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Nuclear

Steam Dryer Loading Analysis Technical Review

January 25 - 26, 2005

Agenda

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- Tuesday, January 25, 2005
  - Introduction
  - Purpose
  - Scale Model Testing (SMT)
  - Acoustic Circuit Analysis
  - Finite Element Analyses (FEA)
  - Dresden Unit 3 Strain Gauges
- Wednesday, January 26, 2005
  - Steam Dryer Instrumentation Installation
  - Quad Cities 10 CFR 50.59 Evaluation

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Introduction

Patrick Simpson
Licensing Manager

Dryer Design Strategy

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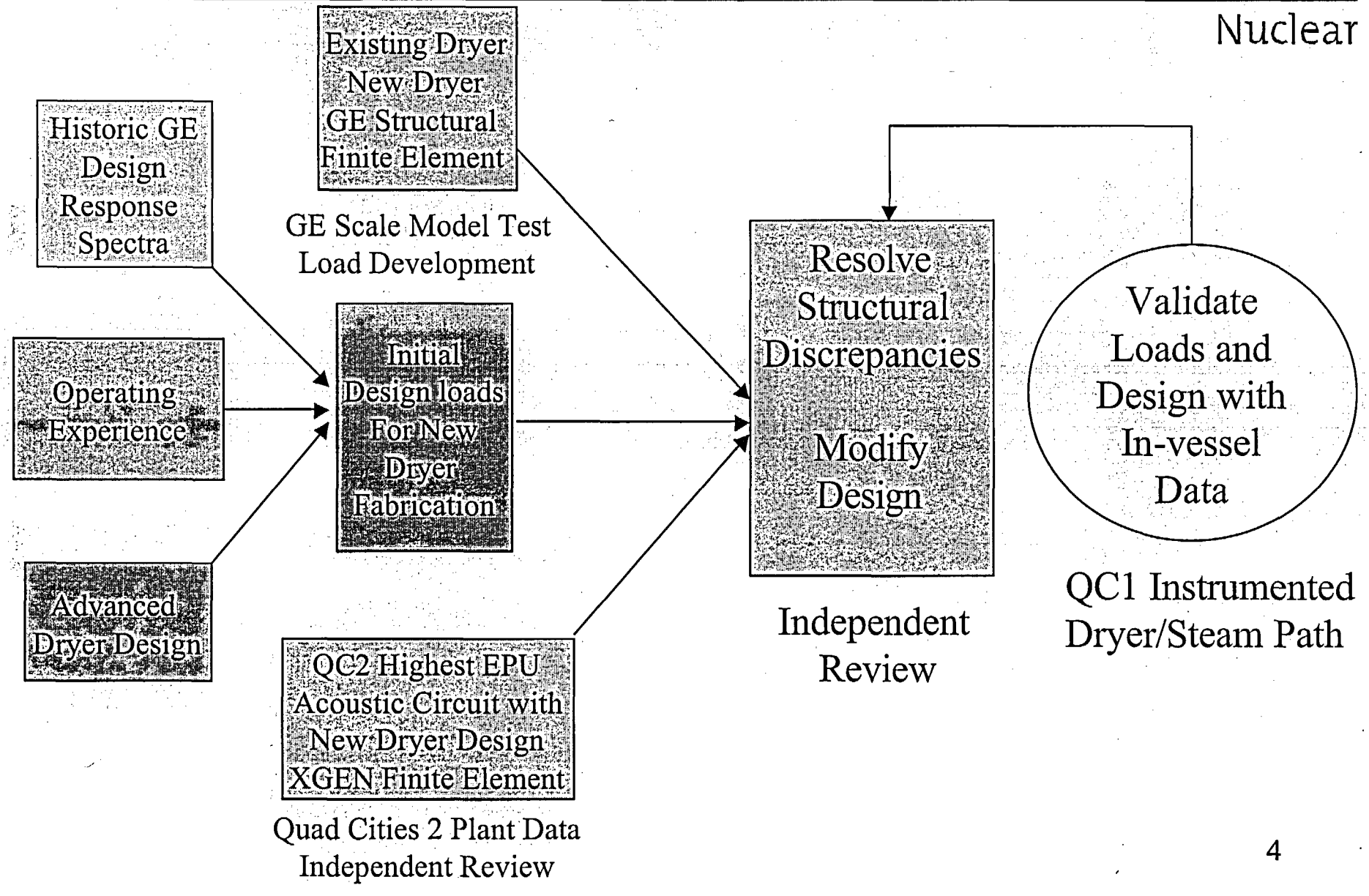

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QC1 Scale Model Test: Steam Dryer Load Definition

Daniel Sommerville
General Electric Nuclear Energy

QC1 Scale Model Test

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Due to the proprietary nature of this information, it was not provided as content in this presentation

GE Proprietary

Exelon Nuclear

Acoustic Circuit Analysis

Dr. Alan Bilanin
Continuum Dynamics, Incorporated

Acoustic Circuit Analysis

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Due to the proprietary nature of this information, it was not provided as content in this presentation

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Finite Element Model Stress Analyses

Guy DeBoo

Asset Management Engineer

FEA Stress Analyses Presented

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- General Electric (GE) SMT load validation analyses
  - Original dryer and 2003 repair with short gussets models
  - Pre-extended power uprate (EPU) and EPU flow rates from Quad Cities Unit 1 (QC1) SMT
- 2004 dryer repair FEA results
  - QC1 SMT with original dryer EPU loads
  - QC2 acoustic circuit with original dryer EPU loads
  - Dresden Unit 2 (D2) acoustic circuit with original dryer EPU loads
- Replacement dryer models
- Replacement dryer loads
  - QC1 SMT with replacement dryer EPU loads
  - QC2 acoustic circuit with replacement dryer EPU loads
- Planned replacement dryer analyses

GE SMT

Load Validation Analyses GE Proprietary{3}

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GE Proprietary – Preliminary

GE SMT

Load Validation Analyses (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

GE SMT

Load Validation Analyses (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

GE SMT

Load Validation Analyses (cont.) GE Proprietary{3}

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Load Validation Analyses (cont.) GE Proprietary{3}

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Load Validation Analyses (cont.) GE Proprietary{3}

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Load Validation Analyses (cont.) GE Proprietary{3}

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Load Validation Analyses (cont.) GE Proprietary{3}

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GE SMT

Load Validation Analyses (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

GE SMT

Load Validation Analyses (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

GE SMT

Load Validation Analyses (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

GE SMT
Load Validation Analyses (cont.)

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- Original dryer cover plate close to failure when subjected to SMT pre-EPU loads
- Original dryer is overstressed at locations that failed when subjected to SMT EPU loads
  - Cover plate stress at 49059 psi
  - Outer hood at internal 5"x7" bracket stress of 37120 psi
- QC2 2003 dryer repair is overstressed at failed locations when subjected to SMT EPU loads
  - Cover plate stress at 38450 psi
  - Outer hood at gusset tip stress of 29802 psi
- SMT loads predict prior dryer operating experience and provide a reasonable basis for dryer qualification

2004 Dryer Repair

FEA Results GE Proprietary{3}

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GE Proprietary – Preliminary

2004 Dryer Repair

FEA Results (cont.)

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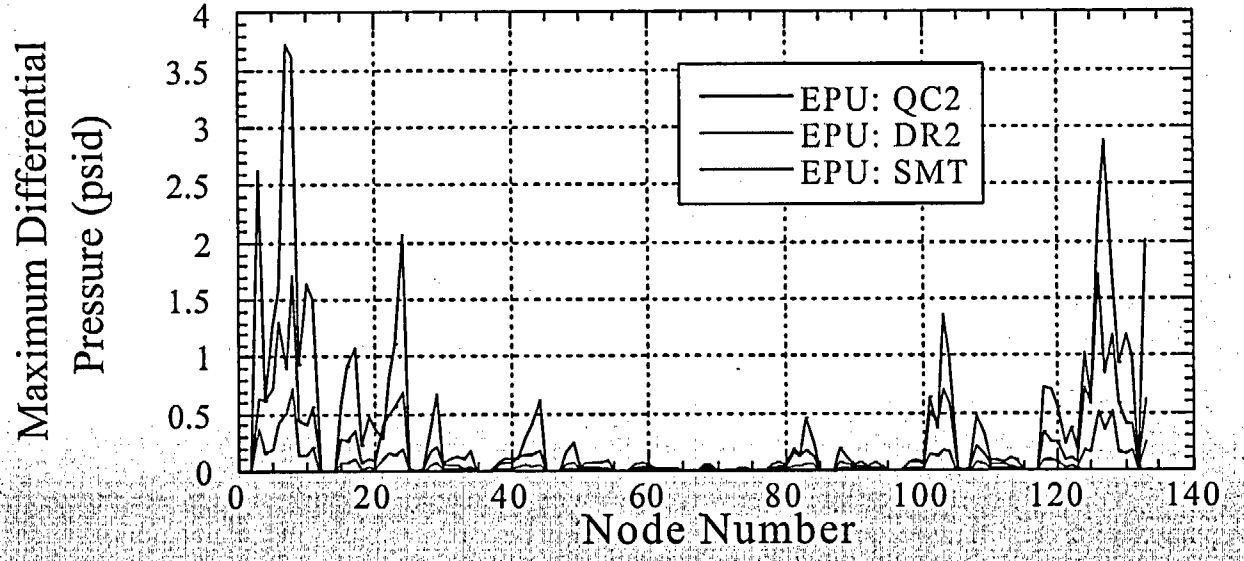

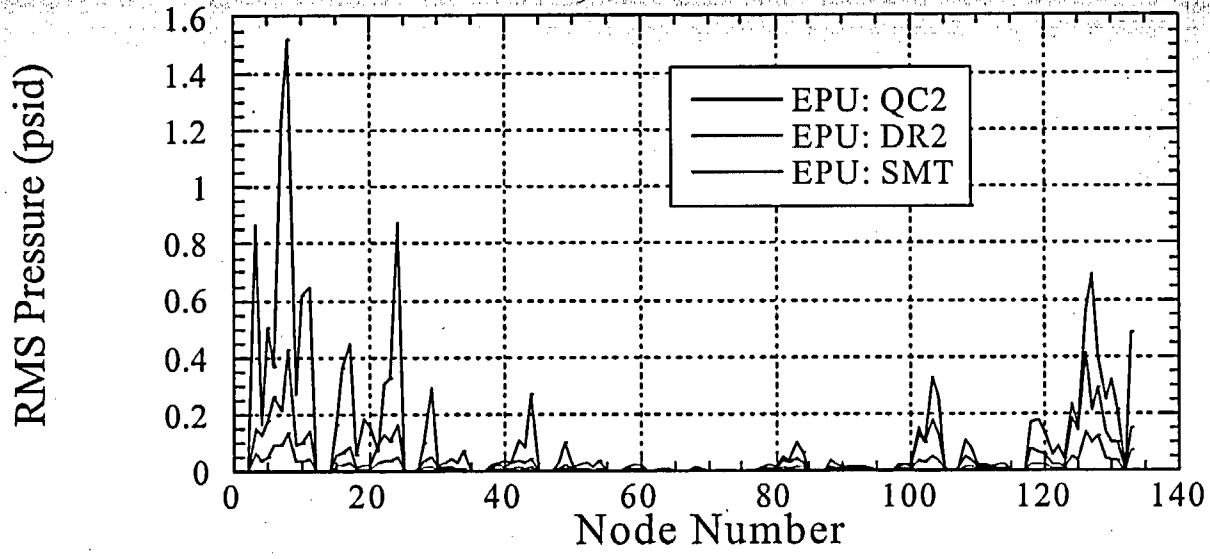

EPU load comparison

2004 Dryer Repair

FEA Results (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

2004 Dryer Repair

FEA Results (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

2004 Dryer Repair

FEA Results (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

2004 Dryer Repair

FEA Results (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

2004 Dryer Repair

FEA Results (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

2004 Dryer Repair

FEA Results (cont.) GE Proprietary{3}

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2004 Dryer Repair

FEA Results (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

2004 Dryer Repair

FEA Results (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

2004 Dryer Repair

FEA Results (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

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2004 Dryer Repair

FEA Results (cont.) GE Proprietary{3}

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2004 Dryer Repair

FEA Results (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

2004 Dryer Repair

FEA Results (cont.) GE Proprietary{3}

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GE Proprietary – Preliminary

2004 Dryer Repair
FEA Results (cont.)

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- SMT load definition produces the largest stress intensities and peak stresses
- Maximum stress intensities and peak stresses for all load cases are below the material fatigue endurance design limit, 13.6 ksi
- D2 acoustic circuit loads from in-plant measured data produces the lowest stress intensities and peak stress values (e.g., 5350 psi vs. 10564 psi)
- 2004 dryer repair is qualified for EPU power levels

Replacement Dryer Models GE Proprietary{3}

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GE Proprietary – Preliminary

Replacement Dryer Models (cont.)

GE Proprietary{3}

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GE Model

GE Proprietary – Preliminary

Replacement Dryer Models (cont.)

GE Proprietary{3}

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GE Model

GE Proprietary – Preliminary

Replacement Dryer Models (cont.)

GE Proprietary{3}

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GE Model

GE Proprietary – Preliminary

Replacement Dryer Models (cont.)

GE Proprietary{3}

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GE Proprietary – Preliminary

Replacement Dryer Models (cont.)

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Replacement Dryer Models (cont.)

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GE Proprietary – Preliminary

Replacement Dryer Models (cont.)

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GE Proprietary – Preliminary

Replacement Dryer Models (cont.)

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Replacement Dryer Models (cont.)

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GE Proprietary – Preliminary

Replacement Dryer Models (cont.)

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GE Model

GE Proprietary – Preliminary

Replacement Dryer Models (cont.)

GE Proprietary{3}

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GE Proprietary – Preliminary

Replacement Dryer Models (cont.)

GE Proprietary{3}

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GE Model

GE Proprietary – Preliminary

Replacement Dryer Models (cont.)

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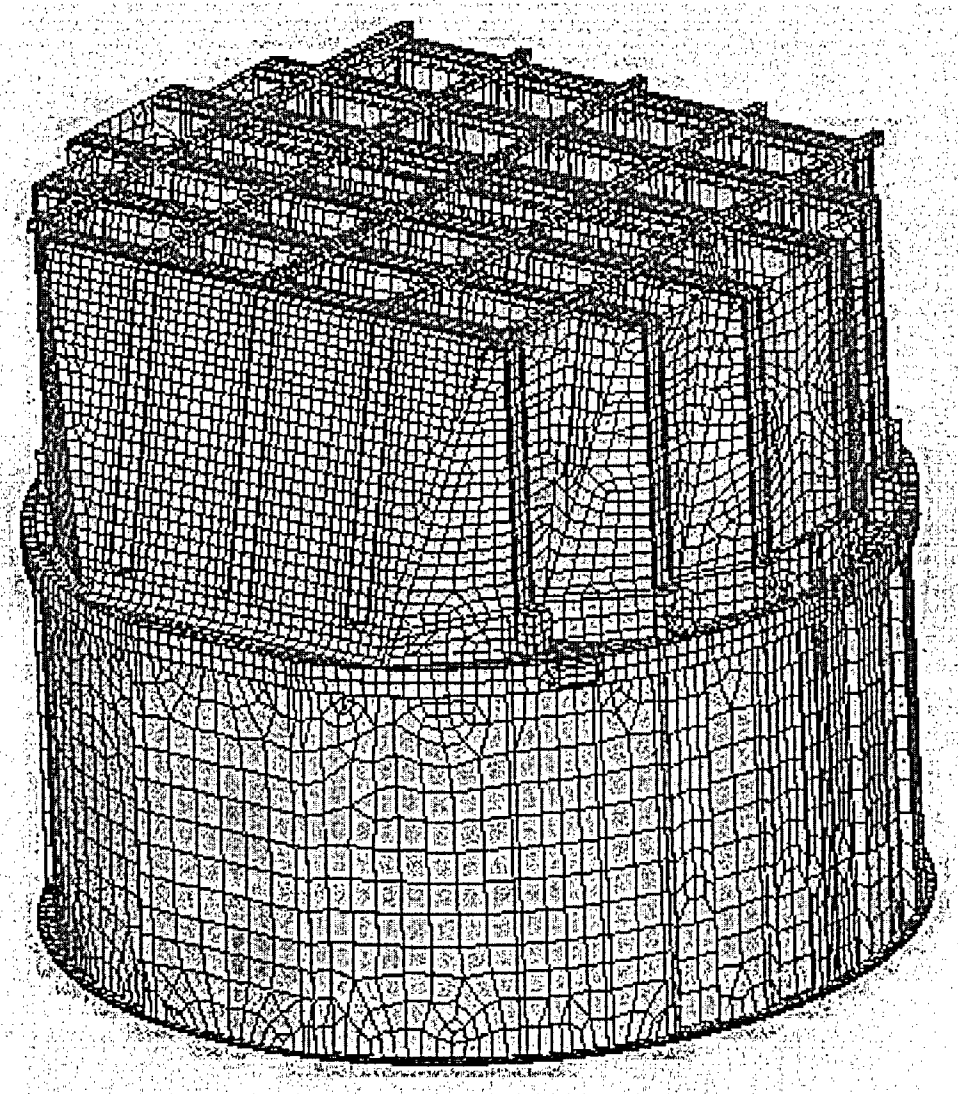

XGEN Model

Replacement Dryer Models (cont.)

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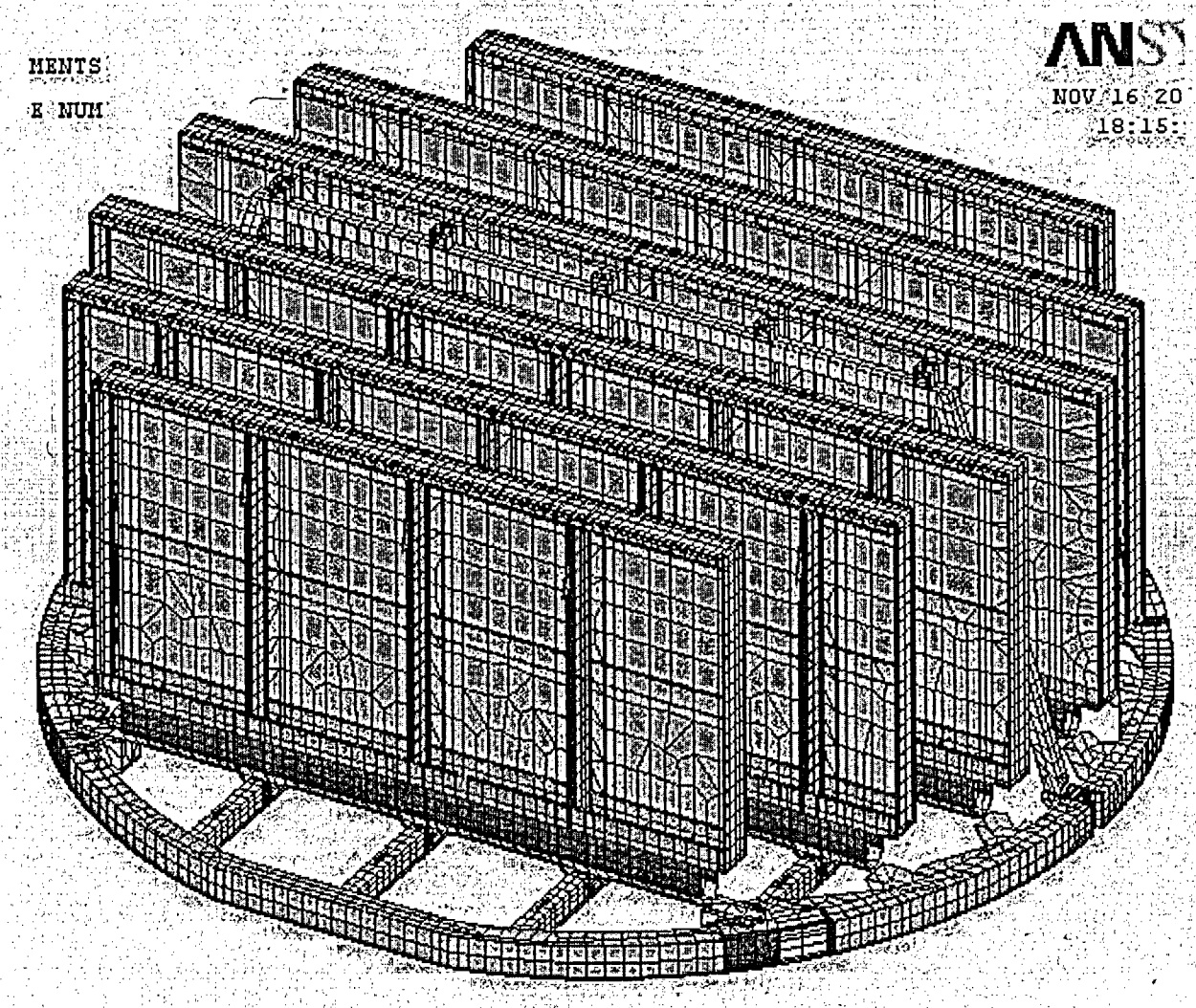

XGEN Model

Replacement Dryer Models (cont.)

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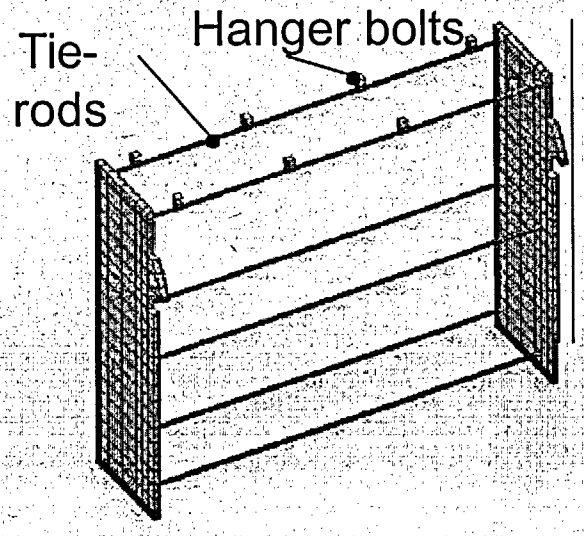

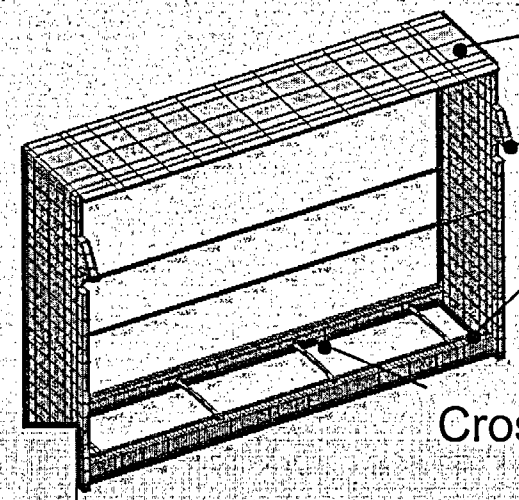

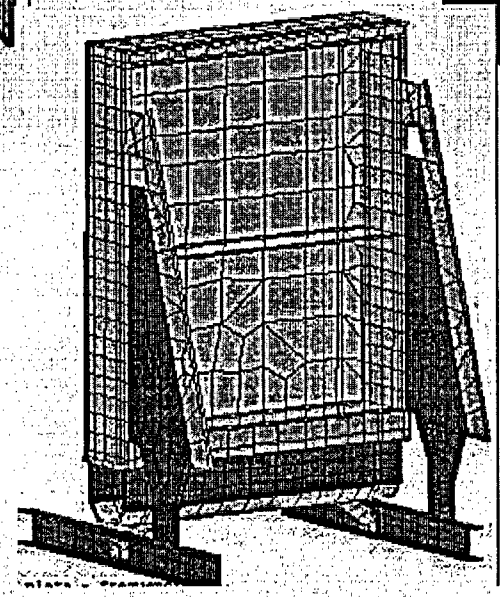

XGEN Model

Replacement Dryer Models (cont.)

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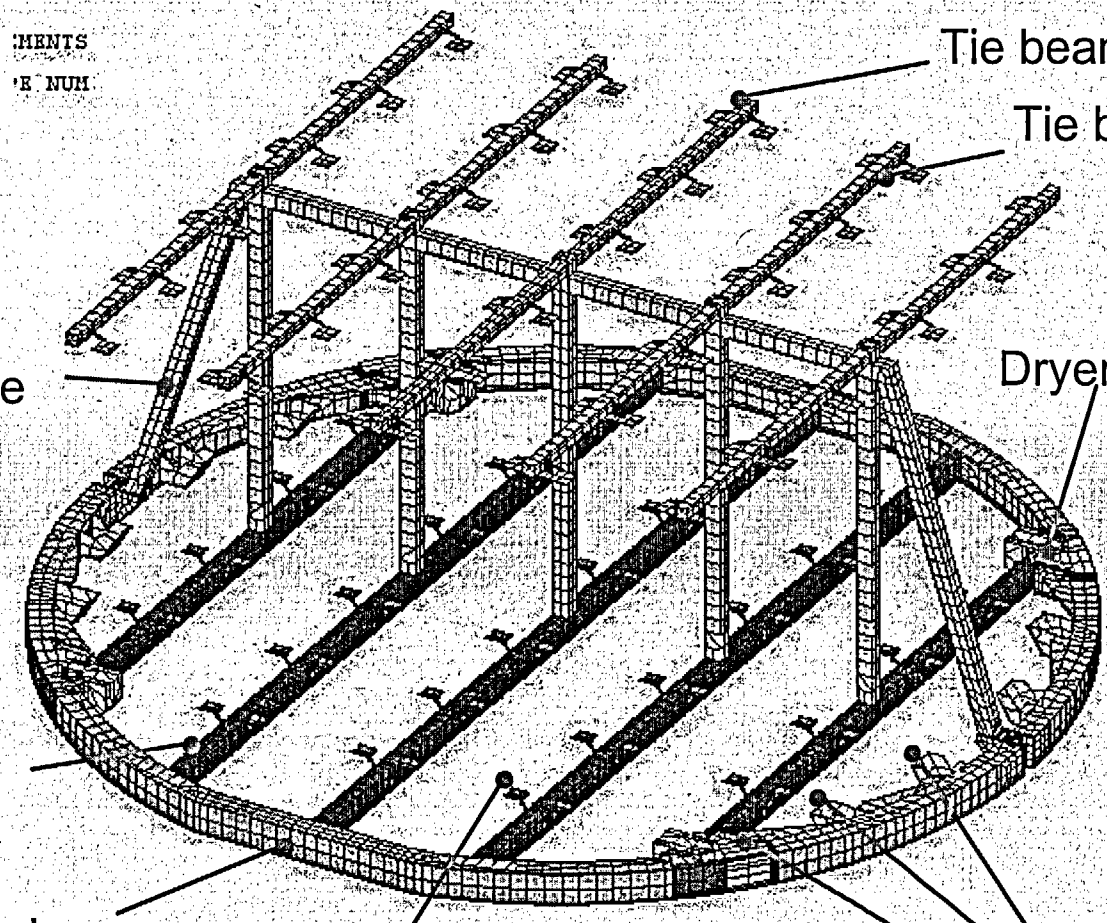

XGEN Model

Replacement Dryer Models (cont.)

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Differences between GE and XGEN models:

- Vane Banks
  - Super-elements in GE model
  - Beam elements represent tie rods and hanger bolts in the XGEN model
- Perforated plates
  - Not in GE model
  - Shell elements in XGEN model with modified modulus to account for holes in the plate
- Submerged portion of skirt
  - Super-elements in GE model - included water elements
  - Shell elements without water or hydrodynamic mass in XGEN model
- Tie bars/beams
  - Attached directly to top plates in GE model – shell elements
  - Tie beam supports modeled in XGEN model – beam and shell elements
- Trough mid-supports
  - Attached with shell element gussets in GE model
  - Supports modeled in XGEN model – beam and shell elements
- Refined load mesh models
  - GE applies refined load mesh to full model
  - XGEN applies refined mesh to partial outer hood model and skirt model

Replacement Dryer

Dryer Design Loads GE Proprietary{3}

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GE Proprietary – Preliminary

Planned Replacement Dryer Analyses

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- Additional analyses with +/- 10% shift in time history time increment to study effect of model frequency shifts
- Local 3D solid element models of trough support blocks, trough mid-support attachments, tie bar supports, etc.
- Stress calculations of local connections to determine peak stresses
- Analysis of design basis loads and stress analyses per design specification loads and acceptance criteria

Summary

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- Design loads
  - SMT loads was shown to be adequate for replacement dryer design based on original and repaired dryer structural performance
  - QC2 plant load applied to the new dryer is a conservative load definition for design purposes based on the expected load changes predicted by SMT
- Stress analyses being performed by multiple, shell and 3D solid, finite element models to determine peak stress concentrations for fatigue analyses

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Dresden Unit 3 Strain Gauges

Joe Sipek
Engineering Programs Manager
Dresden Nuclear Power Station

Exelon Nuclear

Steam Dryer Instrumentation Installation

Reg Wainwright
General Electric Nuclear Engineering

New Dryer Instrumentation

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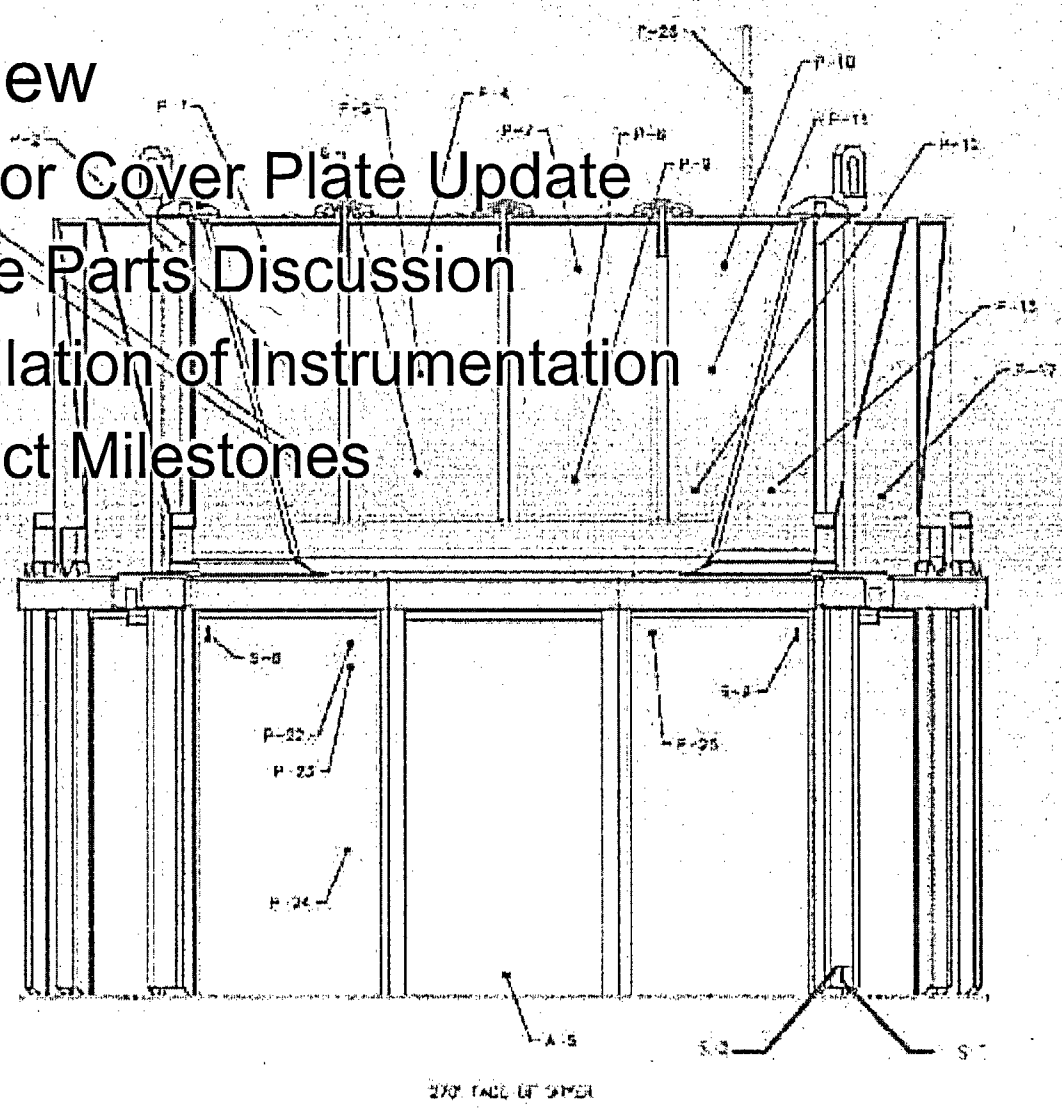
- Overview
  - Sensor Cover Plate Update
  - Loose Parts Discussion
  - Installation of Instrumentation
  - Project Milestones



New Dryer Instrumentation (cont.)

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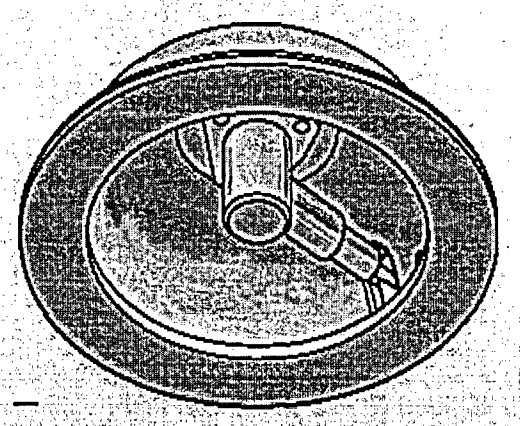
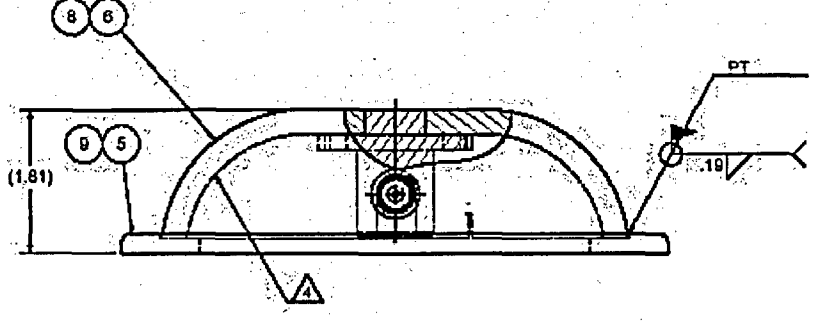
- Sensor Cover Plate Update
  - 1D CFD results recommended the multi-sensor cover plate design to be replaced with the single sensor cover design Results show ± 6-7 % frequency shift for the multi-sensor cover versus ± 3-3.4 % for the single covers
  - Reduced the diameter of the single-sensor cover plate from 7.25" to 6.5"
  - Additional analysis being performed using 3D CFD analysis and wind tunnel testing to refine the 1D correction factor results

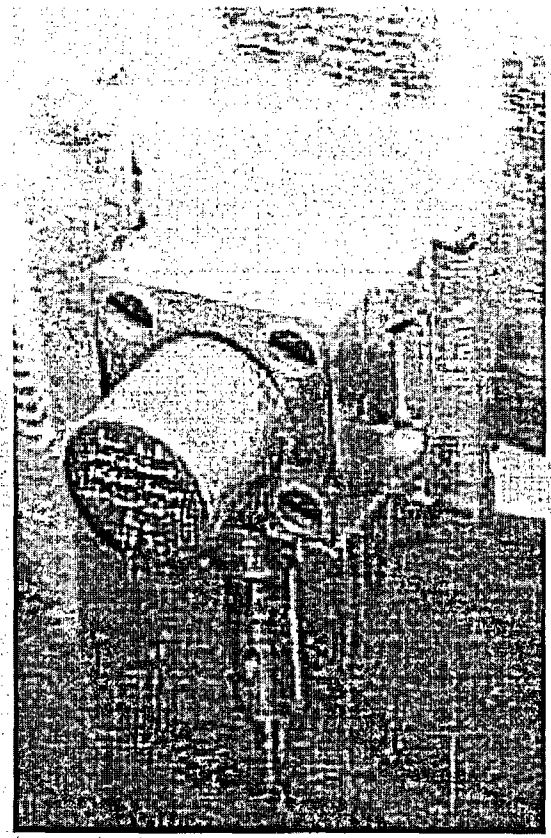




New Dryer Instrumentation (cont.)

Exelon Nuclear

- Loose Parts Discussion
  - All sensors, mounting pads, cover plates, conduit clamps and cable clips will be welded in place
  - Conduit clamps spaced every 7" and cable clips spaced as necessary to ensure secure attachment
  - Mast will be bolted to brackets which are welded to the dryer surface
  - No reports of lost dryer instrumentation components after installation and single cycle operation in the past

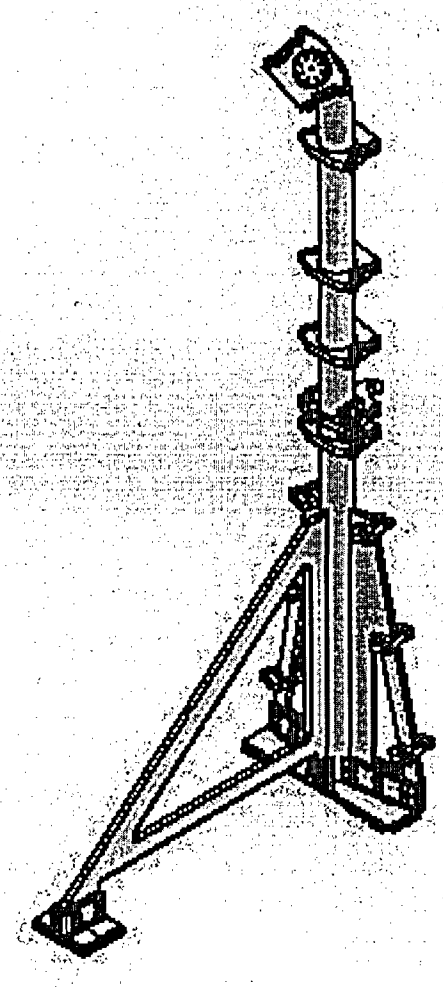


Installed Accelerometer

New Dryer Instrumentation (cont.)

Exelon Nuclear

- Loose Parts Discussion (cont.)
  - Instrumentation component design and installation techniques prevent loose parts from being generated
  - A generic loose parts analysis was performed for Boiling Water Reactor Vessel Internals Project (BWR VIP) 06



New Dryer Instrumentation (cont.)

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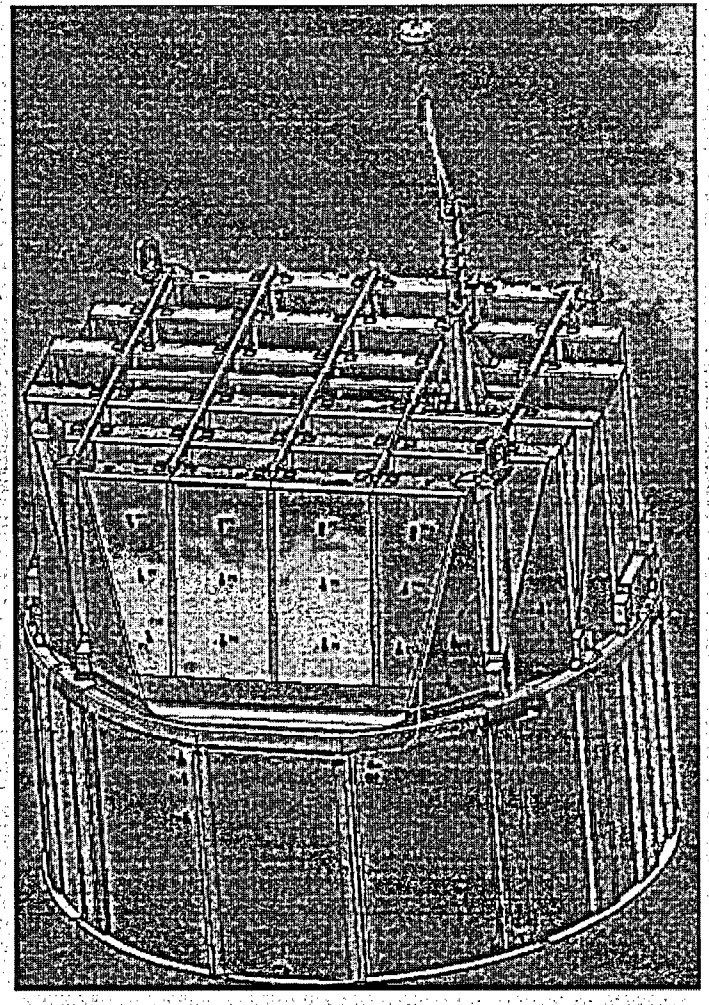
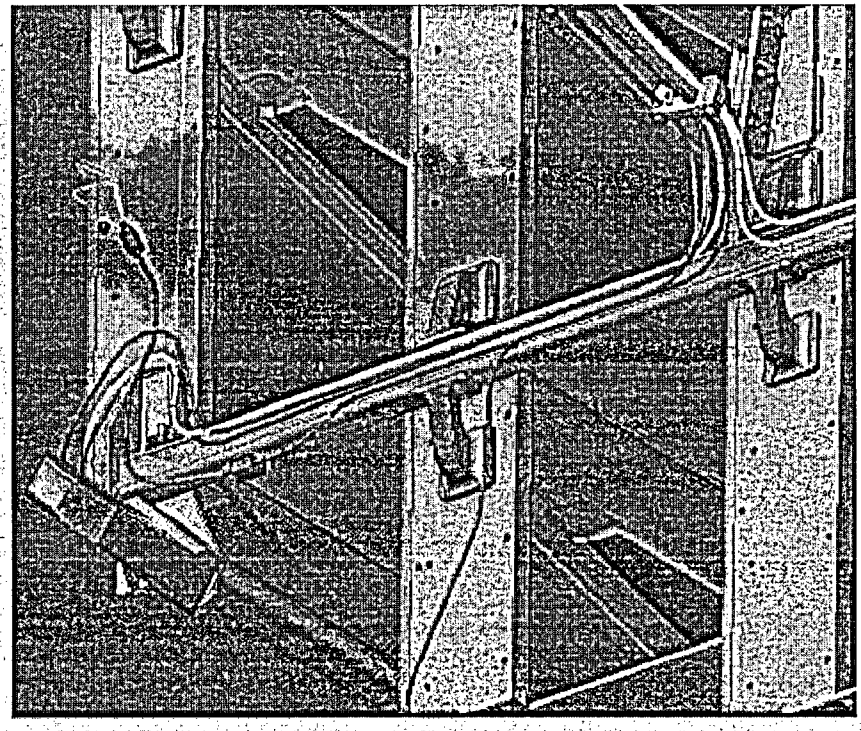
- Instrumentation Installation
  - Routing of instrument strings performed using 3D modeling layouts
  - Instrument mast to be temporarily installed at US Tool & Die (UST&D) for proper string routing, and removed for shipment Final mast installation to be performed at Quad Cities



New Dryer Instrumentation (cont.)

Exelon Nuclear

- Instrumentation Installation (cont.)
  - Total of 84 sensors to be mounted on the new dryer and on the main steam lines.
    - 6 Accelerometers welded to pads on the dryer
    - 27 Pressure sensors welded to pads on the dryer, 25 housed in the cover plates
    - 9 Strain gauges spot welded directly to the dryer
    - 42 Strain gauges spot welded to the main steam lines



New Dryer Instrumentation (cont.)

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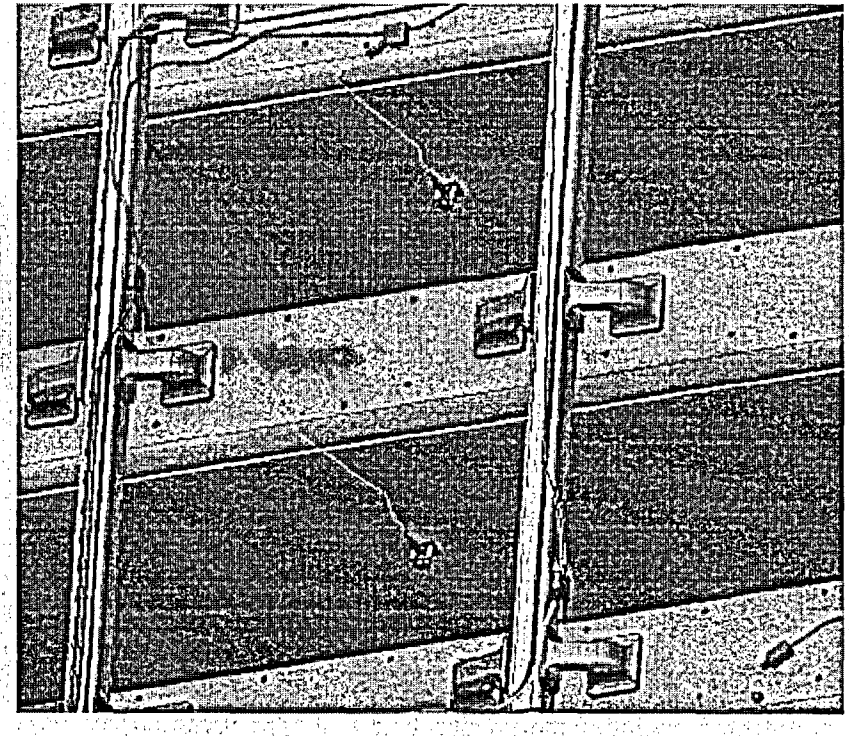
- Installation of Strings
  - Sensor installation to take place at UST&D
  - Sensor functional testing to be performed upon receipt of string shipment, and also after dryer fabrication and string installation is complete



New Dryer Instrumentation (cont.)

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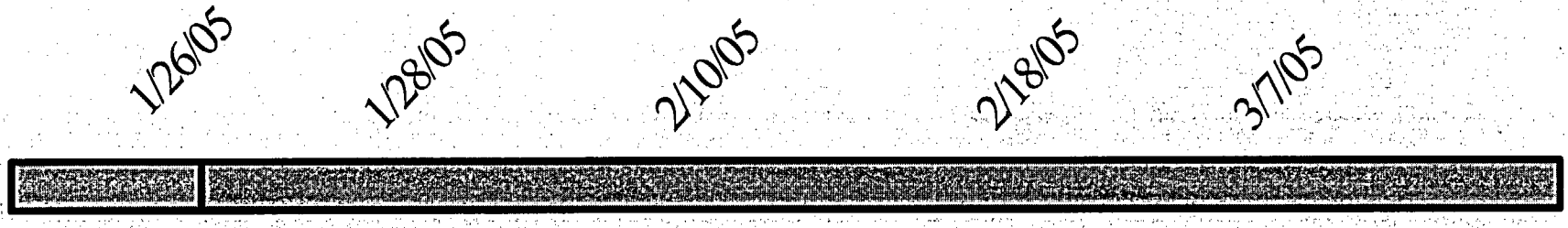
- Project Milestones

– Final functional testing	01/26
– Shipment of strings	01/28
– Installation window begins (UST&D)	02/10
– Hammer testing begins	02/18
– Uncertainty analysis finalized	03/07
– Allowable limits/criteria finalized	03/07



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Quad Cities 10 CFR 50.59 Evaluation

Doug Collins
Senior Engineer
Quad Cities Nuclear Power Station

Topics

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- 50.59 Evaluation Summary
- Enclosure Design
- Enclosure Segment Assembly
- Leakage Testing
- Dryer Enclosure Schedule
- Conclusions

50.59 Evaluation Summary

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- An alternative secondary containment boundary, meeting the applicable design/licensing requirements, will be in place prior to removing the reactor building (RB) siding
- Secondary containment will be protected to the extent required to prevent any adverse impacts on the plant
- There is no increase in the frequency of any accidents or transients as previously evaluated in the UFSAR
- There is no increase in consequences (dose), as the alternate secondary containment boundary will be in place while the RB siding is removed

50.59 Evaluation Summary (cont.)

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- During test hole cutting, contingent methods will be in place to immediately restore secondary containment within the required Technical Specifications (TS) time period, if required
  - Contingency measures are designed to be installed immediately within the 4-hour limiting condition for operation window allowed by the TS
- The activity does not exceed or alter the design basis pressure limit as described in the UFSAR, and there is no change to any evaluation methodology as described in the UFSAR

Enclosure Design

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- Design
  - The outer door and enclosure to be designed for tornado maximum wind speed (will eliminate need to assess the impact of additional missiles)
  - Design will meet seismic conditions
- Outer door
  - Will consist of steel frame with sheet metal on both sides, insulated between (door will be hinged to the reactor building superstructure steel columns)
- Enclosure
  - Will consist of steel frame with sheet metal welded on one side (enclosure will not be insulated due to the short timeframe it will be in use)

Enclosure Design (cont.)

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- Enclosure airlock
  - Will be installed to allow access to the inside of the enclosure (each door will have a light to provide a visual aide to indicate when the other door is open)
- Utilities
  - Some limited utilities for power and lights will be provided
  - Test connections to be provided on the door and enclosure (support leakage testing)

Enclosure Segment Assembly

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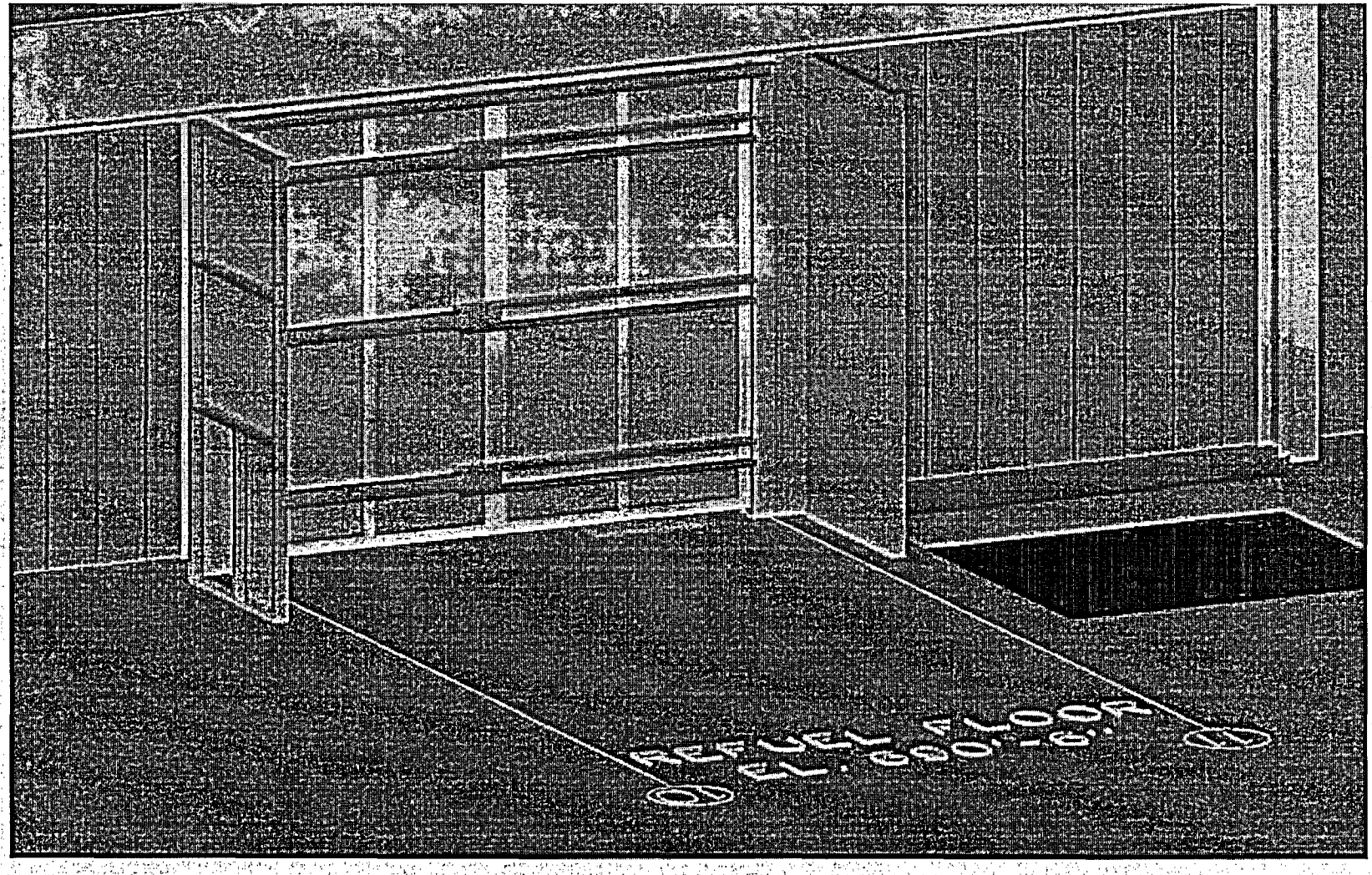

10%

Enclosure Segment Assembly (cont.)

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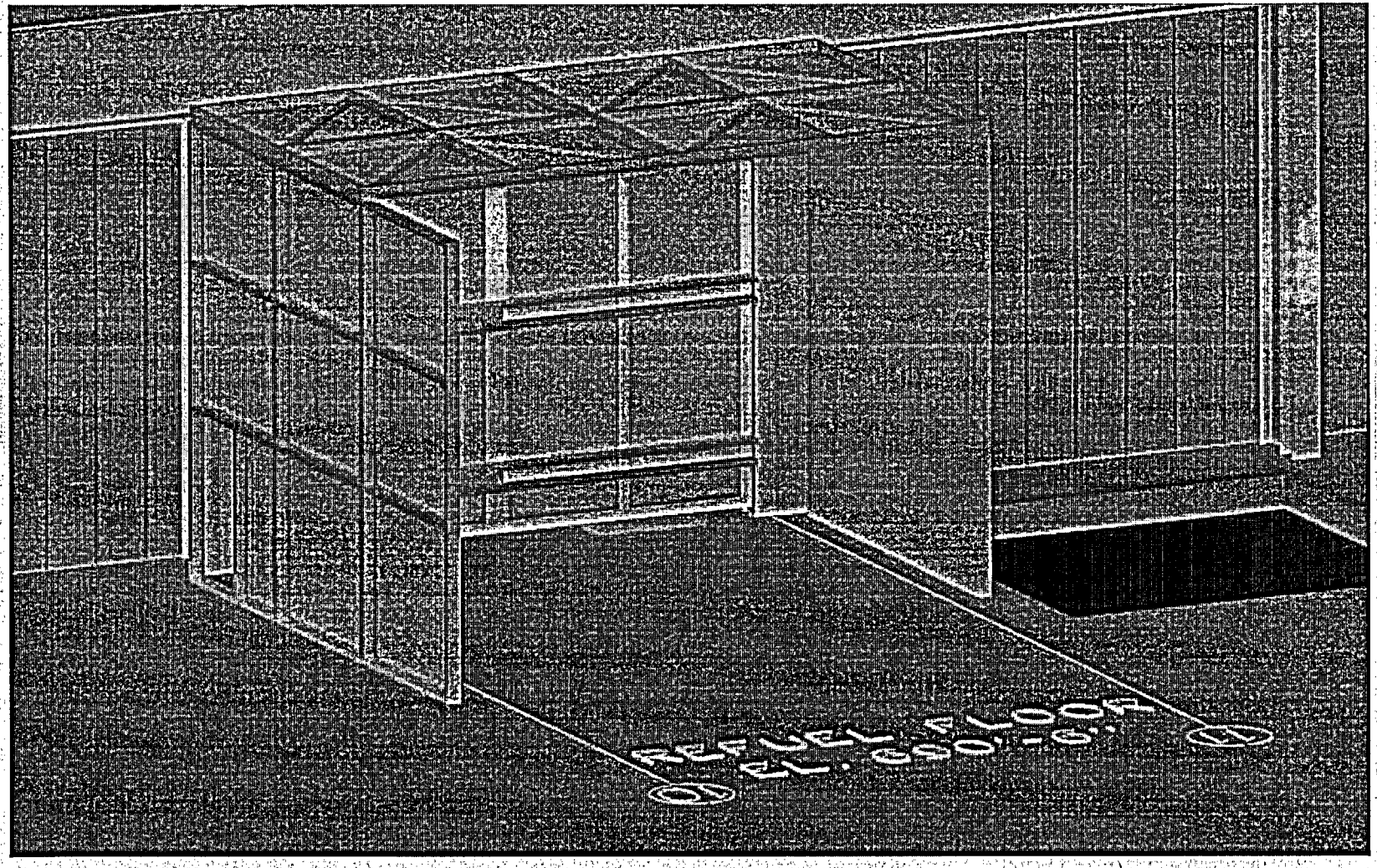

40%

Enclosure Segment Assembly (cont.)

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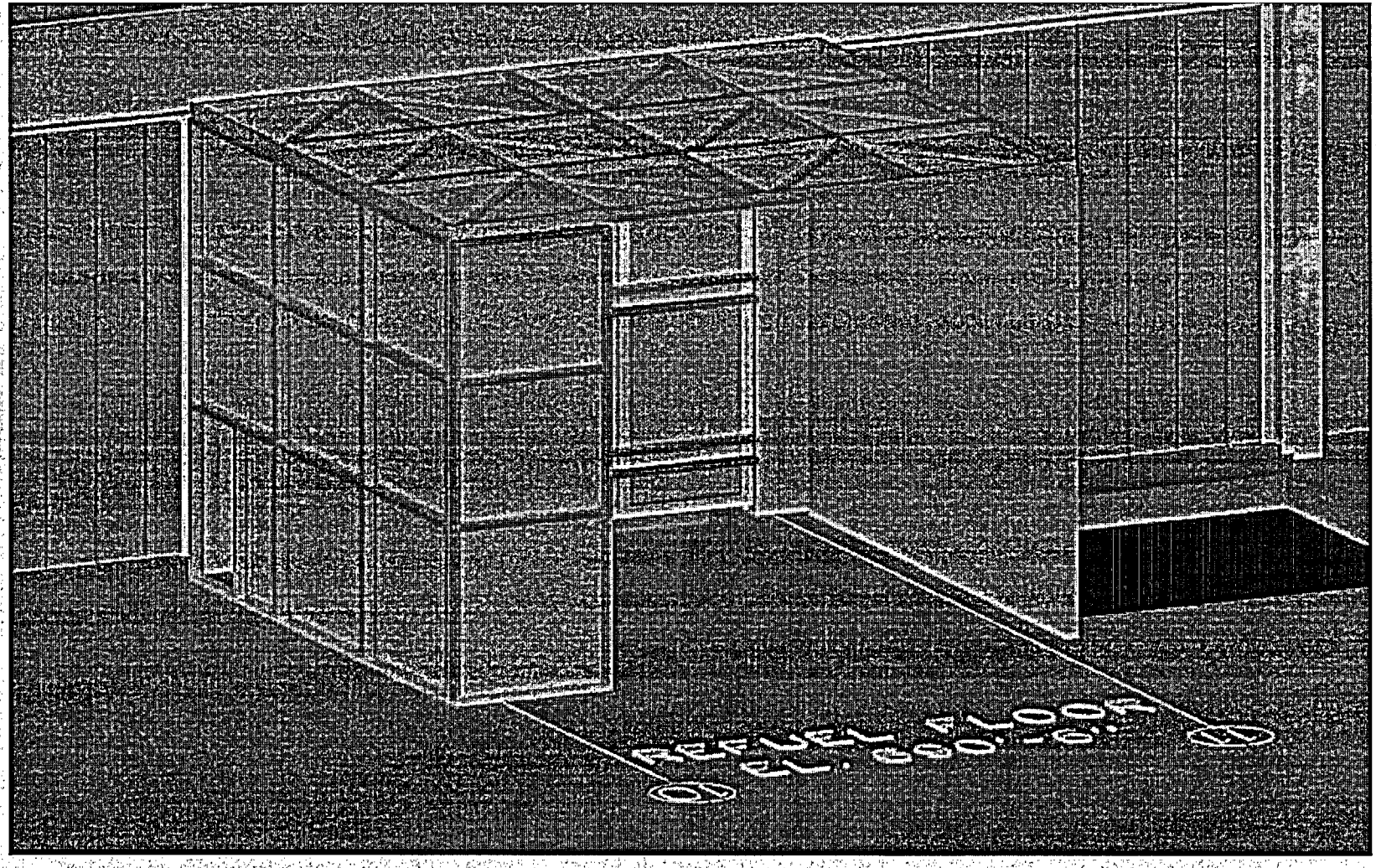

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Enclosure Segment Assembly (cont.)

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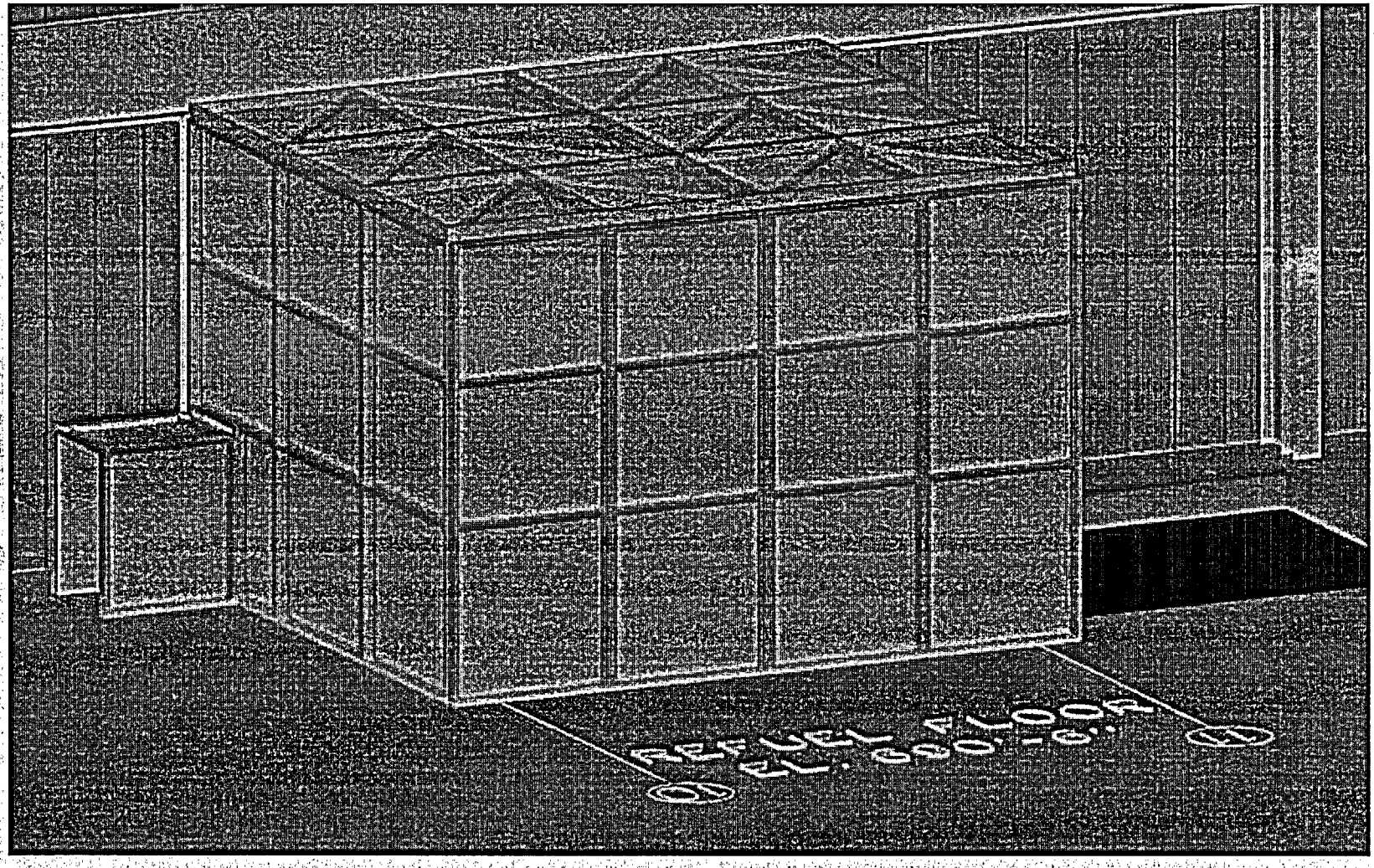

Completed enclosure assembly

Leakage Testing

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- Outer Door Installation
  - Install outer door and siding attachments prior to siding removal and enclosure installation
  - Test outer door-to-siding (pressurize air space between outer door and siding, snoop/smoke test for leaks – test is for information only)
  - Perform baseline secondary containment test of reactor building with door ajar
  - Test outer door-to-siding (cut 4" hole in exterior siding and perform secondary containment test – contingency package to patch hole if test fails)

Leakage Testing (cont.)

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- Enclosure Installation for Unit 1 dryer
  - Install enclosure on refuel floor
  - Test enclosure-to-outer door (pressurize air space between enclosure and new outer door, snoop/smoke test for leaks – test is for information only)
  - Test enclosure (open outer door, perform secondary containment test)
- Enclosure Removal
  - Close outer door
  - Smoke test outer doors, remove enclosure upon completion
- Enclosure Installation for Unit 2 dryer
  - Install enclosure on refuel floor
  - Test enclosure-to-outer door (same as for Unit 1 dryer)
  - Test enclosure (same as for Unit 1 dryer)

Leakage Testing (cont.)

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- Enclosure Removal
  - Close outer door
  - Smoke test outer doors, remove enclosure upon completion (same as for Unit 1)
- Outer Door Removal
  - Install girt beams and inner siding
  - Test outer door-to-inner siding (information test the same as for outer door installation)
  - Install outer siding
  - Test siding (perform secondary containment test with outer door removed)

Summary

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- An alternative secondary containment boundary, meeting the applicable design/licensing requirements, will be in place prior to removing the RB siding
- Secondary containment will be transitioned to the new boundary in a controlled manner, while secondary containment pressure is monitored
- Contingent methods will be available to restore secondary containment at the RB siding boundary within 4 hours, if required

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Closing Remarks

Patrick Simpson
Licensing Manager