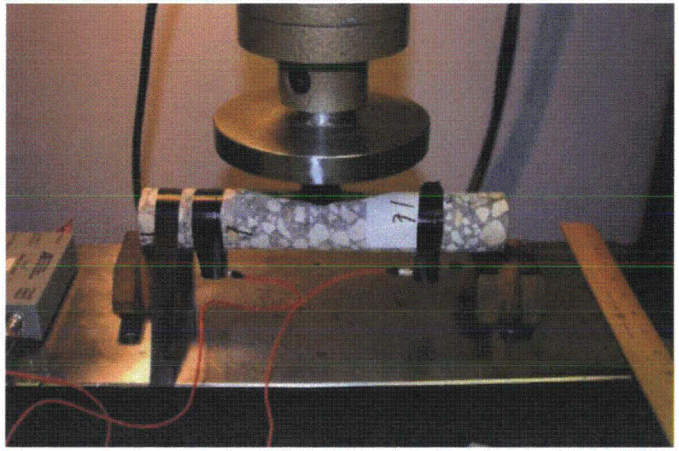
Core sample with low aggregate (Wall)



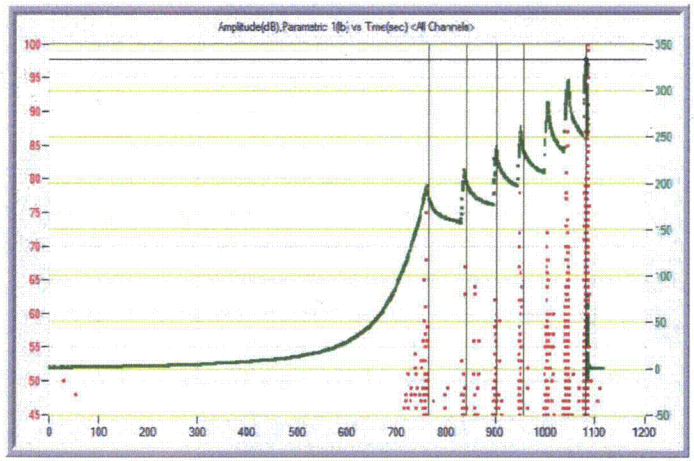
Core sample with normal aggregate (Wall)

Core sample with normal aggregate (Dome)

AE Testing of concrete core



Plot of Amplitude, Load vs. Time



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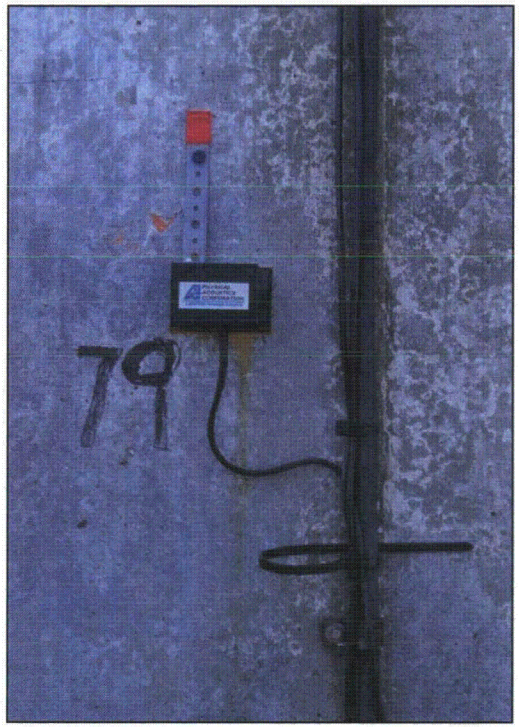
De-tension Phase Monitoring



Acoustic Monitoring Sensor

Panel 2-3 10 ft x 60 ft 2D Array

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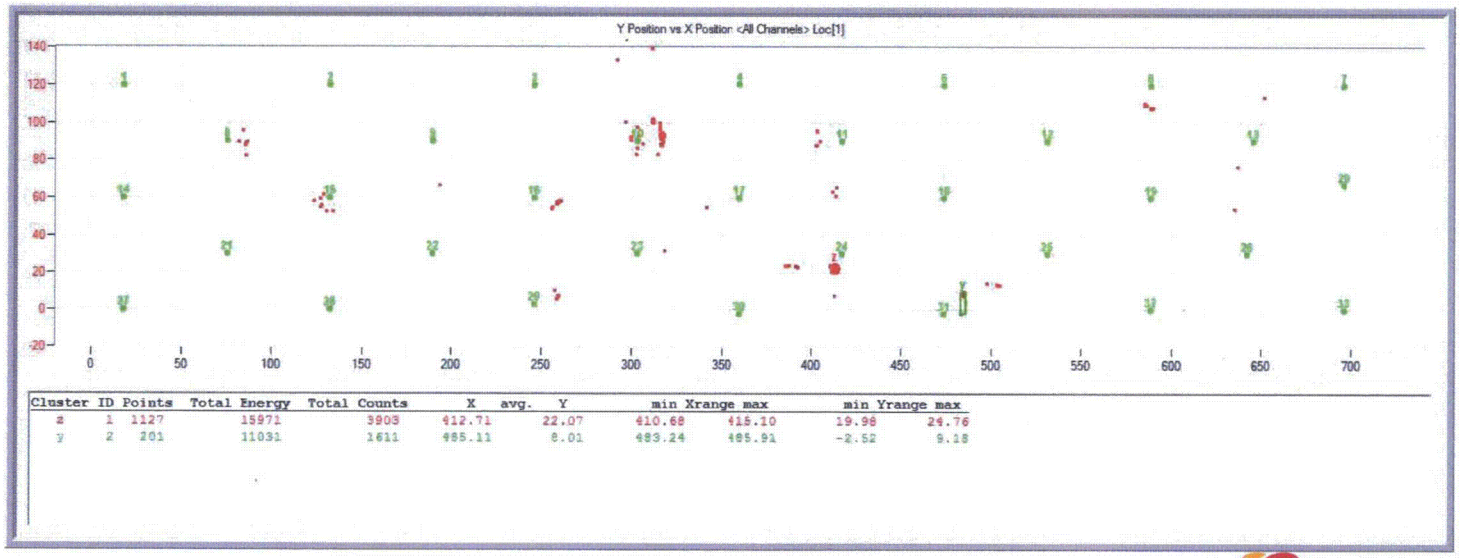
De-tensioning Phase Monitoring

Acoustic Monitoring
Data Acquisition System
2D Array Data Example



Cluster ID	Points	Total Energy	Total Counts	X avg.	Y	min Xrange	max	min Yrange	max
z 1	1127	15971	3903	412.71	22.07	410.68	415.10	19.98	24.76
y 2	201	11031	1611	485.11	8.01	483.24	485.91	-2.52	9.18

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De-tensioning Phase Monitoring

- Reactor Building Concrete Temperature Monitoring
  - Analysis requires control of concrete wall temperature gradient
  - 2 monitoring locations exterior (4" within concrete core)
  - 2 monitoring interior instrument channels
  - CRT Operations Lead will monitor using OSI/PI
  - Daily reporting of avg ΔT, and provide target value to OPS for containment wall temperature control
  - Ops controls containment wall using: RB cooling (SW or CI) and purge fans

- Criteria established in Engineering Change
  - $\leq$ 10 degree avg. between inside CV and outside
  - Based on 7-day rolling average

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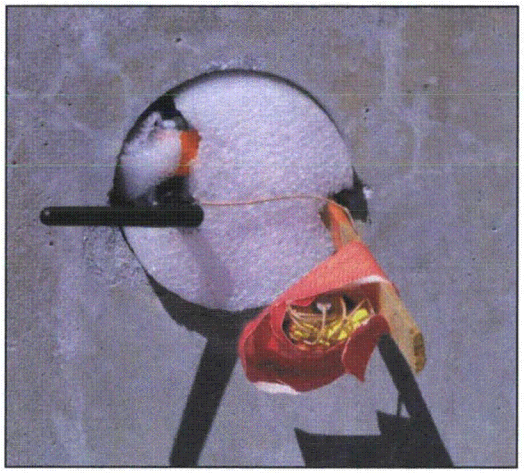
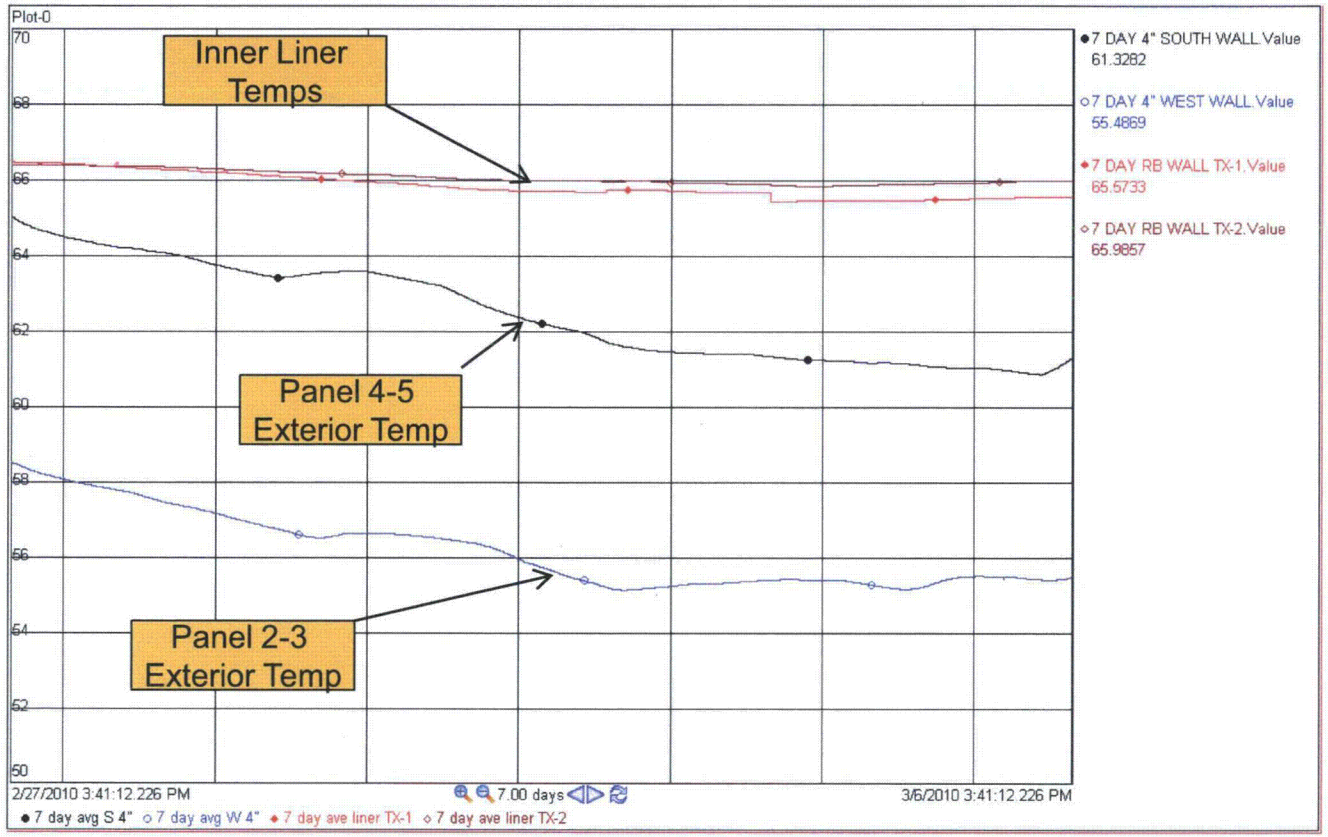
De-tensioning Phase Monitoring



Exterior Wireless Transmitter



OSU/PI 7 day rolling average trend

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De-tensioning Phase Monitoring

- Impulse Response (IR) testing and core boroscopic inspections
  - Contingency IR testing based on monitoring results
  - Post de-tensioning IR testing in 5 panels and dome required
  - All panels and dome except the delaminated panel
  - Boroscopic inspections of existing cores except within the delaminated panel and cores with strain gages and temperature monitoring devices

Engineering Logistics

- Engineering Staffing
  - 24 hr PGN and SGT integrated engineering team coverage
  - PGN Responsible Supervisors (Ortalan, Marckese)
  - Minimum of 2 PGN Responsible Engineers (RE) each shift
  - Dedicated PGN engineer coverage at monitoring station
  - Field Revisions completed by PGN RE's
  - Field Revisions approved by PGN Supervisors
  - Work package revisions reviewed by PGN engineering

- Engineering Change Package
  - EC 75218 Revision incorporates option 10F
  - EC Revision ready for Responsible Supervisor and PGM approval
  - SGT Work Package revision with Responsible Engineer review

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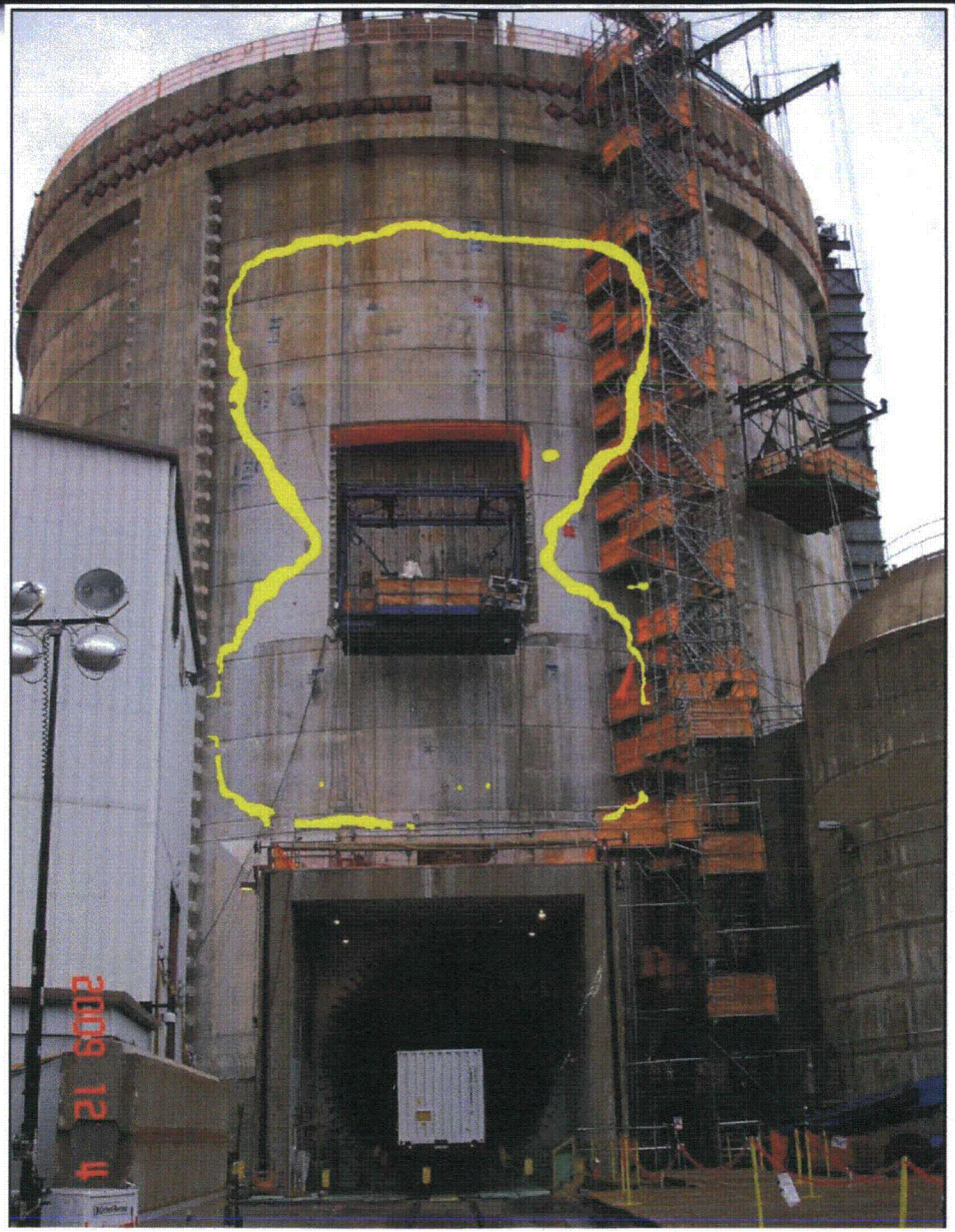
Summary & Questions

Questions