Fort Calhoun Station
Containment Internal Structures (CIS)

Introductions

- Omaha Public Power District (OPPD) – Fort Calhoun Station (FCS)

Bruce Rash – Recovery Director
Terry Simpkin – Manager, Site Regulatory Assurance
Brian Davis – Recovery Engineering Director
Bernie Van Sant – CIS Project Engineering Lead
Tom Dailey – CIS Project Manager
Russ Placke – Design Engineer

Introductions – Cont'd

- Stevenson and Associates (S&A)
  - Dr. Tsiming Tseng
  - Mike Allison
  - Doug Seymour
- Automated Engineering Services Corp. (AES)
  - Eric Halverson
  - Andrew Carmean
- Sargent & Lundy (S&L)
  - P. K. Agrawal
- MPR Associates, Inc. (MPR)
  - Caroline Schlaseman

Agenda

Opening Remarks

Desired Outcomes

History and Identification of Containment Internal Structures (CIS) Issue

Discovery Process and Extent of Condition

Modeling Methodology, Inputs and Assumptions

Licensing Basis and Operability Criteria

Planned Actions for Restart

Support for NRC Inspection Activities

Post-Restart Actions

Closing Remarks

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Opening Remarks

- OPPD committed to safe restart of FCS
- Containment pressure boundary is unaffected by this issue
- Current calculations show containment internal structures (CIS) nonconforming but operable for outage conditions
- Continue to evaluate the online case
- OPPD is determined to establish licensing basis safety margins for CIS
- OPPD dedicated to support NRC inspection of CIS operability for restart

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Desired Outcomes

- NRC understanding and feedback on OPPD CIS operability criteria
- NRC understands OPPD's path forward on resolution of CIS issue
- NRC inspection team is provided with solid foundation on CIS problem identification, scoping and resolution to support inspection planning

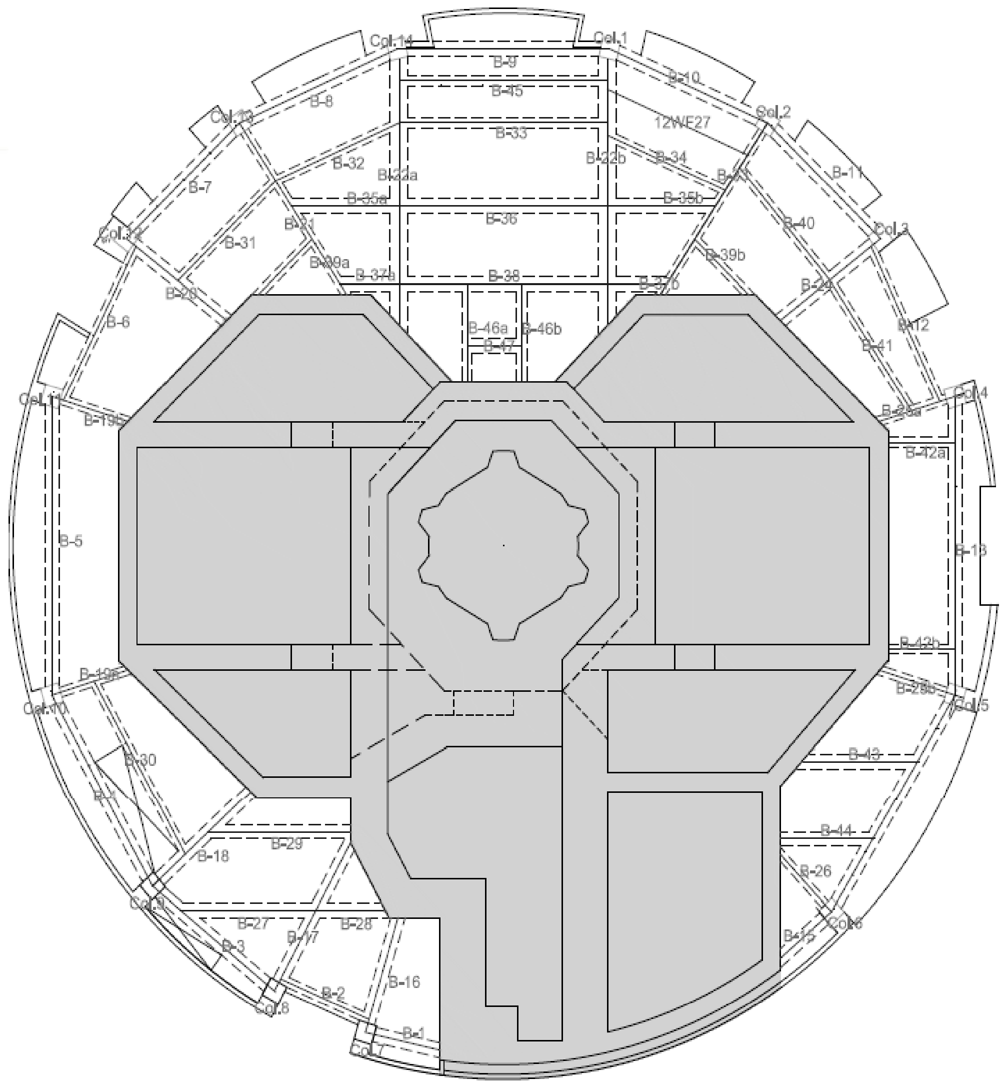
History and Identification of CIS Issue

Bernie Van Sant
CIS Project Engineering Lead

History and Identification of CIS Issue

- Issue involves the concrete containment internal structure (CIS)
- CIS involves:
  – Support for plant components and systems inside containment
- CIS does not involve:
  – Containment pressure boundary
  – Steam Generator compartments or reactor cavity

Elevation 1013’



History and Identification of CIS Issue

- Original Analyses of the CIS
  - Performed hand calculations in accordance with American Concrete Institute (ACI) 318-63 during the 1960's using the load combinations identified in Updated Safety Analysis Report (USAR) Section 5.11
  - Atomic Energy Commission (AEC) review confirmed design was adequate prior to issuance of operating license
  - No significant design changes to CIS

History and Identification of CIS Issue

- Discrepancy discovered during an extended power uprate analysis for containment cooling water system pipe supports
  - Loads on one beam at the 1060’ elevation exceeded design capacity
  - Extent of condition investigation initiated

Discovery Process and Extent of Condition

- Issues identified with original CIS calculations
  - Incorrect, incomplete or missing calculations
  - Inconsistencies between calculations and drawings
  - Incomplete consideration of all load combinations
  - Simple numerical errors

Discovery Process and Extent of Condition

- Extent of condition evaluation done for 2 beams: B-59 and B-103
- B-59 did not meet working stress design (WSD) acceptance criteria
- Companion beam (B-58) also evaluated - did not meet WSD acceptance criteria

Discovery Process and Extent of Condition

- Extent of condition assessment expanded to sampling of CIS on all three elevations
- 9 more beams and 1 column selected
- Assessment stopped after 6 beams - all beams did not meet acceptance criteria
- Given results, decision was made to completely reanalyze the CIS

Modeling Methodology, Inputs and Assumptions

Russ Placke
Design Engineer

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Modeling Methodology, Inputs and Assumptions

- Built 3-dimensional model of CIS
- GTSTRUDL™ Version 29.1 selected for analysis
- GOTHIC™ Version 8.0 selected for analysis of differential pressure (dP) across CIS floors

Modeling Methodology, Inputs and Assumptions

- Performed rigorous analysis
- Design for dead loads, live loads, seismic loads, and pipe break pressure loads
- Confirmed as-built configuration through extensive walkdowns
- Validated assumptions and input parameters
- Conducted challenge boards and independent third party reviews
- Analysis rigorously documented

Modeling Methodology, Inputs and Assumptions

CIS Model Description

Doug Seymour
(S&A)

Modeling Methodology, Inputs and Assumptions

CIS Design Model Description

- Finite element frame analysis
- Loads evaluated include dead loads, live loads, seismic loads, and pipe break pressure loads
- Differential pressure load increased by dynamic load factor (DLF)
- USAR seismic response spectrum utilized

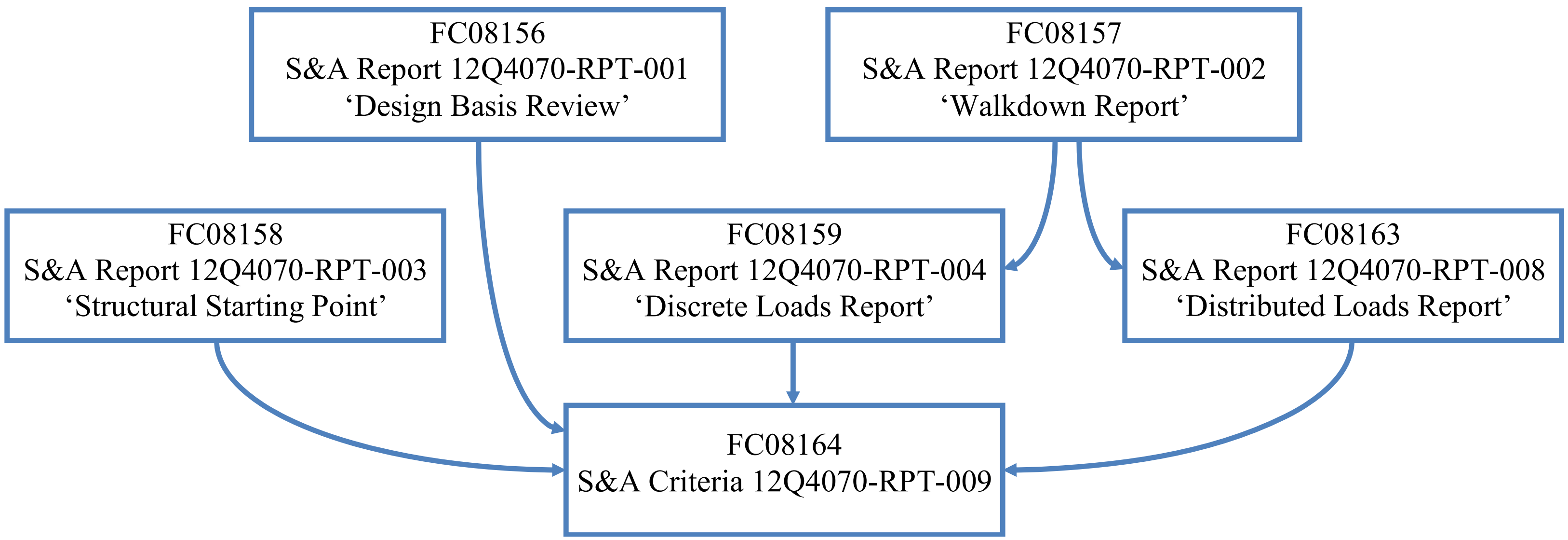
Modeling Methodology, Inputs and Assumptions

CIS Design Model Different from Licensing Basis

- Modal analysis performed
  - Includes flexibility of beams and columns
  - Modal and directional responses combined in accordance with NRC Regulatory Guide 1.92
- Licensing Basis does not require modal analysis
  - CIS taken to be vertically rigid above basemat
  - Constant, non-varying vertical acceleration provided
- Design model more conservative than licensing basis

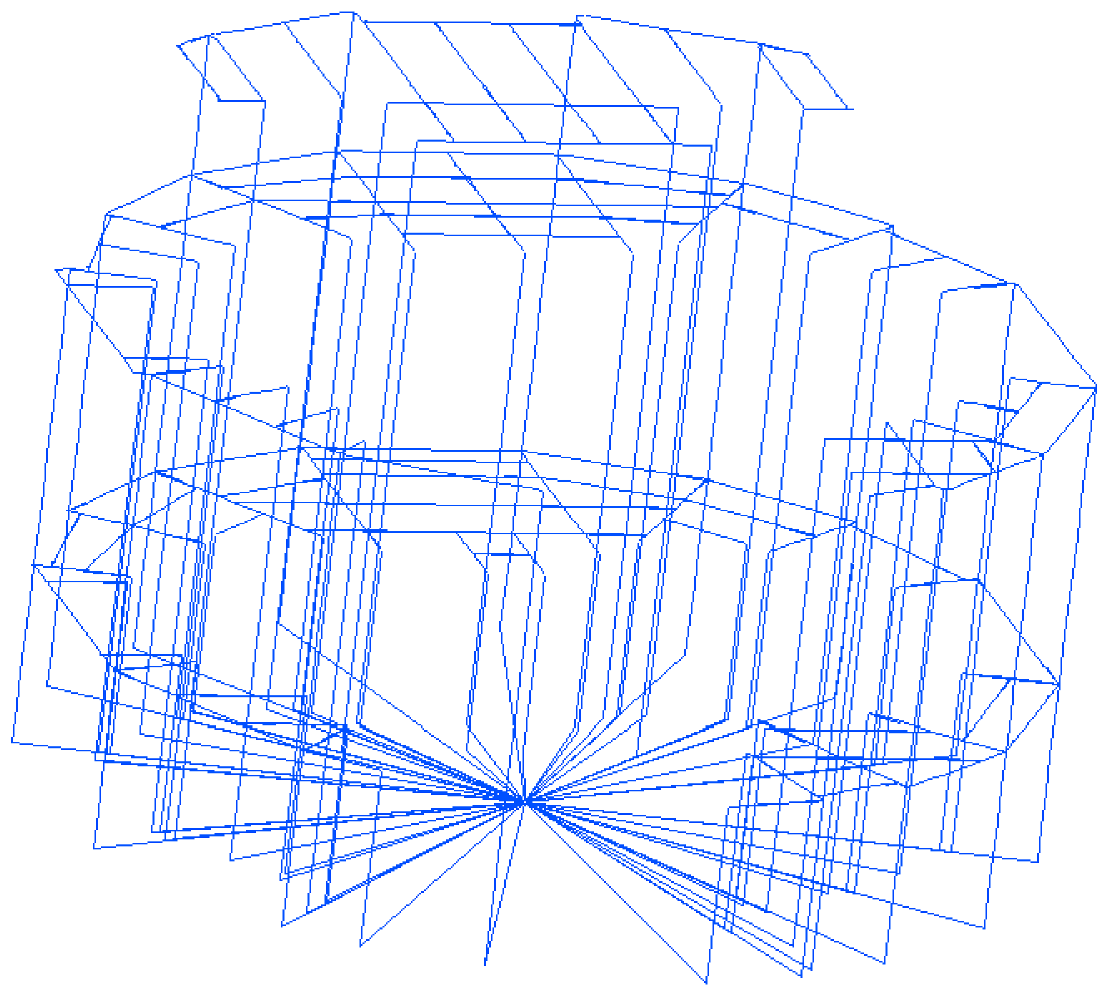
Reanalysis Elements

Flowchart of foundational S&A reports



Third party reviews were performed on each element.

GTSTRUDL™ Model of CIS



Modeling Methodology, Inputs and Assumptions

GOTHIC Model Description

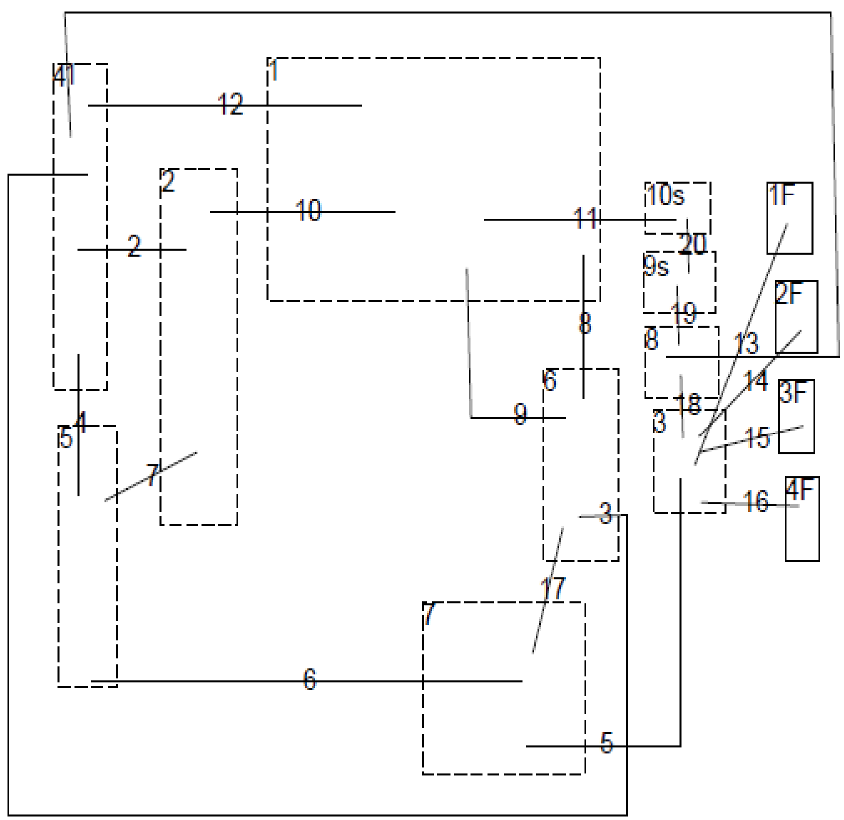
Andrew Carmean
(AES)

Modeling Methodology, Inputs and Assumptions

GOTHIC Model Description

- Analysis to more accurately calculate dPs across CIS floors for input to GTSTRUDL™
  - NUREG-0800 was used as guidance, specifically Section 6.2.1.2.II
  - Conservative Assumptions
    - No credit for heat sinks (increases dP)
    - Conservative initial conditions were assumed
  - Subdivided containment into 10 separate volumes
    - Volumes and flow paths based on plant drawings

GOTHIC Model Volumes



- Vol. 1 – Upper Containment
- Vol. 2 – SG RC-2A
- Vol. 3 – RC-2B (994'-1009')
- Vol. 4 – Cont. Outer Annulus (1013')
- Vol. 5 – Cont. Outer Annulus (994')
- Vol. 6 – Pressurizer Room
- Vol. 7 – Quench Tank Room Basement
- Vol. 8 – RC-2B (1009'-1028')
- Vol. 9 – RC-2B (1028'-1046')
- Vol. 10 – RC-2B (1046'-1056')

Modeling Methodology, Inputs and Assumptions

CIS Design Model Preliminary Results

Russ Placke
Design Engineer

Modeling Methodology, Inputs and Assumptions

CIS Design Model Preliminary Results

- Model utilized modal analysis, which is more conservative than licensing basis
- Of 135 beams, 47 beams did not meet acceptance criteria for working stress and/or ultimate strength
- Of 14 columns, 5 columns did not meet acceptance criteria for working stress and/or ultimate strength
- Design issues principally in beams that support the safety injection tanks, ventilation coolers or reactor vessel head laydown areas
- All beams and columns are currently operable

Licensing Bases and Operability Criteria

- Based on the design model results, an initial operability evaluation analysis has been performed
- Modeling methodology for the operability evaluation is different from the design model
- Comparison of licensing and operability evaluation criteria is discussed in subsequent slides
- Continuing to refine operability evaluation analysis to ensure adequate conservatism and margin

Licensing Bases and Operability Criteria

- CIS Design Purpose
  - Licensing Basis
    - Functional integrity with licensing basis design margins under the most extreme environmental loadings
  - Operability Criteria
    - Structure functions to support equipment and system operability and safe shutdown functions
- Primary Code
  - Licensing Basis and Operability Criteria
    - ACI 318-63

Licensing Bases and Operability Criteria

- Loads considered
  - Licensing Basis and Operability Criteria
    - Dead loads (D)
    - Live loads (L)
    - Accident pressure loads (Pc)
    - Design earthquake loads (E)
    - Maximum hypothetical earthquake loads (E’)

Licensing Bases and Operability Criteria

- Load Combinations
  - Licensing Basis
    - Working Stress

      D+L and D+L+E
    - No Loss of Function

      D+E’

      D+L+E’

      D±0.05D+1.5Pc

      D±0.05D+1.25Pc+1.25E

      D±0.05D+Pc+E’
  - Operability Criteria
    - Same as Licensing Basis for No Loss of Function

Licensing Bases and Operability Criteria

Doug Seymour
(S&A)

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Licensing Bases and Operability Criteria

- Ductility
  - Ductility not permitted (licensing basis)
  - Ductility not used (operability criteria)
- Material Properties
  - Concrete strength for CIS not specified in licensing basis (design basis for CIS is 4 ksi)
  - Concrete 28-day strength test data rolling average (operability criteria for CIS is 5.5 ksi)
- Seismic Modeling
  - The CIS is considered vertically rigid per the USAR, Appendix F, Revision 8, Section 2.5 (licensing basis and operability criteria)

Licensing Bases and Operability Criteria

- Moment Redistribution
  - Licensing Basis and Operability Criteria
    - Per ACI 318-63, Section 1502(d)
- Damping for Concrete Structures
  - Licensing Basis and Operability Criteria
    - 2% for design earthquake (E)
    - 5% for maximum hypothetical earthquake (E')
- Success Criteria
  - Licensing Basis and Operability Criteria
    - Interaction Ratio = demand/capacity
      - Less than or equal to 1.0

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Summary of Licensing Bases and Operability Criteria Differences

- Differences Between Licensing Basis and Operability Criteria

Item	Licensing Basis	Operability Criteria
Purpose	Functional integrity with licensing basis design margins under the most extreme environmental loadings	Structure functions to support equipment and system operability and safe shutdown functions
Load Combinations	Working stress design and no loss of function	No loss of function
CIS Concrete Strength	CIS concrete strength not specified in licensing basis (design basis for CIS is 4 ksi)	5.5 ksi

Licensing Bases and Operability Criteria

- Conservatisms in Operability Criteria
  - Increase in concrete strength from age hardening is conservatively neglected
  - Ductility and increased damping for the dynamic pressure loading is conservatively neglected
  - Higher permissible moment redistribution, which later concrete codes permit, is conservatively neglected
  - Stair live loads used are conservatively high
  - Damping and ductility for lateral seismic loads on laterally-unrestrained beams are conservatively neglected

Operability Assessment Preliminary Results

- Outage Case
  - All structural members in CIS are operable - meet no loss of function load case acceptance criteria

- Normal Operation Case
  - 3 beams exceed 1.0 interaction ratio
  - Continuing to refine analyses, assumptions, and inputs

Planned Actions for Restart

Brian Davis
Recovery Engineering Director

Planned Actions for Restart

• Issue final calculations	December 20, 2012
• Third party review of calculations	December 28, 2012
• Address third party review comments	January 4, 2013
• Verify comment resolution	January 8, 2013
• Owner acceptance review	January 11, 2013
• Issue operability evaluation	January 11, 2013

- NRC inspection of operability evaluation during January 2013

- Continue engineering and construction planning activities

Support for NRC Inspection Activities

- Provide availability of calculations and operability evaluation
- Support technical teleconferences as needed
- FCS site familiarization and CIS walkdowns
  - Proposed - Week of January 7, 2013
- Modeling reviews in Boston, MA
  - Proposed - Week of January 14, 2013
- FCS onsite inspection or additional visits to Boston, MA as needed

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Post Restart Actions

- Optimize modification designs
- Complete engineering change packages for modifications
- Install modifications during future outages

Design Options

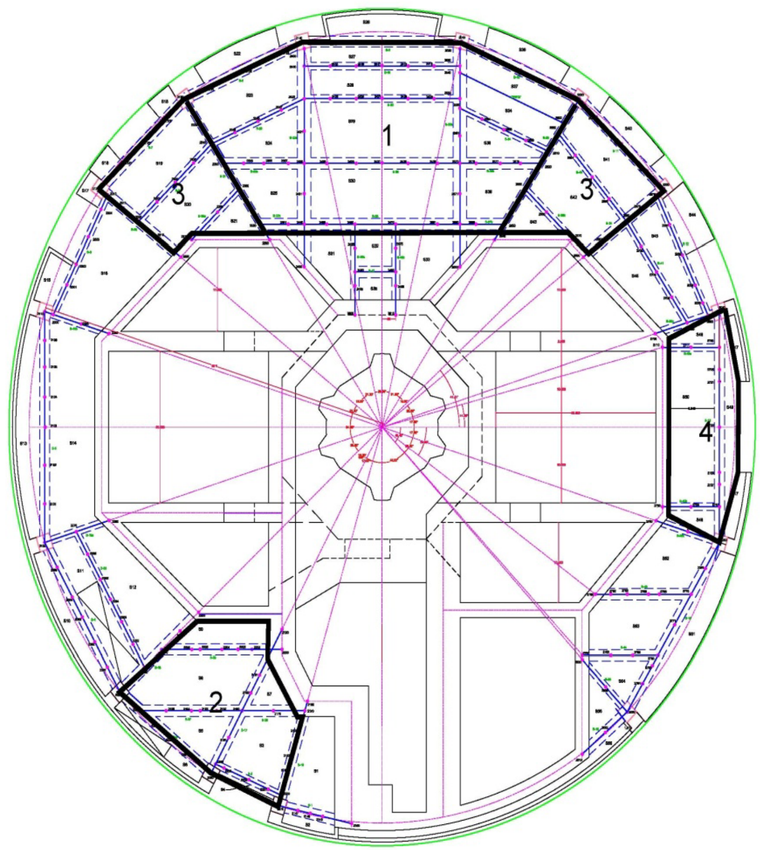
Tom Dailey

CIS Project Manager

Design Options

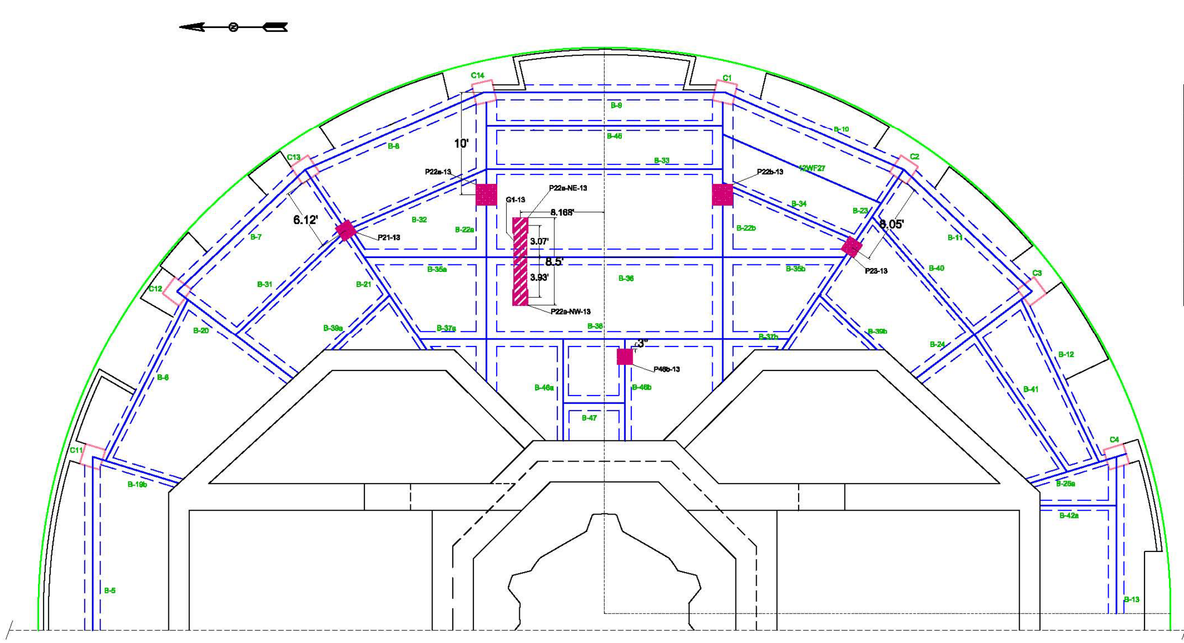
- Structural Steel
  - Easiest to design and install
  - Discounted due to thermal expansion-induced loads on columns
- Precast Concrete
  - Caused excessive interferences along haul path
  - Required large footprint to up-end column sections
  - Excessive weight has inherent handling & rigging risks
- Cast-in-place Concrete (current preferred option)
  - Fewer interferences compared to structural steel and precast concrete option
  - Formwork can be transported manually
  - Proven methodology, less labor and shortest duration

Modification General Areas



Ground Floor EL. 1013'

Mod-1 General Arrangement



Ground Floor El. 1013'

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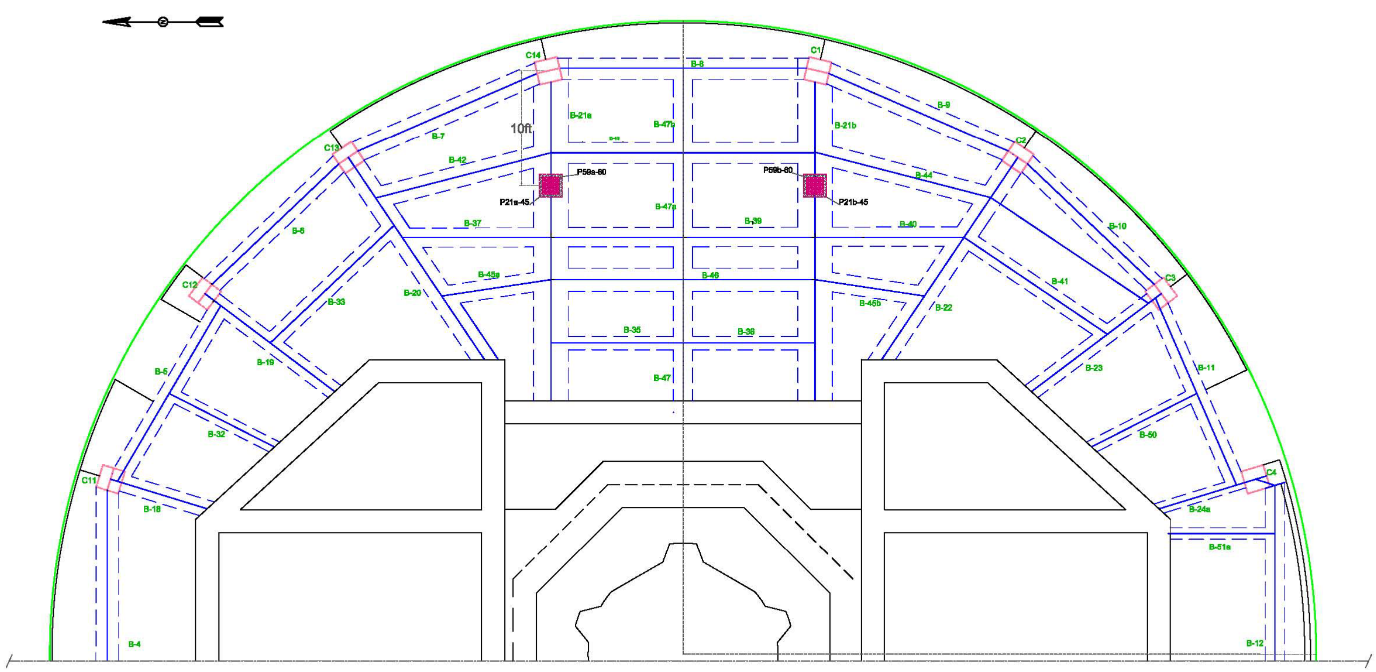
Mod-1 General Arrangement



Operating Floor EL. 1045'

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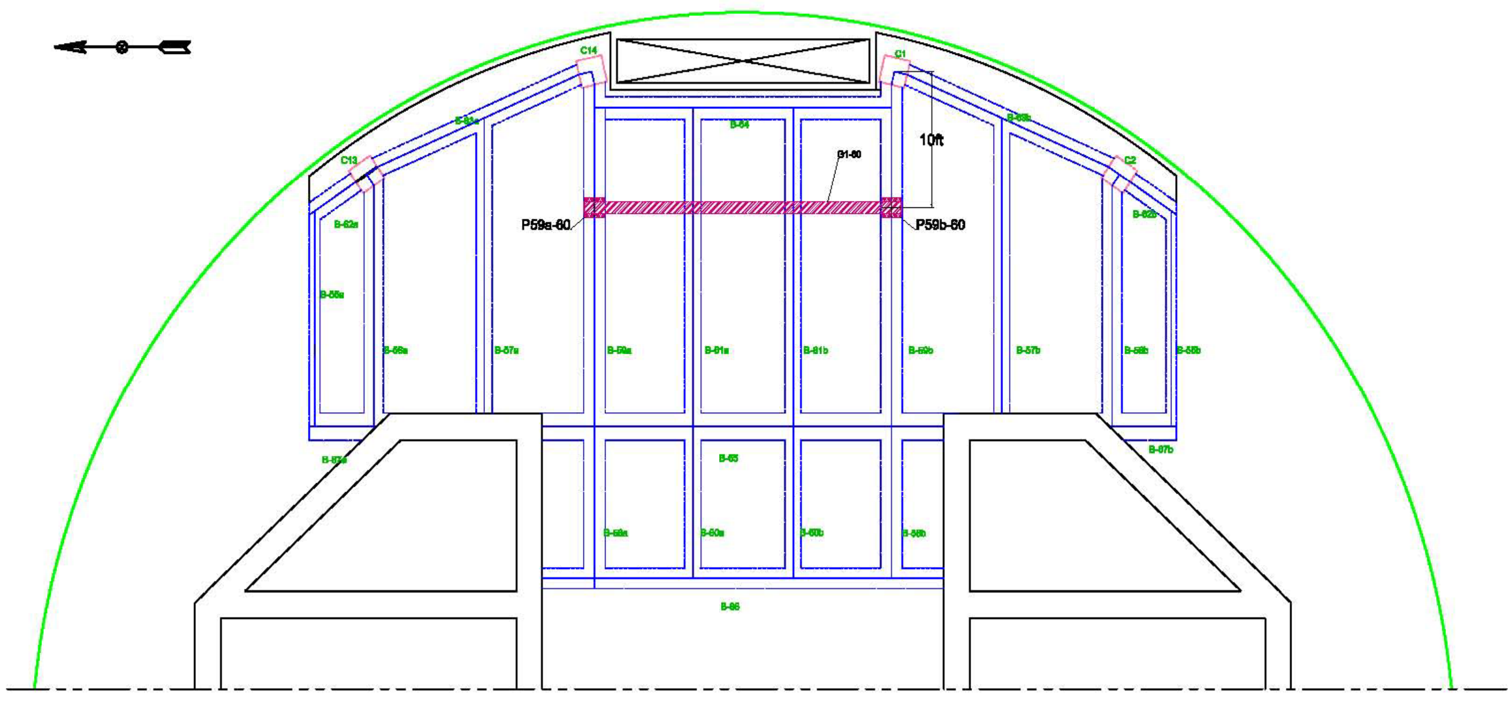
Mod-1 General Arrangement



El. 1060’

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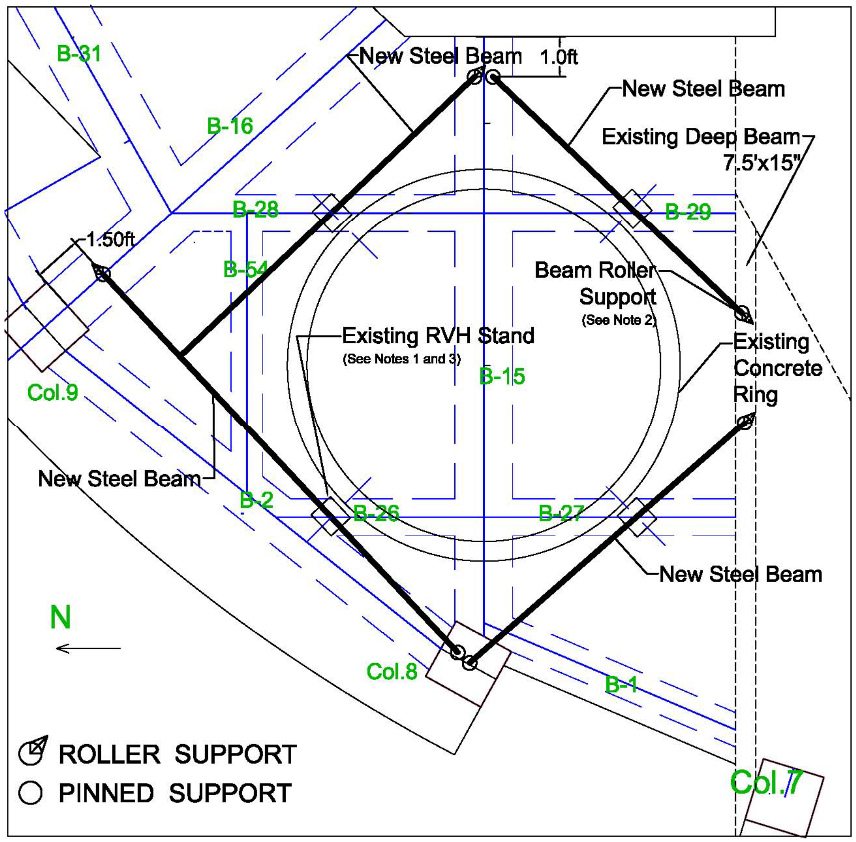
Mod-2 General Arrangement



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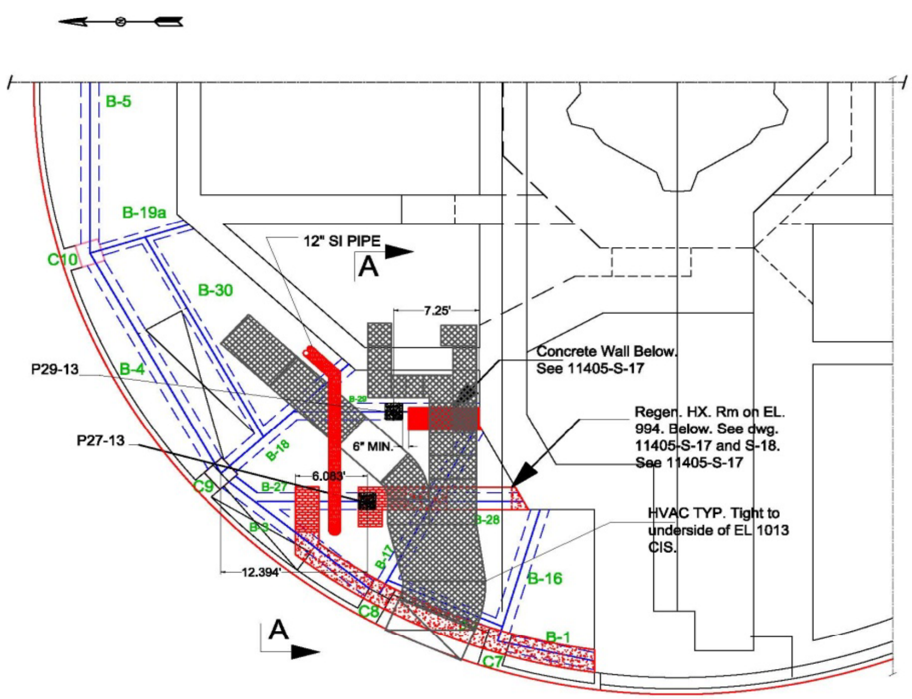
Mod-2 General Arrangement

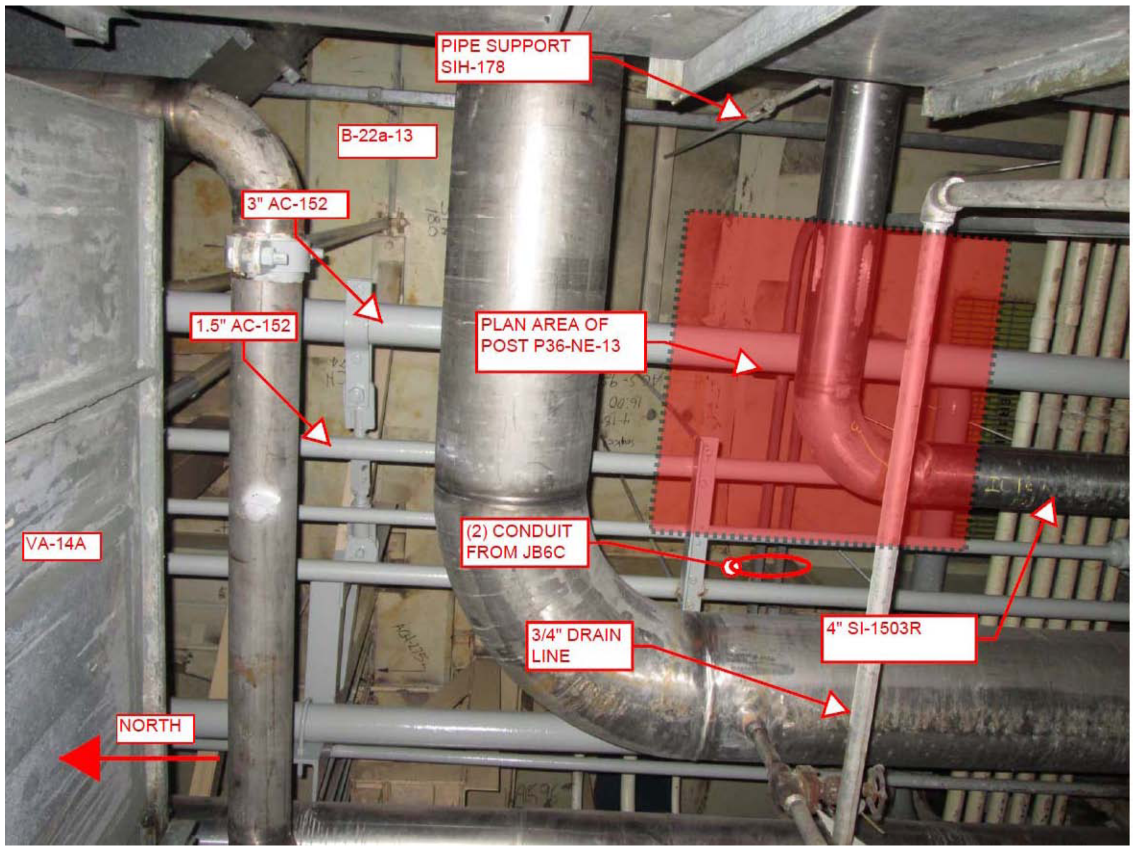


Ground Floor El. 1013' - CIS 7 O'clock region

Installation Challenges

- Numerous interferences
  - 4 kV reactor coolant pump motor cable/conduit
  - Large ventilation ductwork
  - Conduit banks
  - Component Cooling Water piping
  - Pipe supports
  - Miscellaneous steel platforms, stairs, etc.
- Containment configuration not conducive to material handling
- Concrete must be pumped long distances

Typical Interferences



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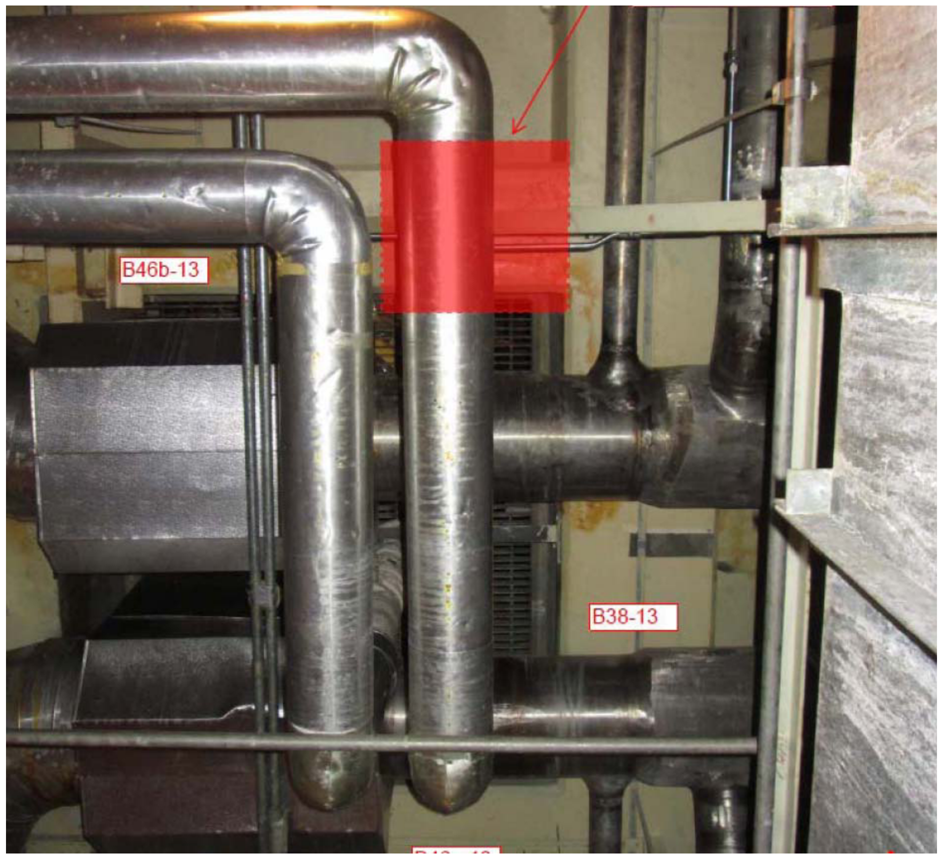
Typical Interferences



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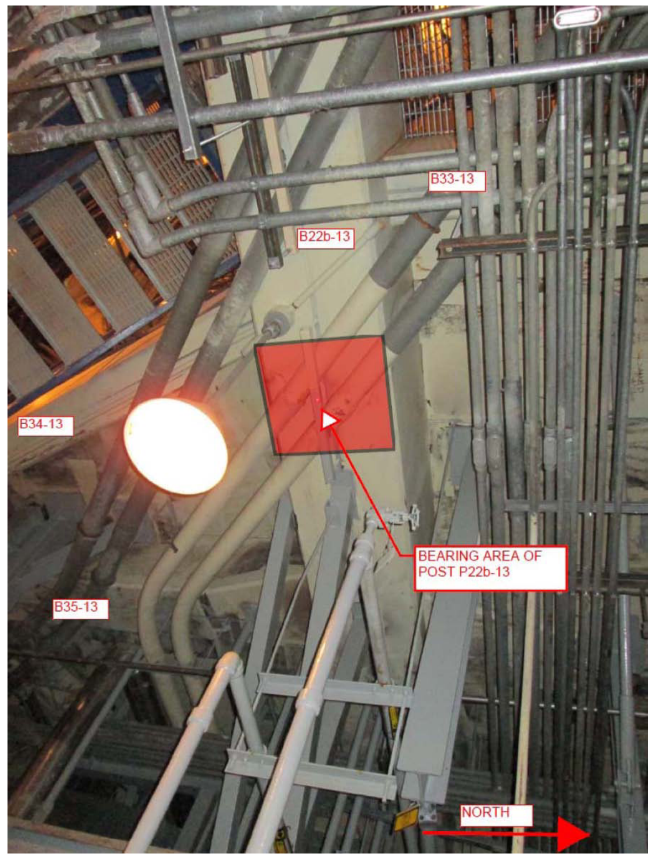
Typical Interferences



Modification Analysis

Bernie Van Sant
CIS Project Engineering Lead

Modification Analysis

- Analyses required to complete CIS engineering change packages
  - Finalize structural analysis of CIS
  - Optimize design of new columns and beams
  - Design relocation of interferences
    - Seismic and hydraulic analysis of piping rerouting
    - Seismic and cable analysis for conduit rerouting
    - Seismic and air flow analysis of ductwork rerouting
    - Structural analysis of new commodity supports

Other Design Considerations

- Impact on other analyses will have to be addressed
  - Containment pressure analysis
  - High energy line break analysis for columns and relocated equipment
  - Containment sump analysis
  - Other analyses, as required

Closing Remarks

Bruce Rash

Recovery Director

Closing Remarks

- OPPD committed to safe restart of FCS
- Containment pressure boundary is unaffected by this issue
- Current calculations show CIS nonconforming but operable for outage conditions
- Continue to evaluate the online case
- OPPD is determined to establish licensing basis safety margins for CIS
- OPPD dedicated to support NRC inspection of CIS operability for restart