NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

Configuration Management of the National Bureau of Standards Reactor

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SURF Colloquium, August 15th, 2024

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Div. 610, Reactor Operations and Engineering

CENTER FOR NEUTRON RESEARCH

CHRNS CENTER FOR HIGH RESOLUTION NEUTRON SCATTERING

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Personal Background

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- Education:
  - University of Vermont
  - Patrick Leahy Honors College
  - Rising Junior
- Major: Mechanical Engineering
- Minors:
  - Electrical Engineering
  - Pure Mathematics
- Interests:
  - Nuclear Engineering
  - Energy Systems
  - Power Systems

Tau Beta Pi
The Engineering Honor Society

Presentation Outline

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- NBSR History and Background
- NBSR Configuration Management
- My Project and CAD Modeling
- CAD Misalignment Identification
- Thermal Column Analysis
- Future Work and Conclusion
- Questions

NBSR Background

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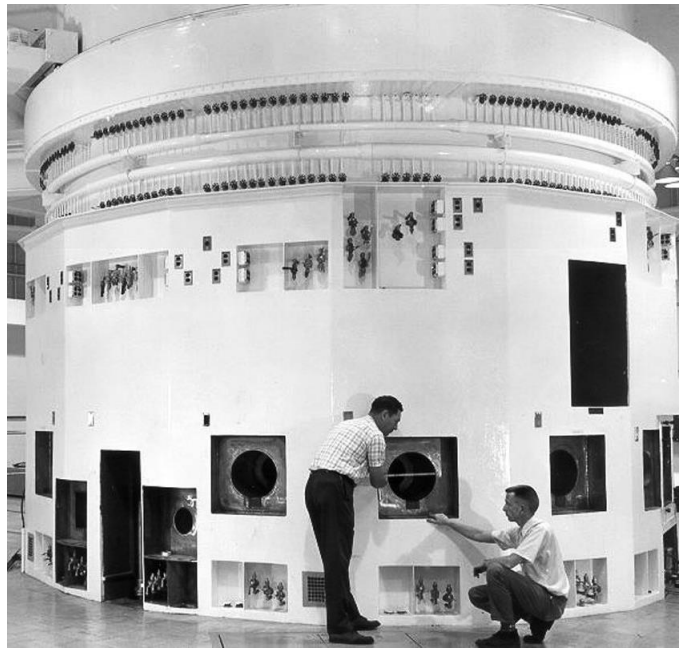
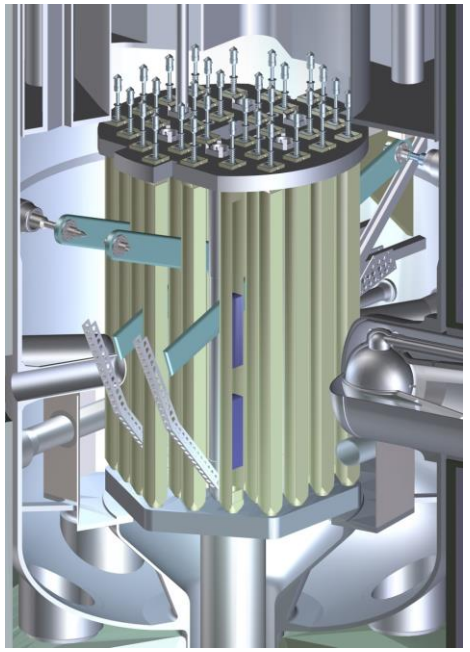
- Designed in early 1960s
- Operational since 1967
- Tank Type Reactor
- 20 MW Operating Power
- Does **NOT** produce electricity
- Primary Coolant: Heavy Water (D_2O)
- Secondary Coolant: Water (H_2O)
- Incident Recovery:
  - February 3rd, 2021
  - Performing necessary maintenance
  - Upgrading reactor components





Configuration Management

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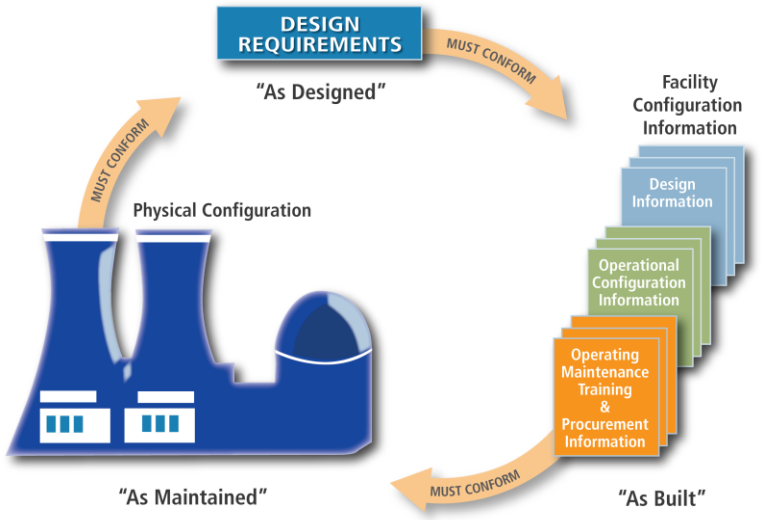
- What is Configuration Management?
  - Maintain and operate a system in a desired state
  - **Design Requirements:**
    - What is required to be there
  - **Facility and Information Management:**
    - What is documented to be there
  - **Physical Configuration:**
    - What is actually there
  - Conformity among all aspects
- Facility changes are reflected among all aspects
- Operations conducted using documented procedure
- Maintenance is authorized and documented



Configuration Management

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- Configuration management program review was conducted
- NCNR strives to follow recommended guidelines:
  - American National Standards Institute (ANSI)
  - Nuclear Information and Records Management Association (NIRMA)
  - *American National Standard for Guidelines for Configuration Management of Nuclear Facilities*

ANSI
American National Standards Institute

NIRMA

My Project

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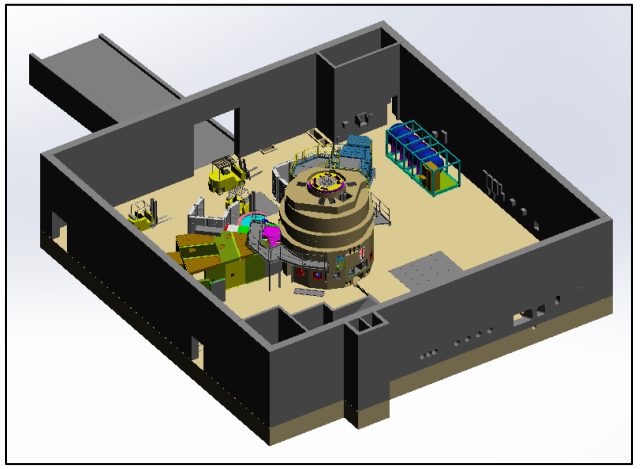
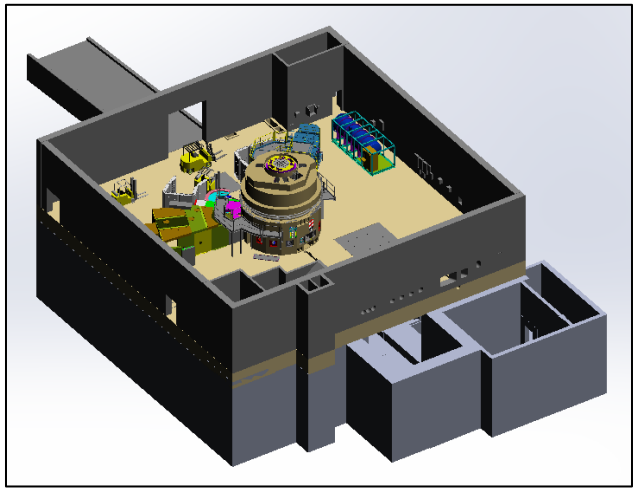
- NCNR does not have models for all NBSR systems, structures, and components
- Computer-Aided Design (CAD) Modeling:
  - CAD Model = 3D Model
  - Review technical drawings
  - Updating existing CAD models
  - Creating new CAD models
- Assemble CAD models in SolidWorks
- Compile errors and misalignments
- Perform simulations in SolidWorks



Original Confinement Model



Current Confinement Model

Reactor Piping

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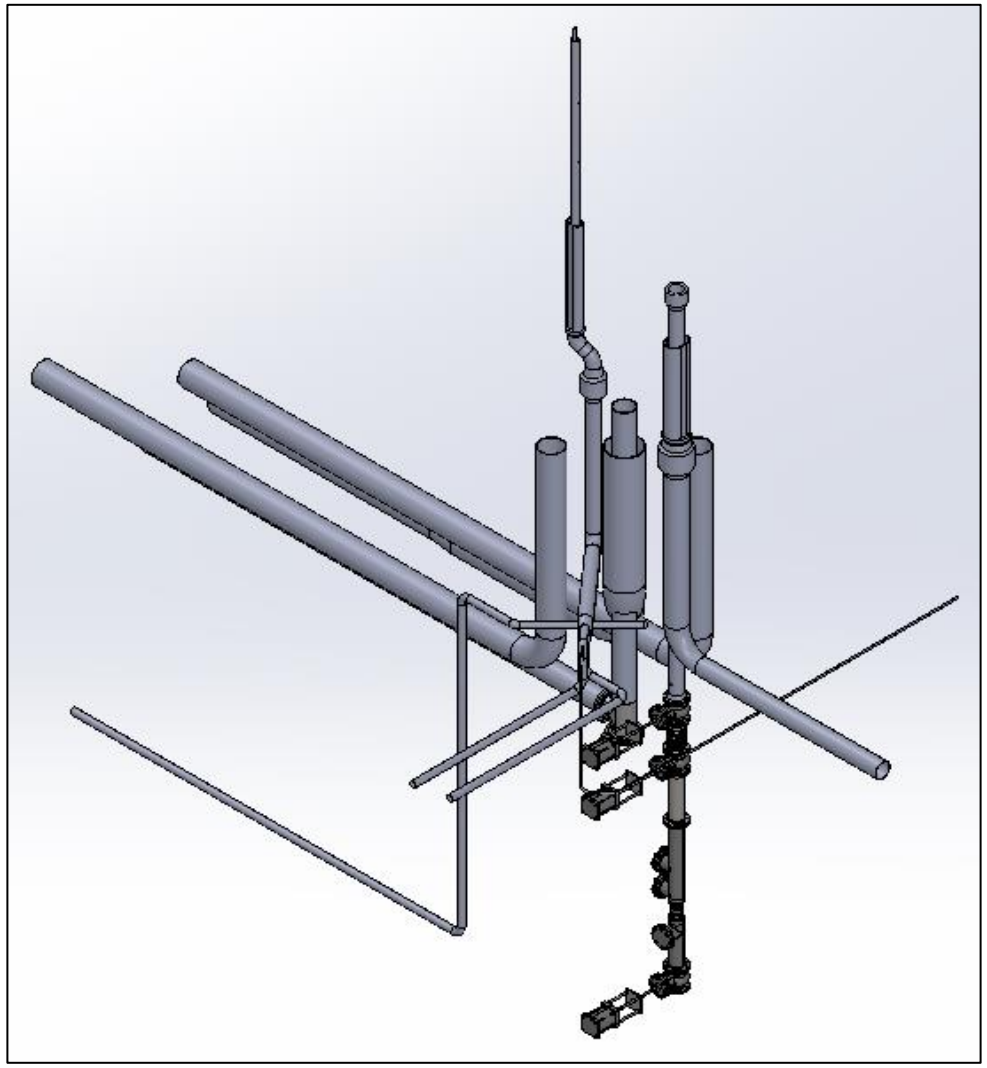
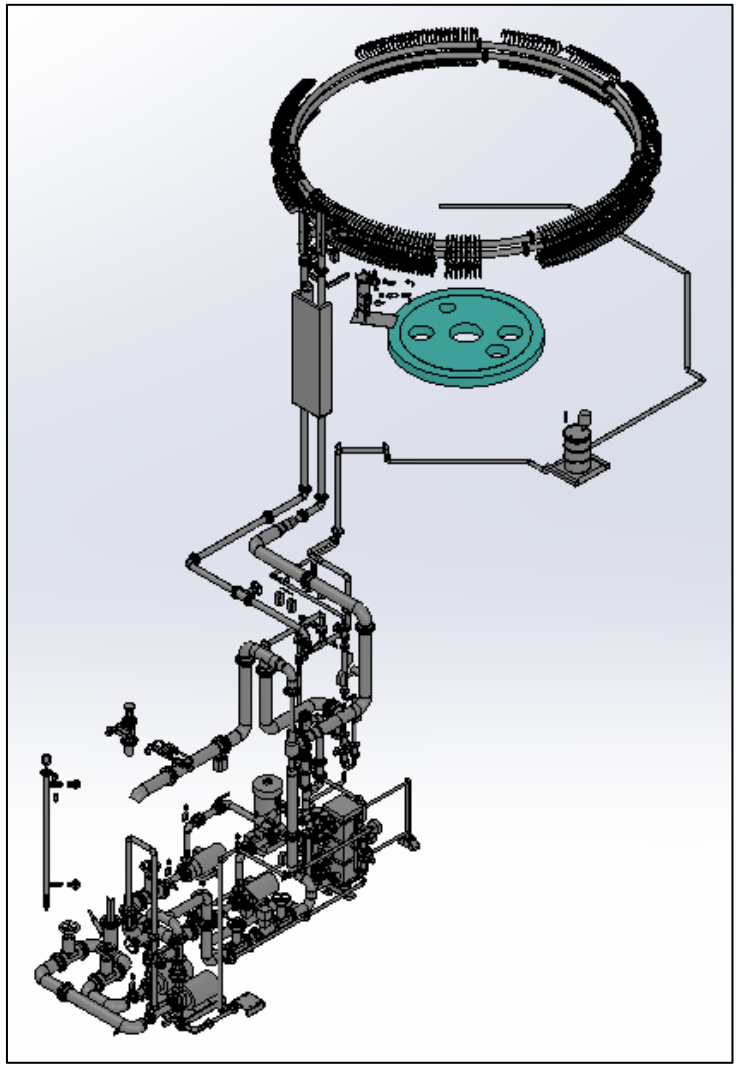
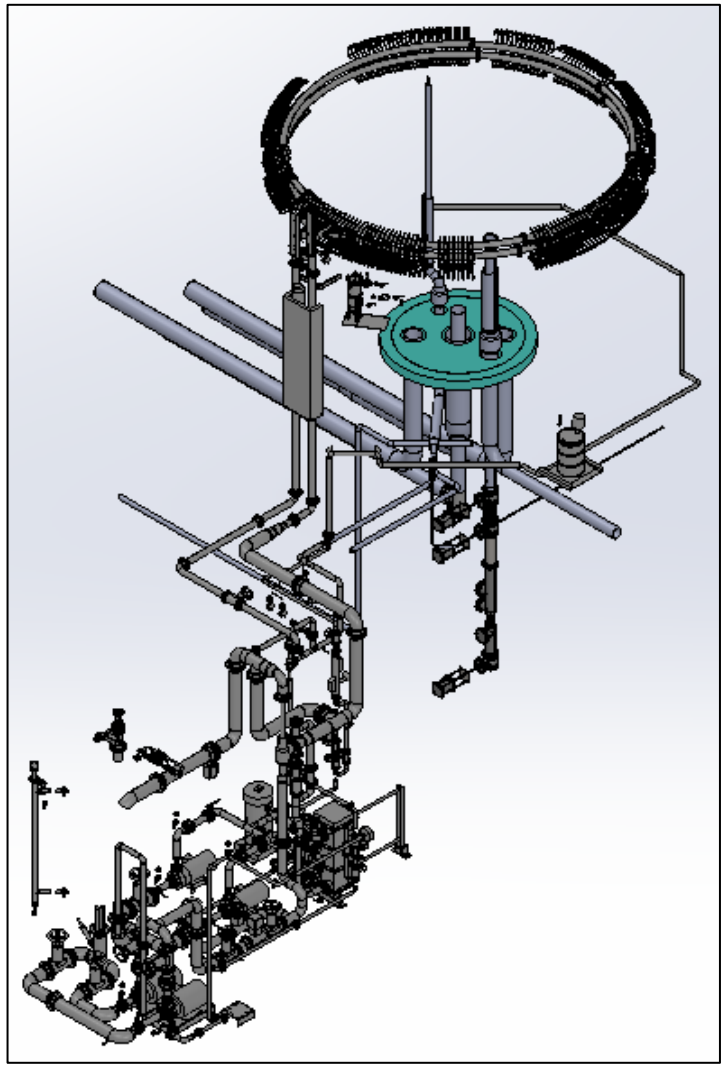


Reactor Pedestal Piping



Thermal Shield Piping



Combined Reactor Piping

Updated Reactor Model

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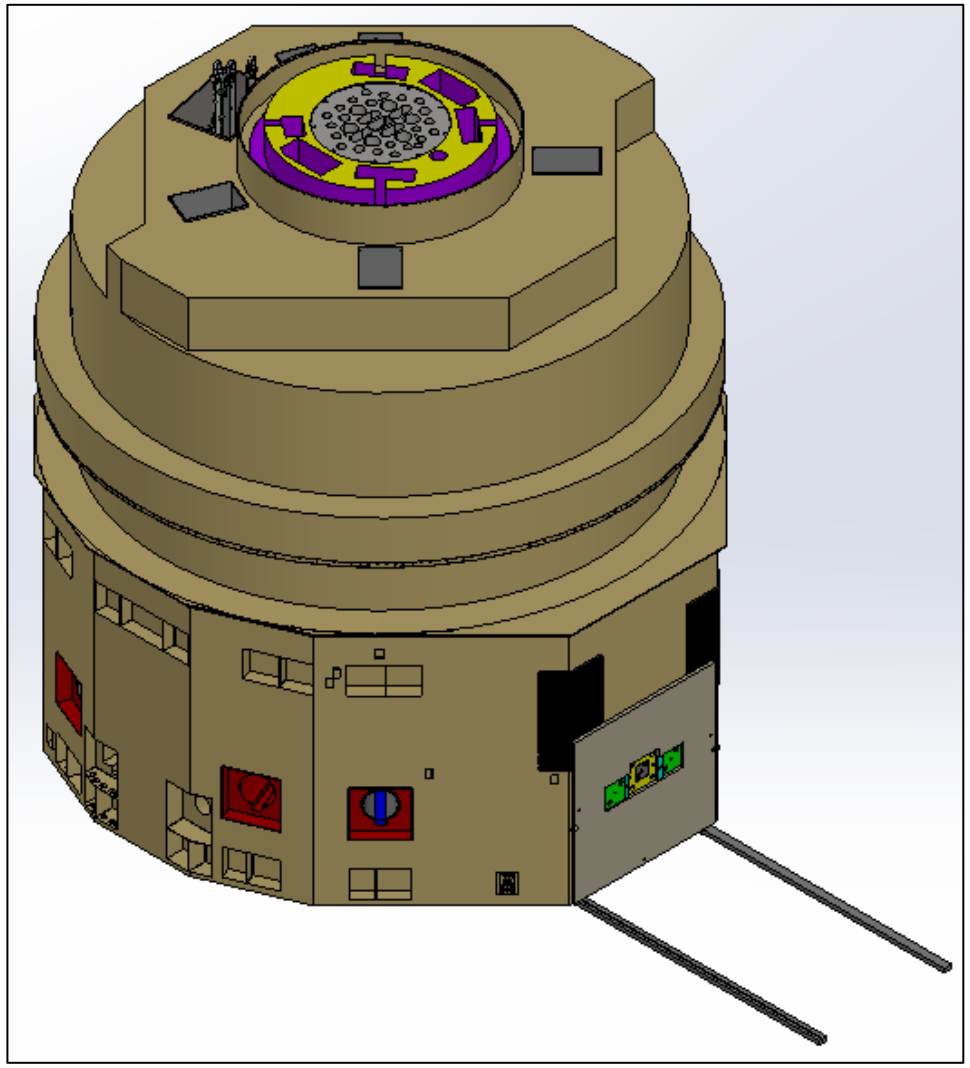
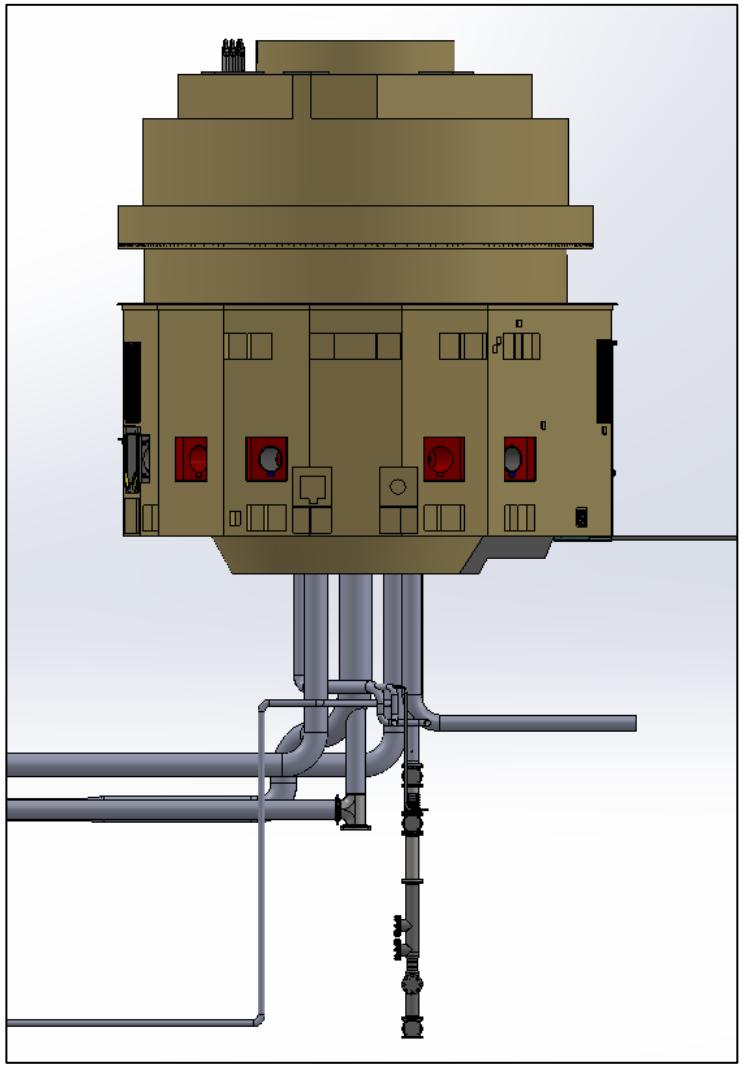
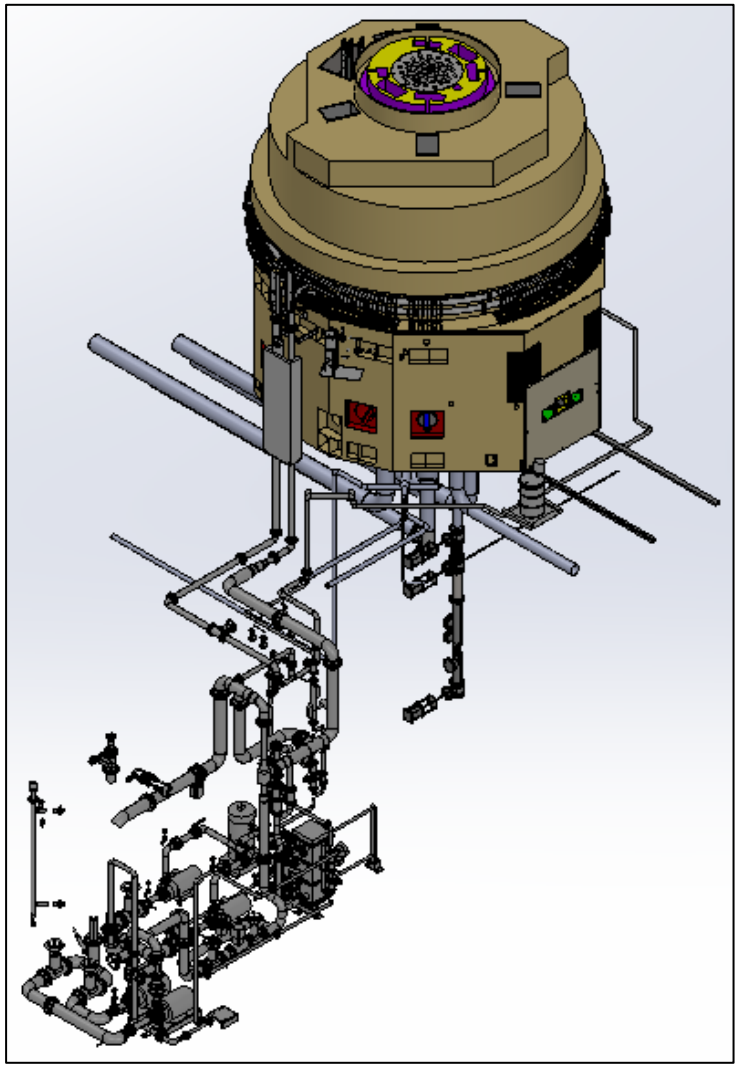


Original Reactor Model

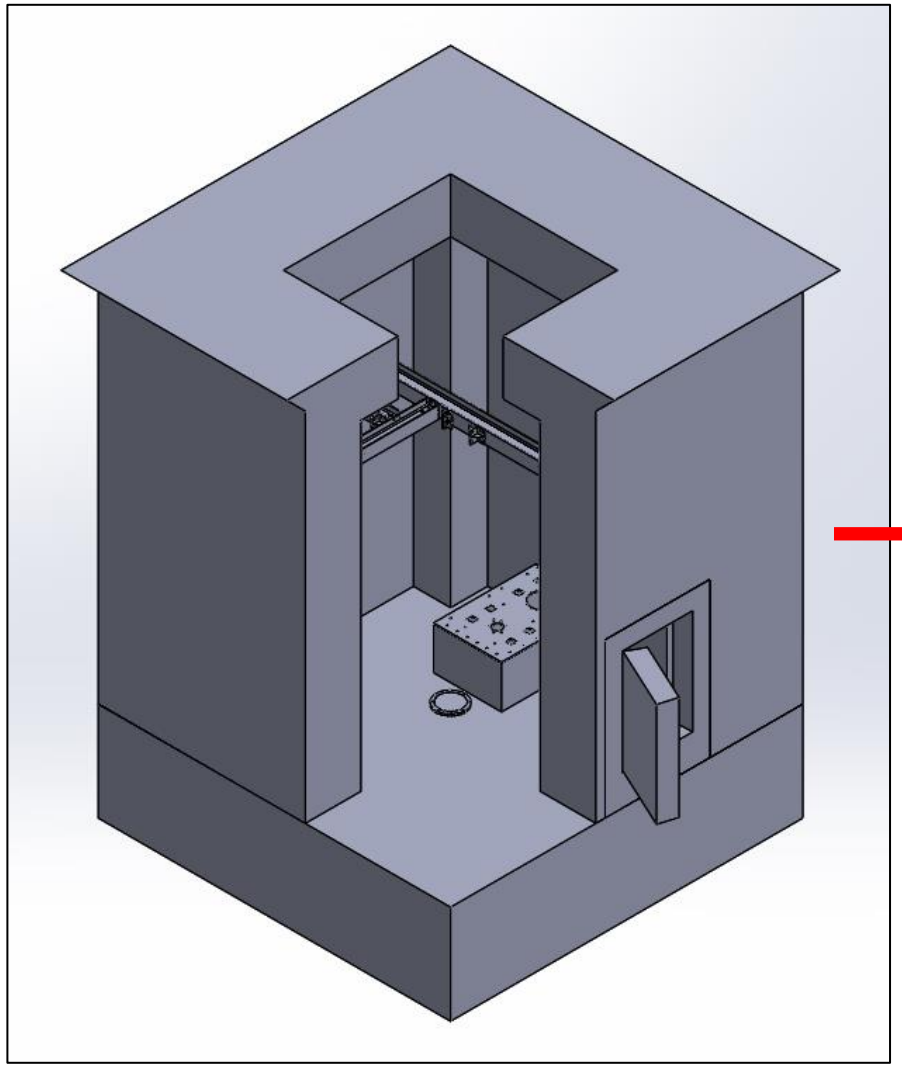


Reactor Pedestal Piping Elevation



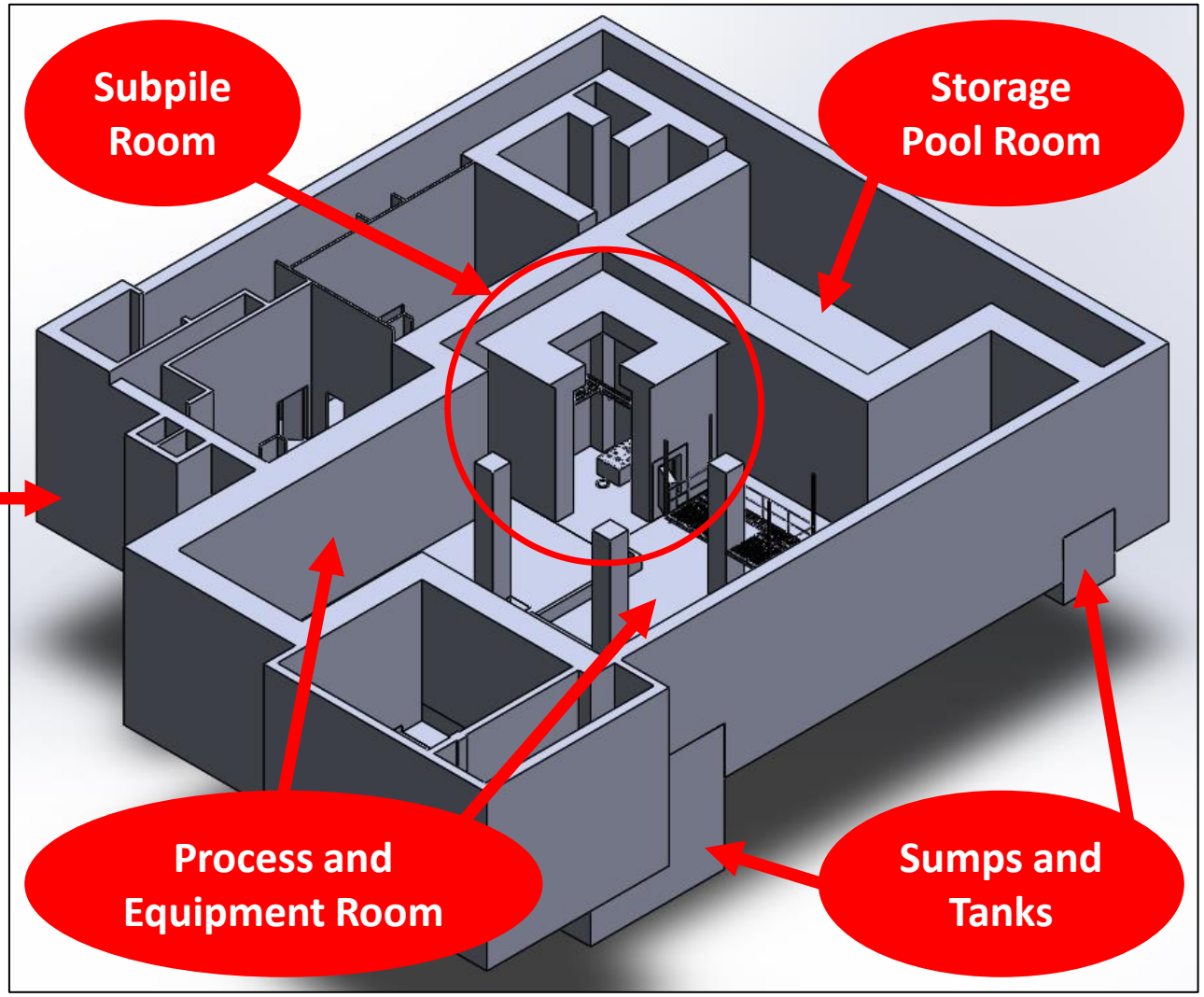
Reactor Model With All Piping

Subpile Room



First developed model of Subpile Room

SOLIDWORKS



Model expanded to include the entire Basement

Purpose of CAD Models

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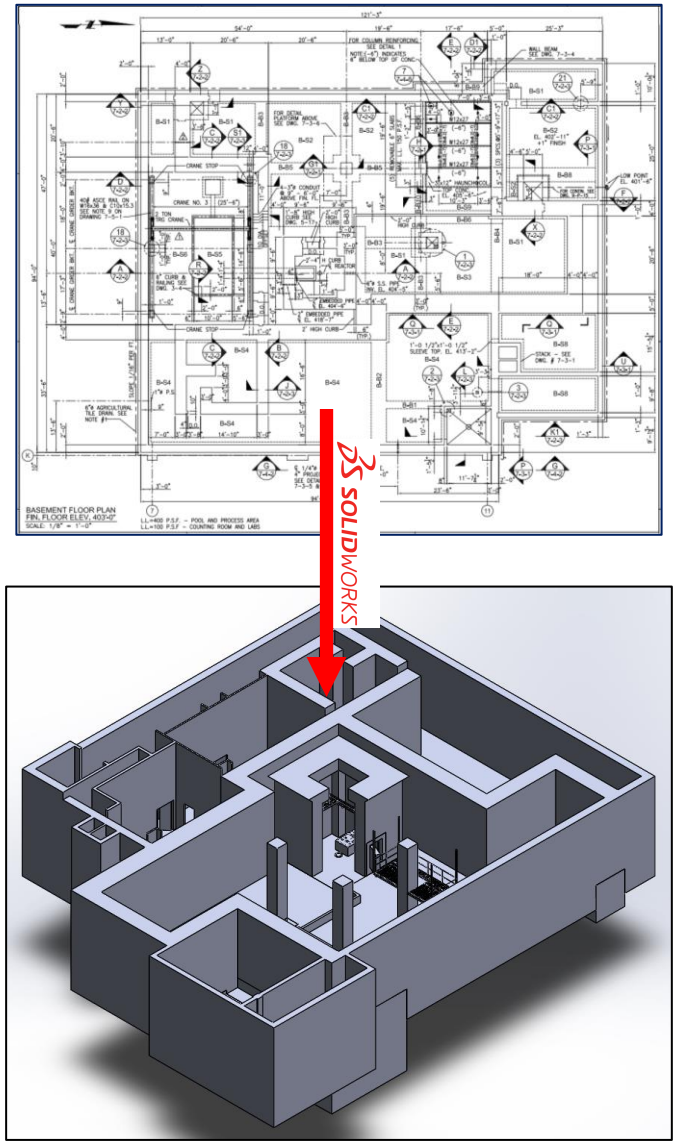
- Provide 3D Reference
- Geometry provides spatial dimensions
- Identify Misalignments:
  - Easily visualize and locate errors
  - Correct and update technical drawings
  - Ensure consistency in technical drawings
  - Improve NCNR configuration management
- Easily implement SolidWorks Simulation:
  - Stress and Strain Analysis
  - Bucking and Fatigue Analysis
  - Fluid Flow Analysis



Internal Reactor Piping

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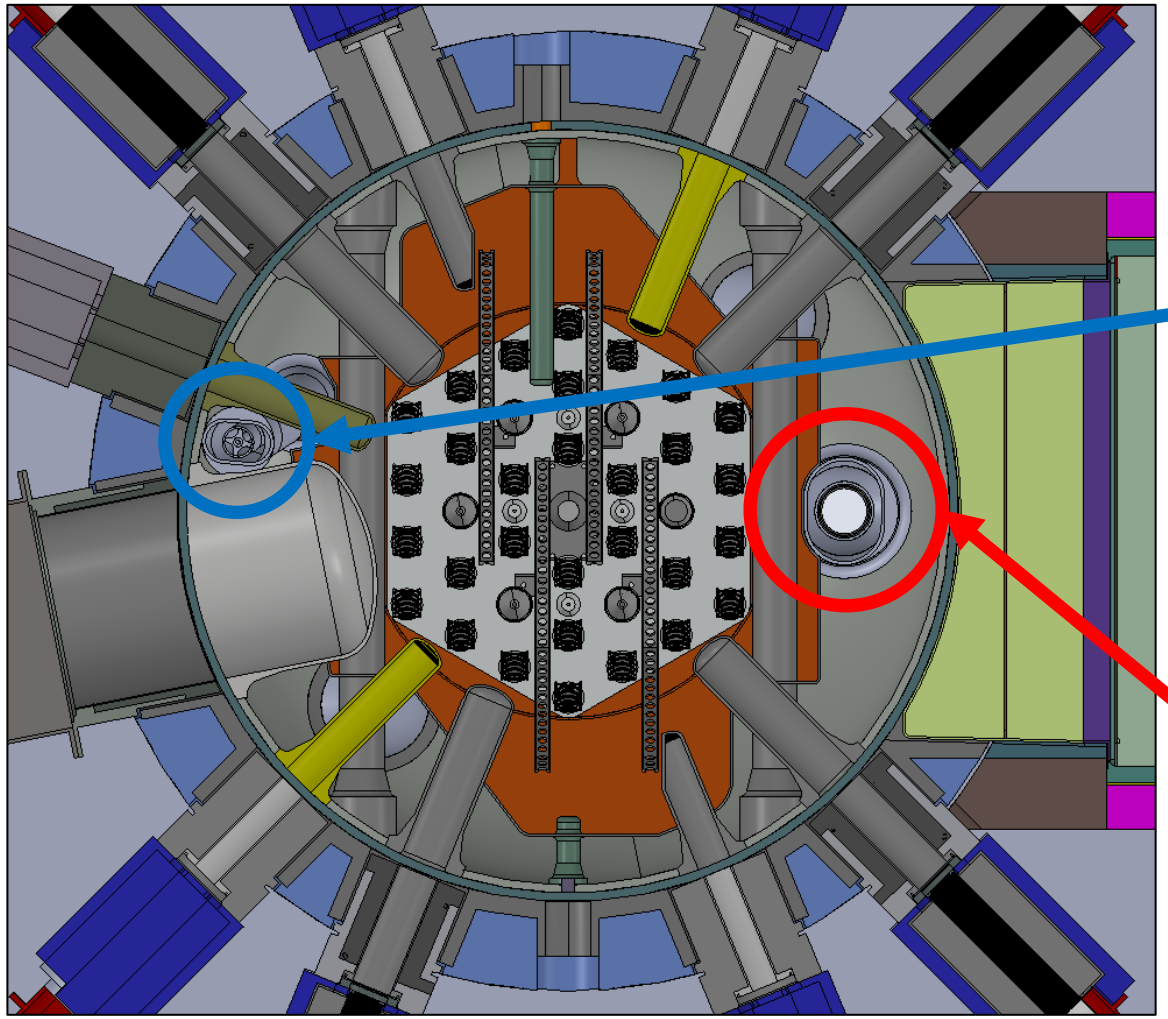
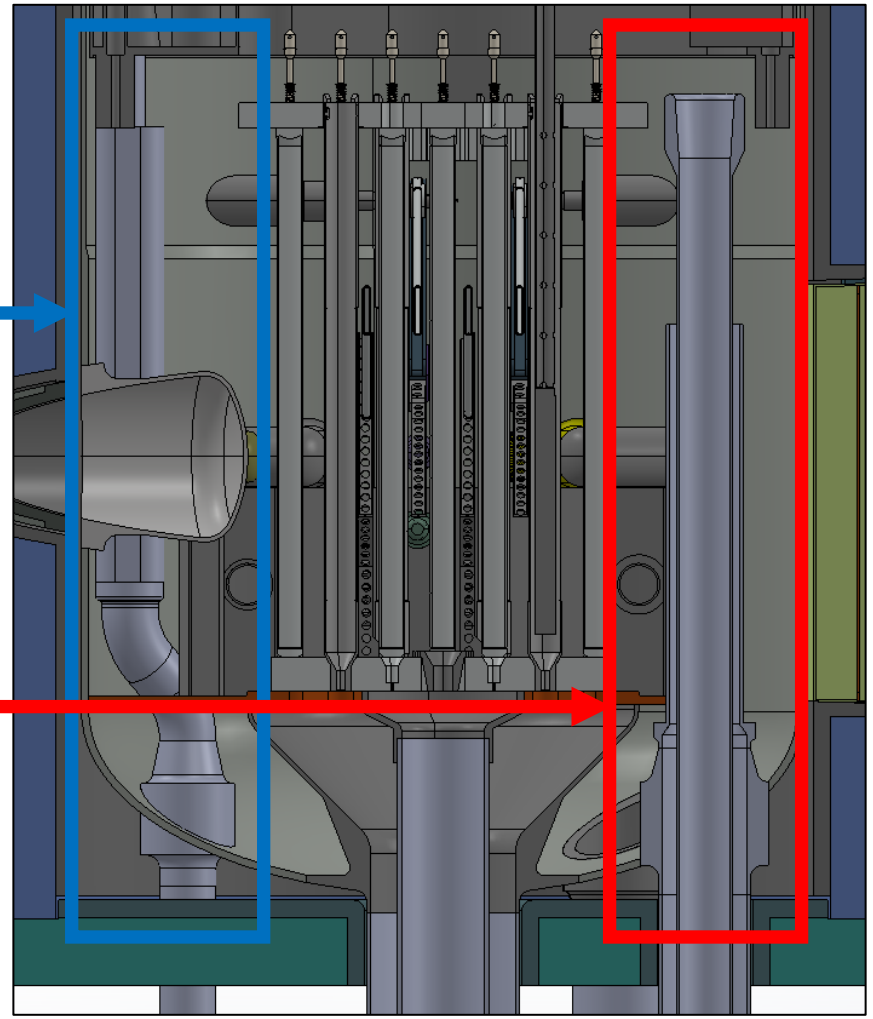


Reactor Core Top View Cross-Section

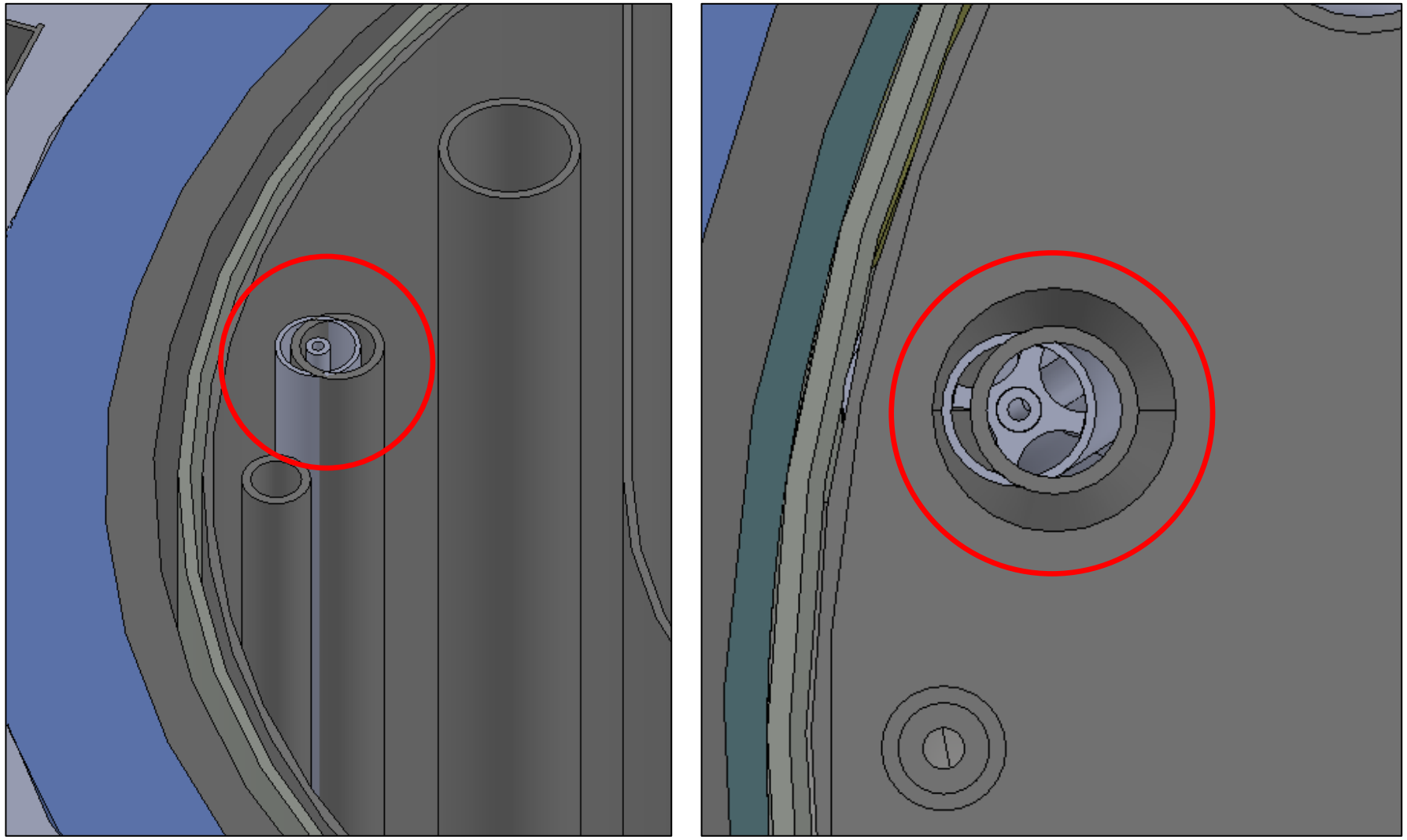
Level Control Piping

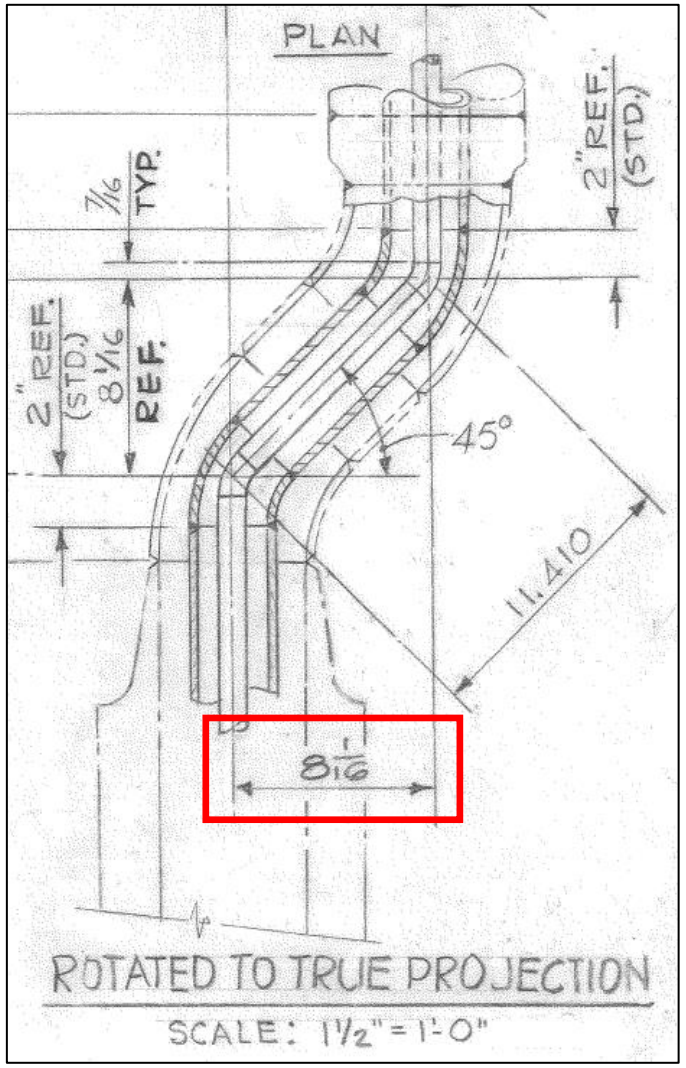
Fuel Transfer System



Reactor Core Side View Cross-Section

Piping Misalignments





Level Control Pipe Misalignment with Reactor Vessel Internal Piping

Original Technical Drawing

Piping Misalignments

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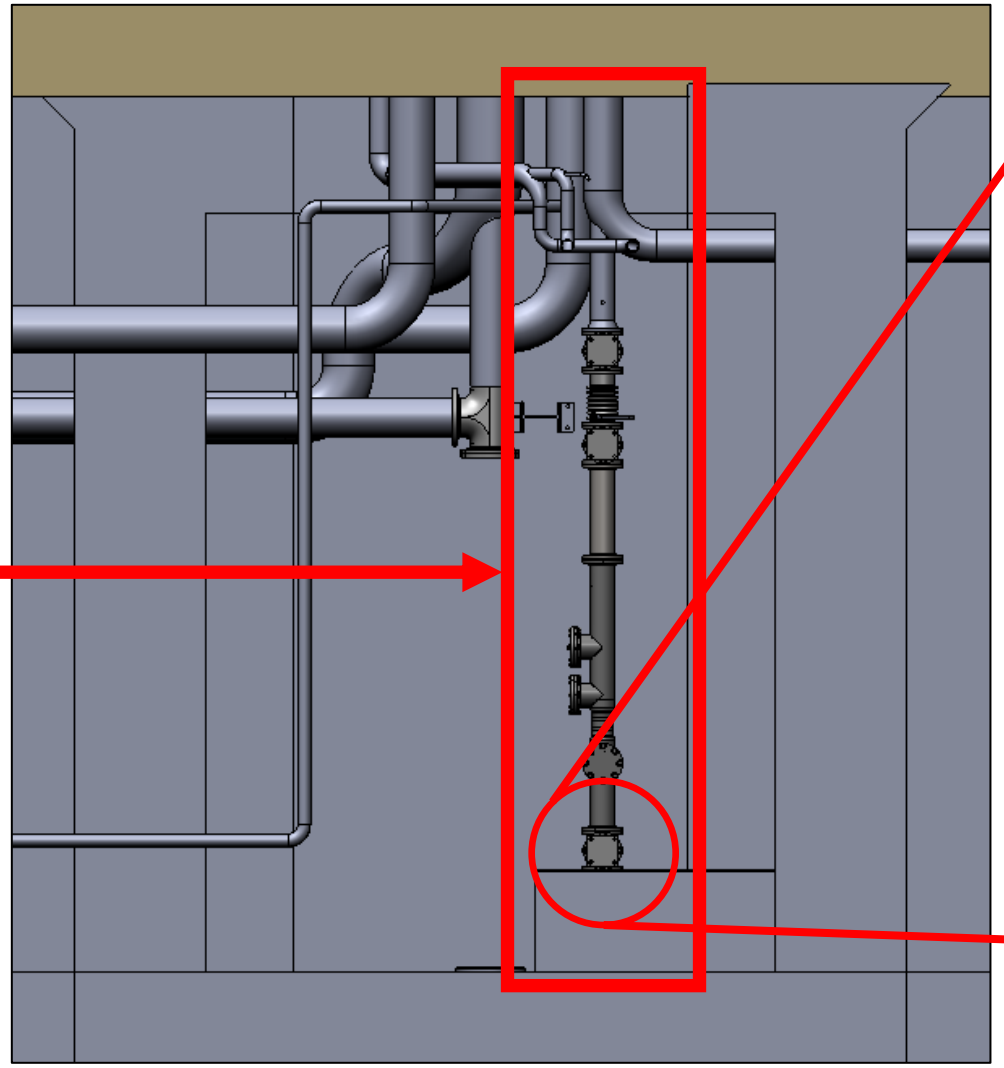
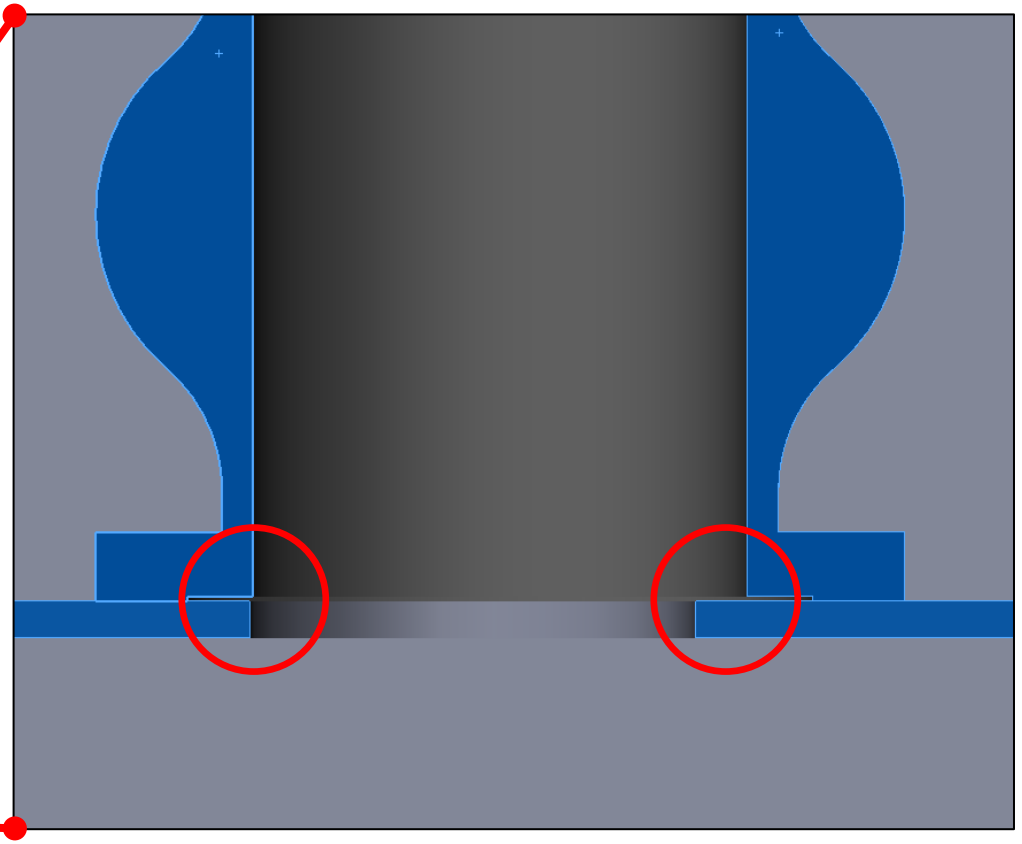


Subpile Room Side View Cross-Section



Intersection Between Fuel Transfer System and Subpile Room Cover Plate

SolidWorks Simulation

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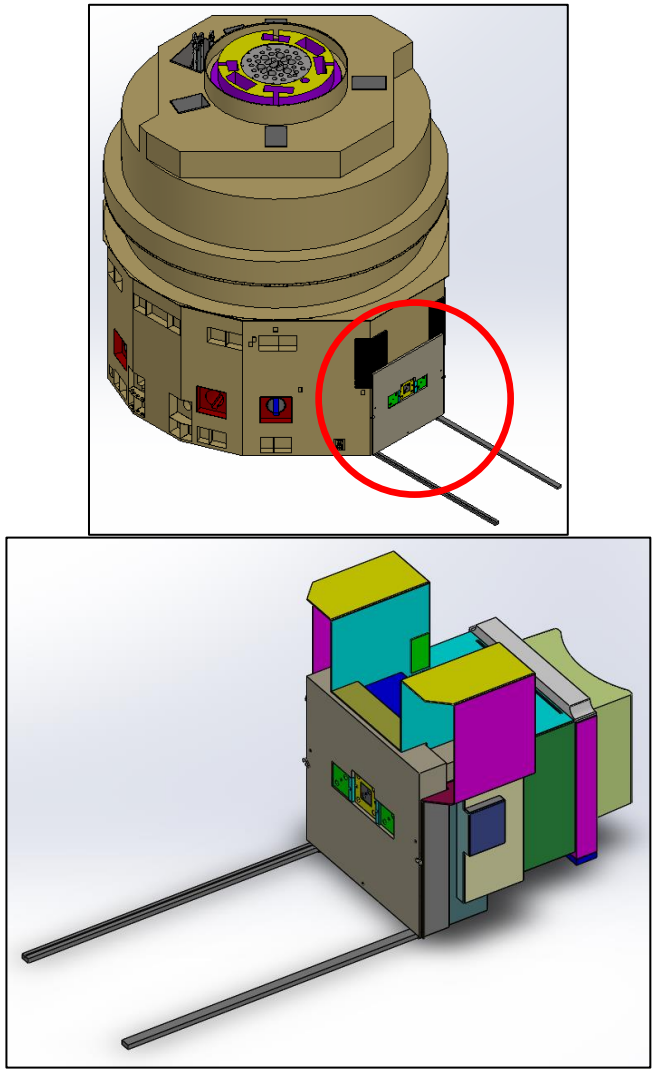
- Engineers **LOVE** computational simulations
- SolidWorks Simulation:
  - Easily mesh CAD models
  - Native software runs FEA and CFD
- FEA = Finite Element Analysis:
  - Forces
  - Pressure
  - Stress and Strain
- CFD = Computational Fluid Dynamics:
  - Fluid Flow
  - Heat Transfer

Thermal Column

- Isolated from Primary and Secondary Cooling
- Primary Coolant: Water (H_20)
- Provides cooling to bismuth shield
- Decreases heat and radiation emission
- History of leaks
- CFD Analysis:
  - Model internal flow
  - Model heat transfer
  - Understand fluid properties
  - Identify design flaws
  - Identify leak source



Thermal Column

Thermal Column Mold

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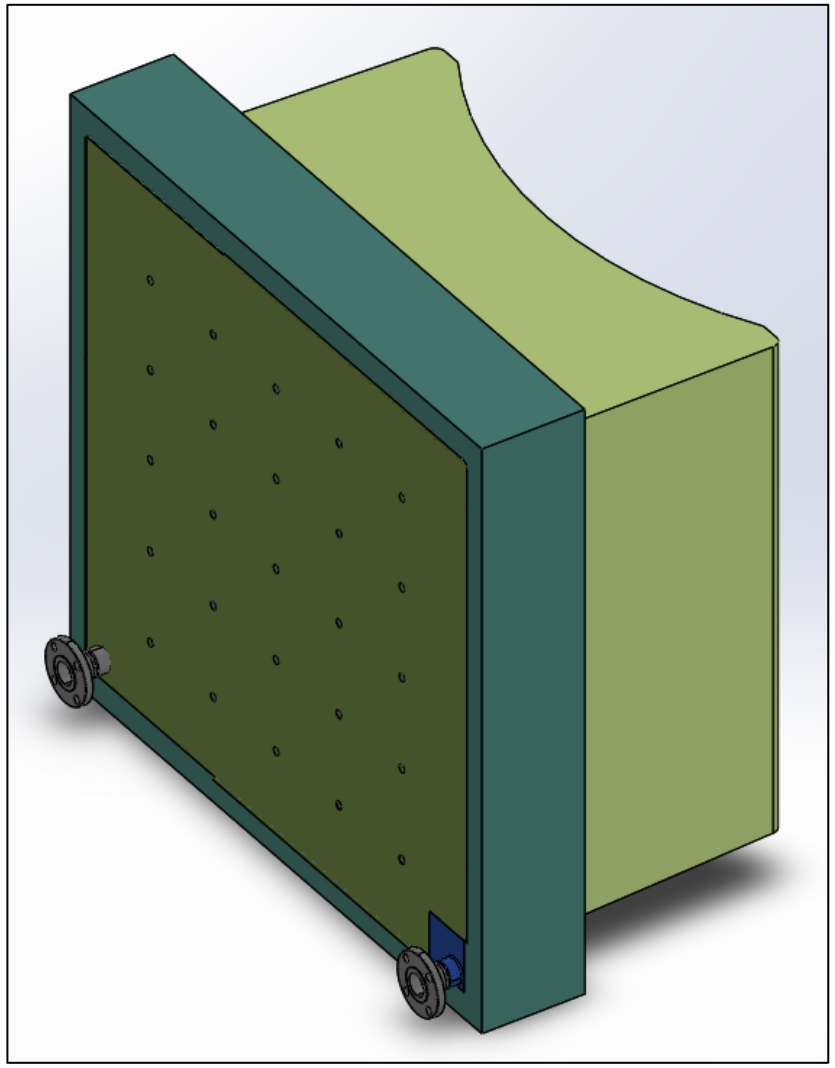
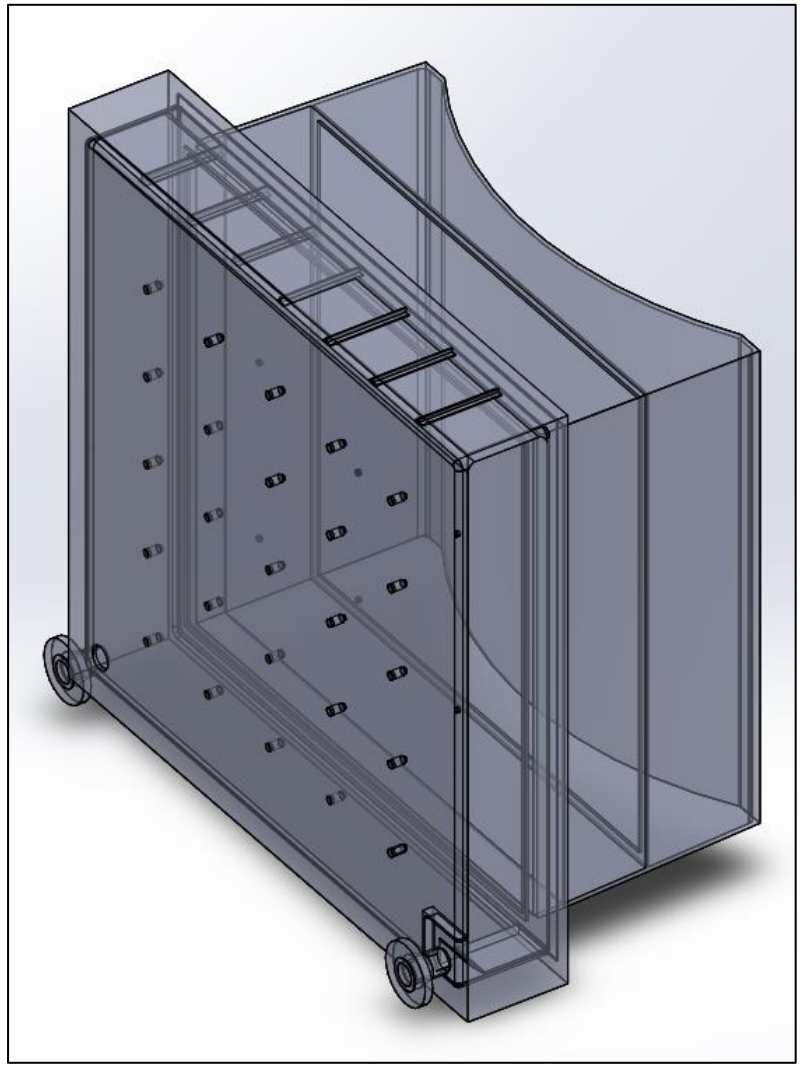
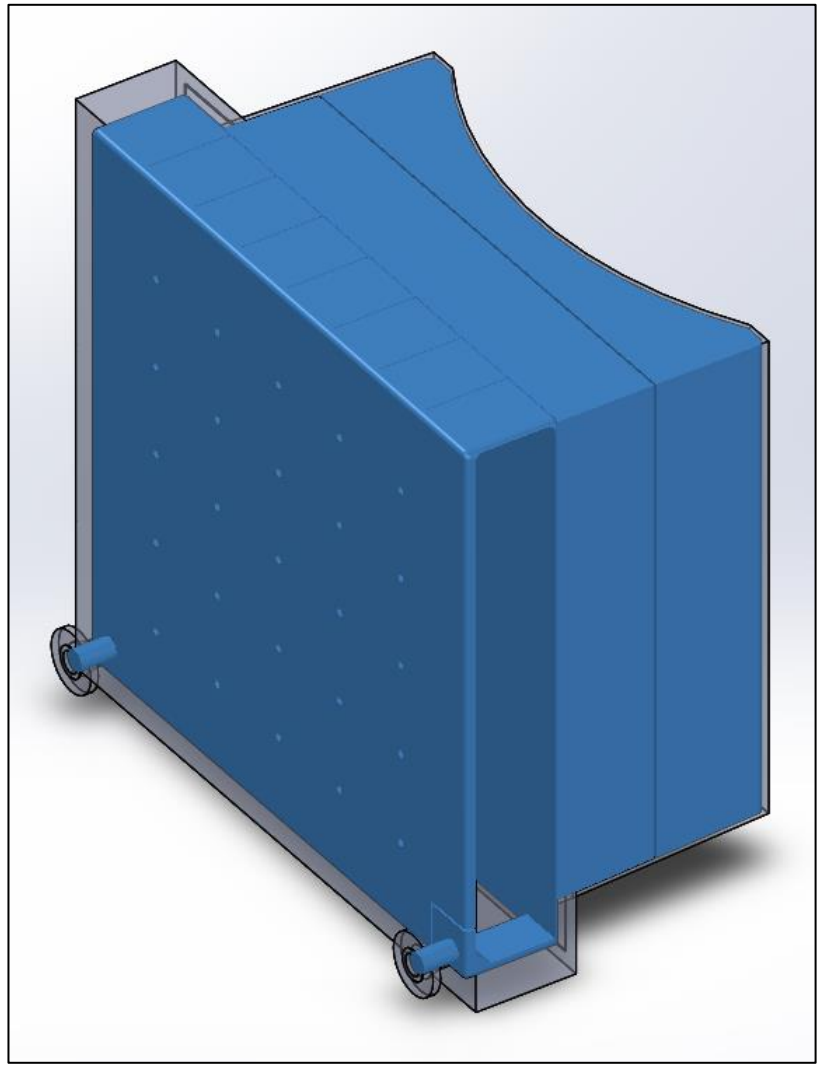


Thermal Column Tank



Thermal Column Mold



Fluid Subdomain

CFD Results: Flow

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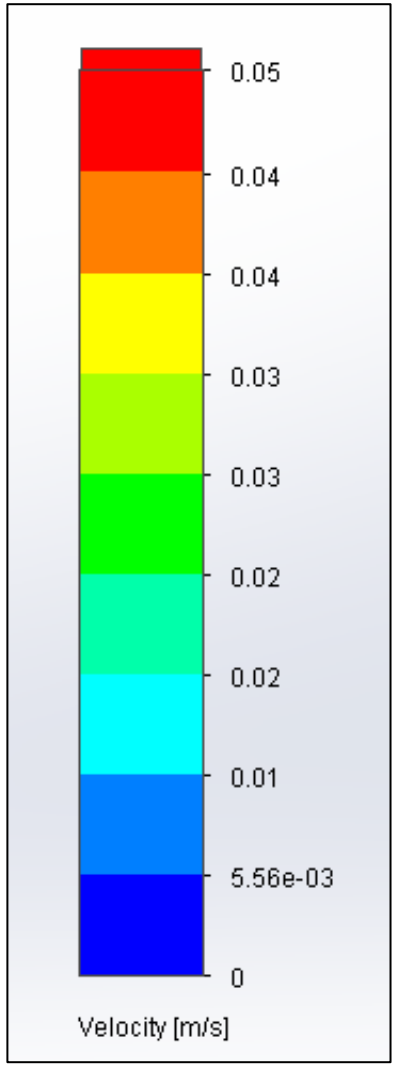
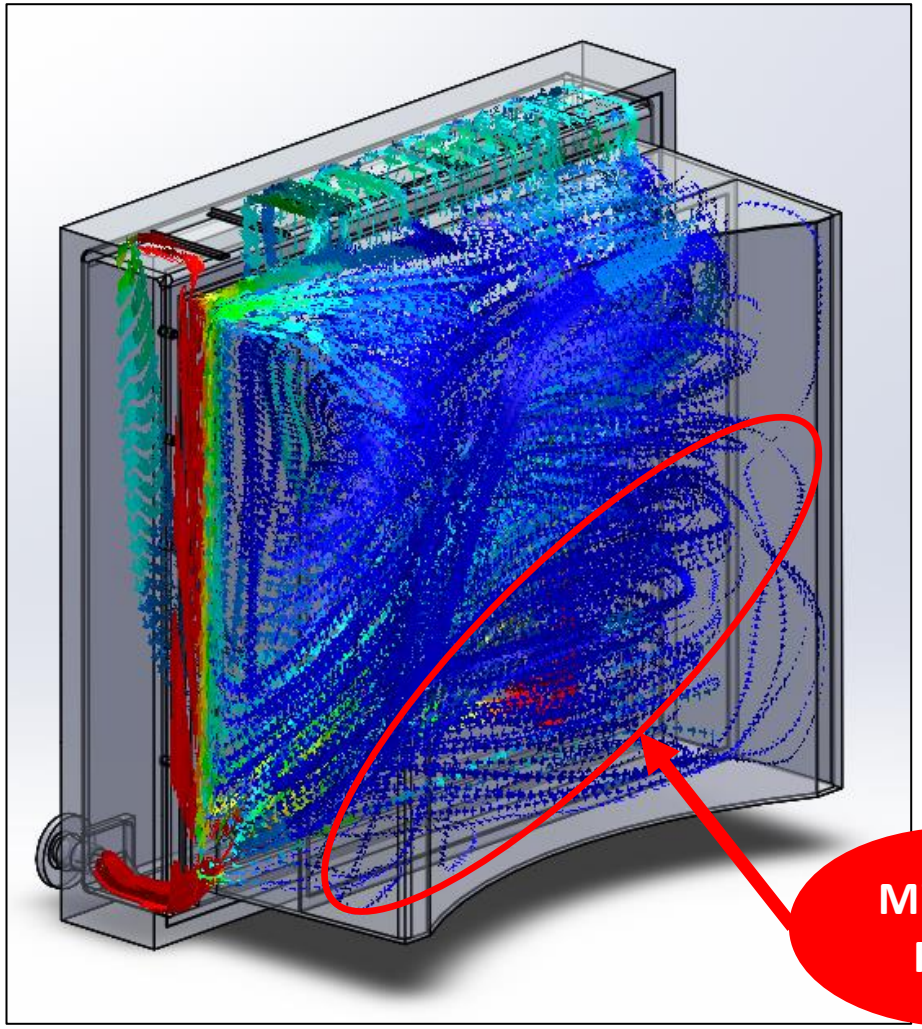
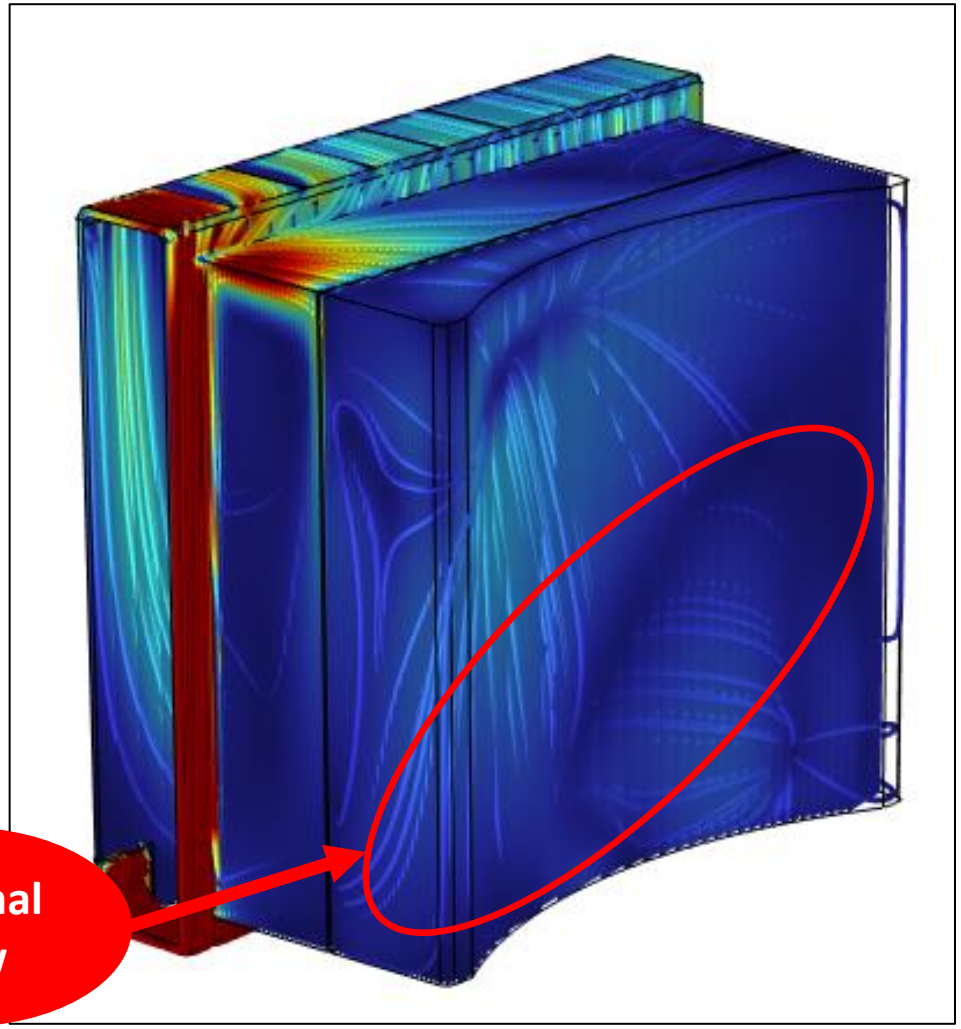
Thermal Column Tank Water Velocity Flow Trajectories Without Heat Transfer







Minimal Flow

SolidWorks
(k-ϵ, 15% Turbulence Intensity)

COMSOL Multiphysics
(k-ϵ, 15% Turbulence Intensity)

CFD Results: Flow

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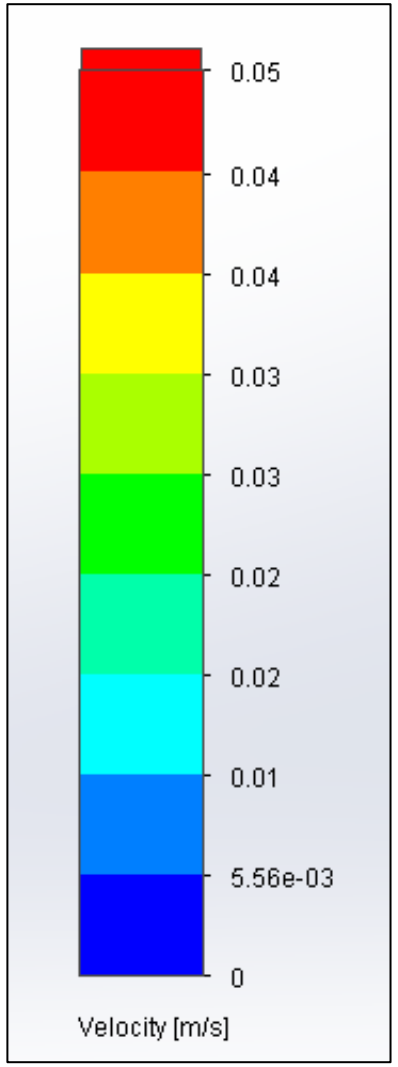
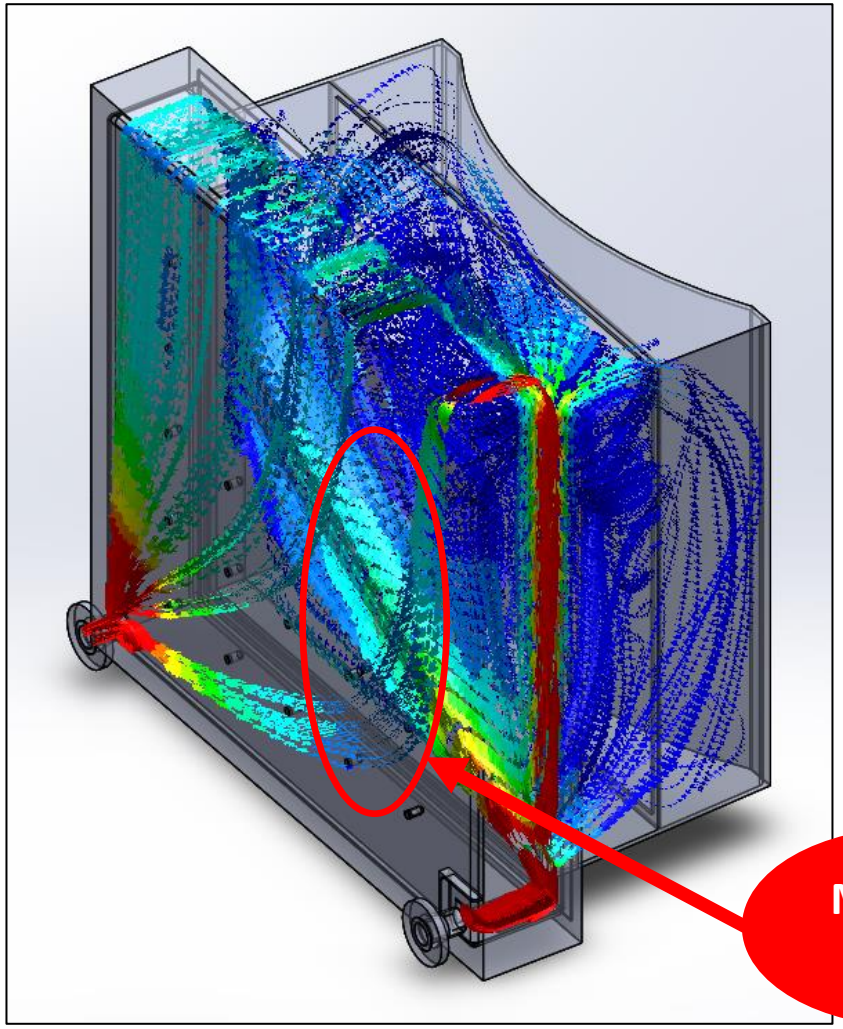
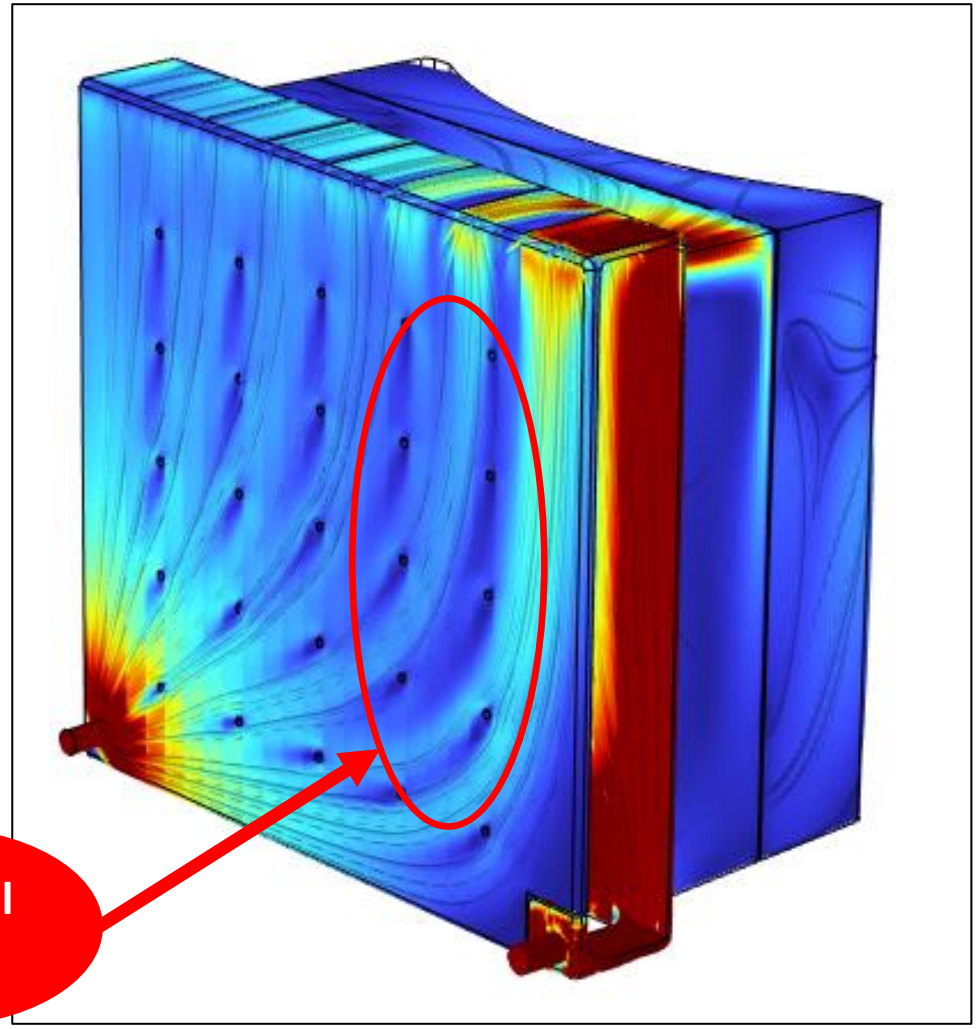
Thermal Column Tank Velocity Flow Trajectories Without Heat Transfer





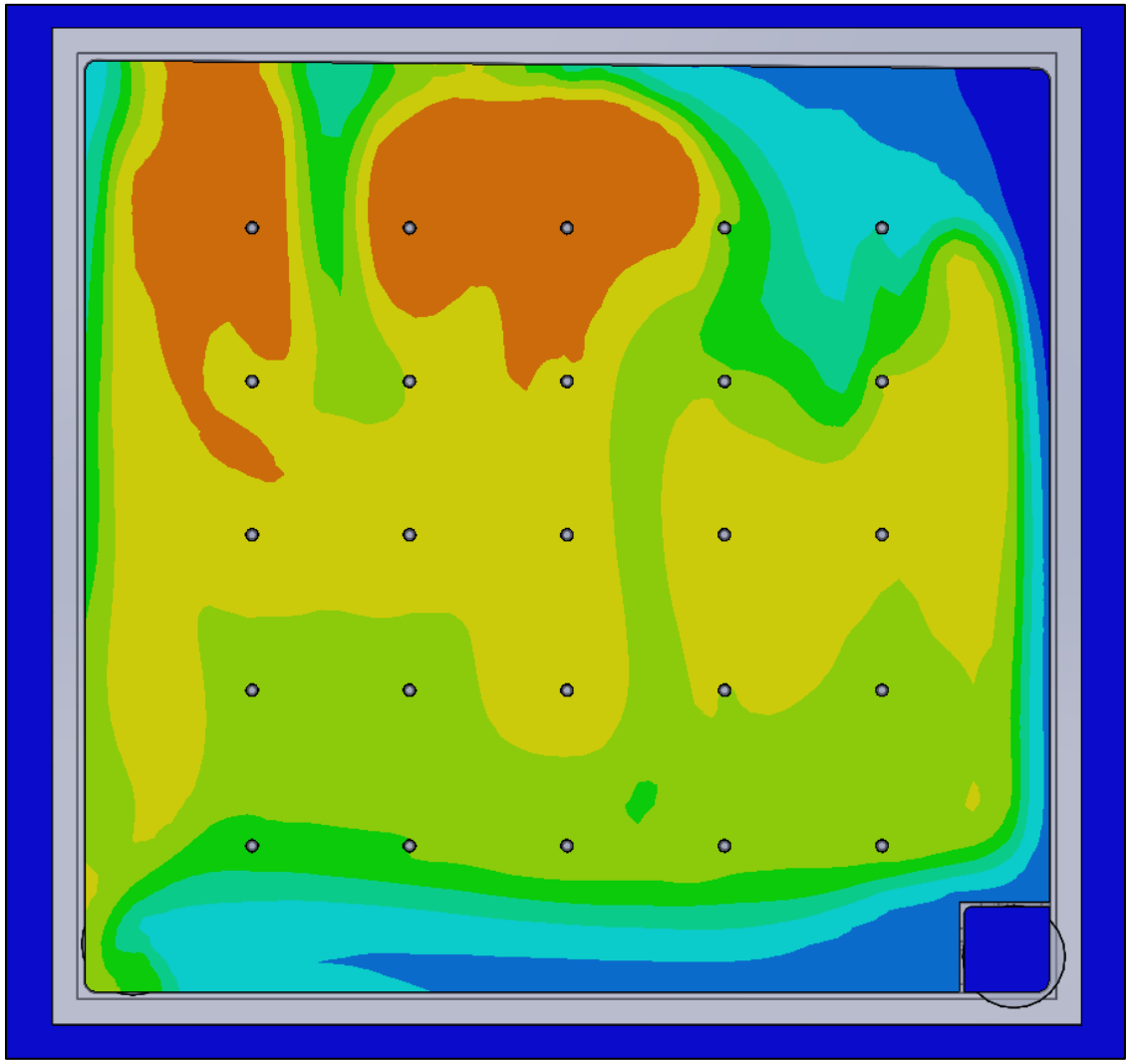


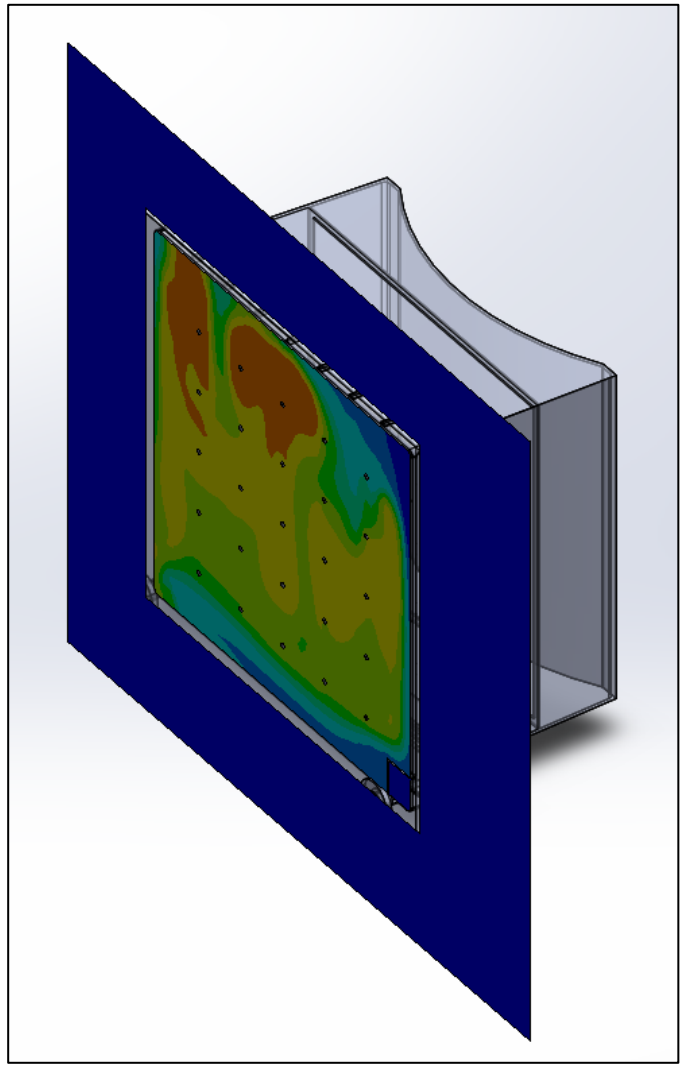
Minimal Flow

SolidWorks
(k-ϵ, 15% Turbulence Intensity)

COMSOL Multiphysics
(k-ϵ, 15% Turbulence Intensity)

CFD Results: Heat





Thermal Column Tank Water Temperature Cut Plot With Heat Transfer - SolidWorks

Future Work

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- Further expand CAD models:
  - Update existing CAD models for basement systems
  - Insert existing CAD models into SolidWorks assembly
  - Create new models for other basement systems
  - Continue reactor piping
- Perform further analysis:
  - Aging reactor has aging systems
  - Determine when maintenance is needed
  - Good models makes for easy computational analysis
- Update technical drawings:
  - Engineers submit tickets
  - Review is conducted and appropriate changes are made

Acknowledgements

- Mentors: Dr. Abdullah Weiss and Daniil Sokol
- SURF and NCNR Directors:
  - Cara O'Malley
  - Julie Borchers
  - Leland Harriger
  - Susana Teixeira
- Fellow SURF Students
- NCNR ROE
- Neutrons Softball

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Questions?

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Appendices

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Confinement Basement

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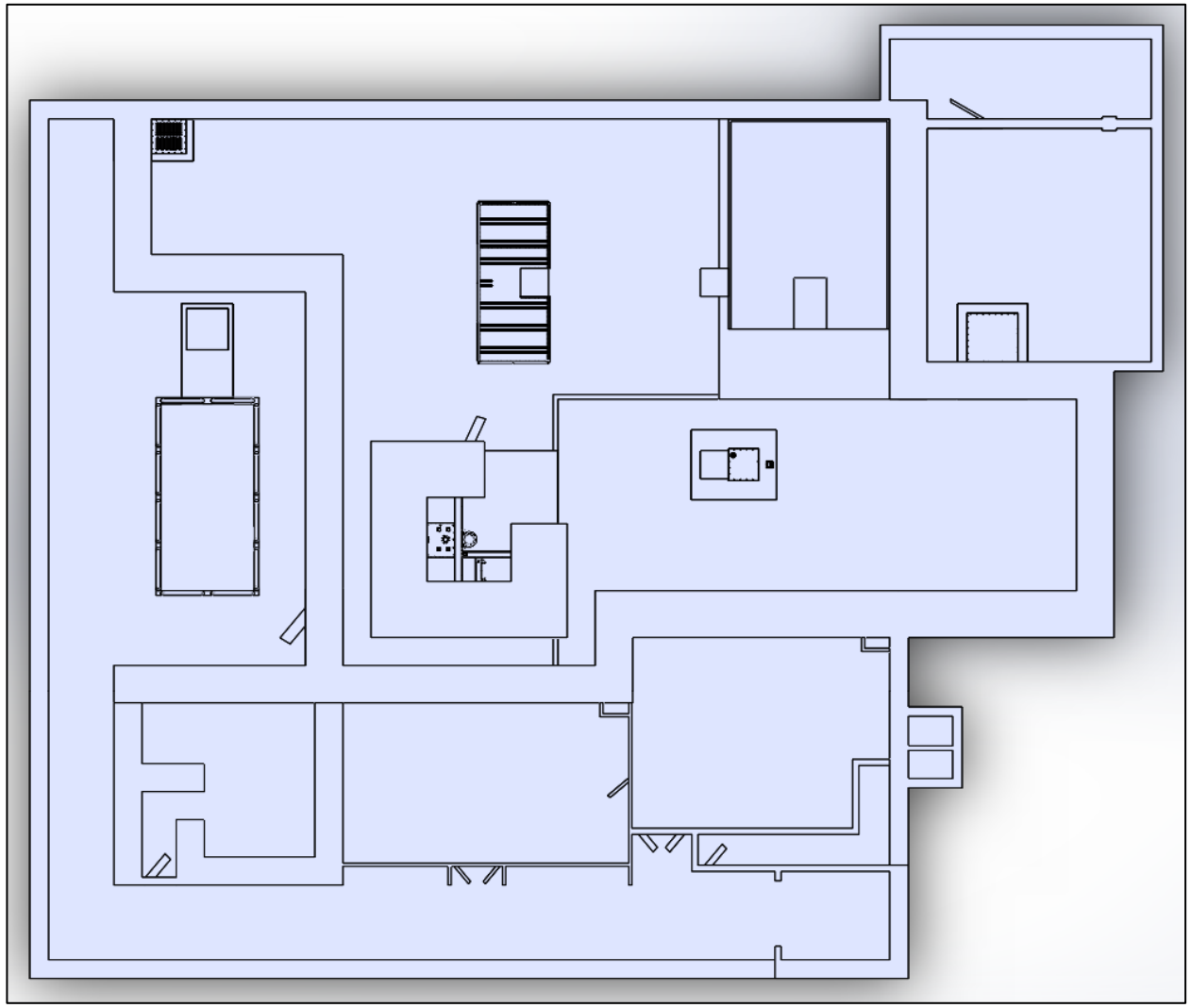
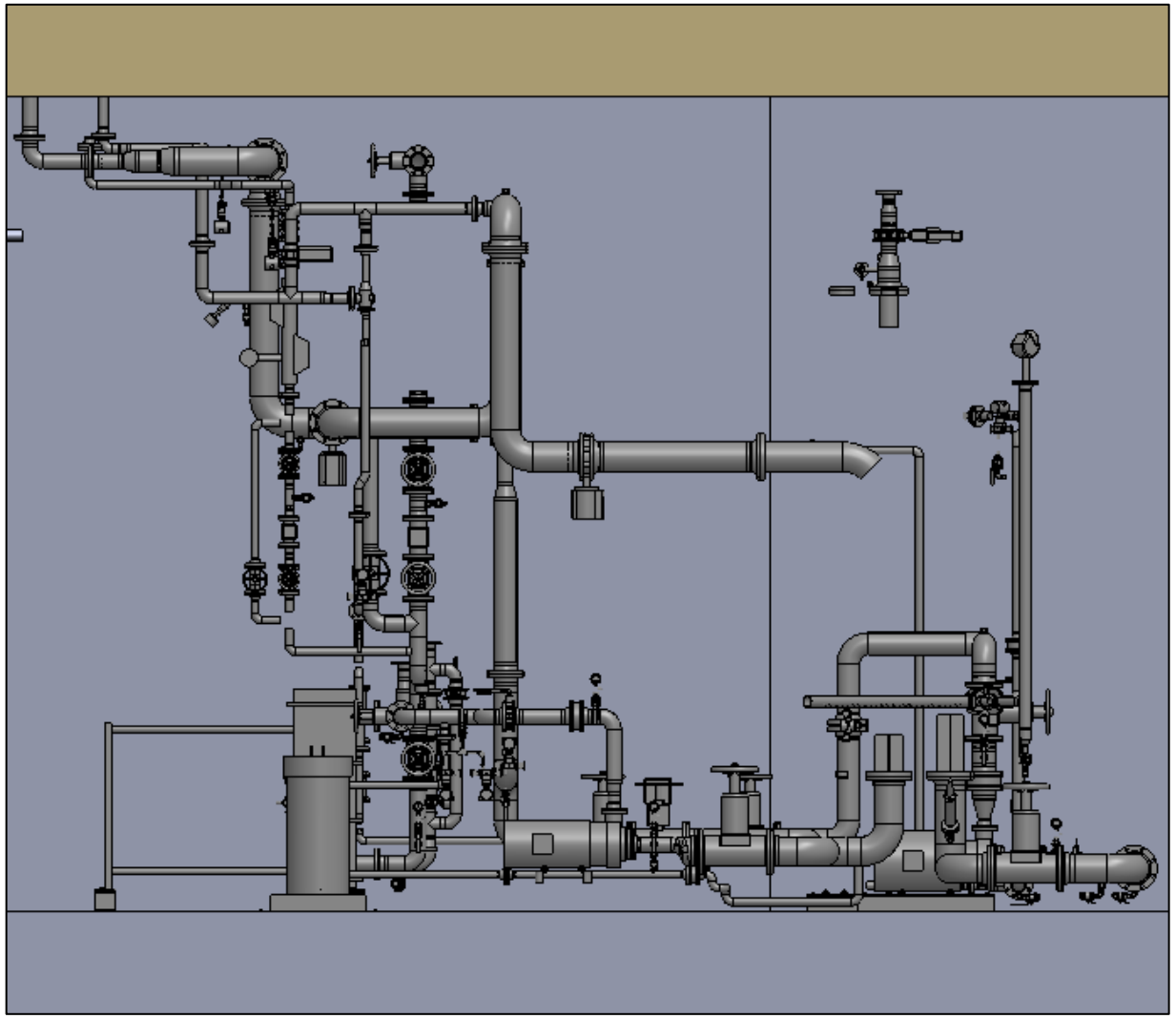
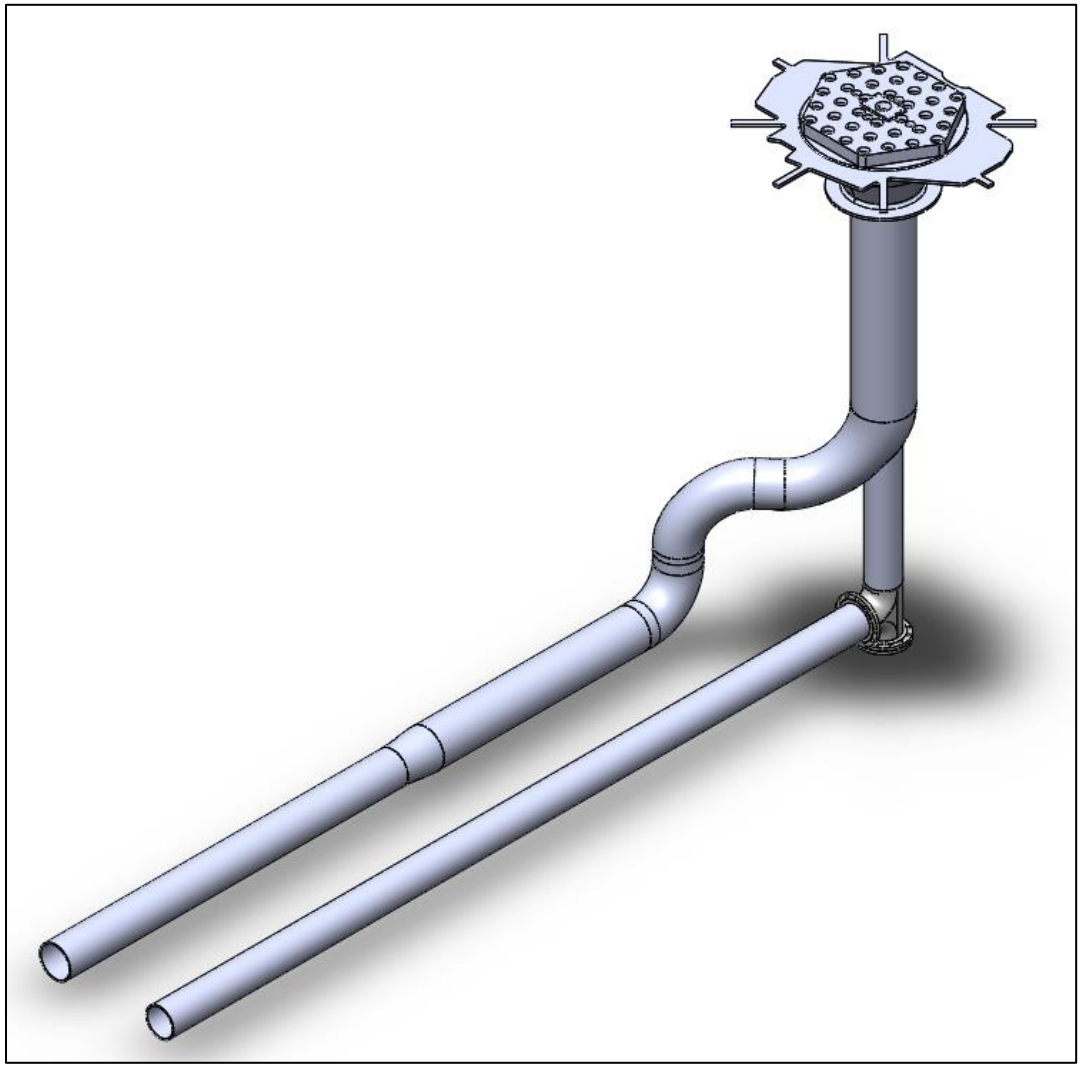


Confinement Basement Top View

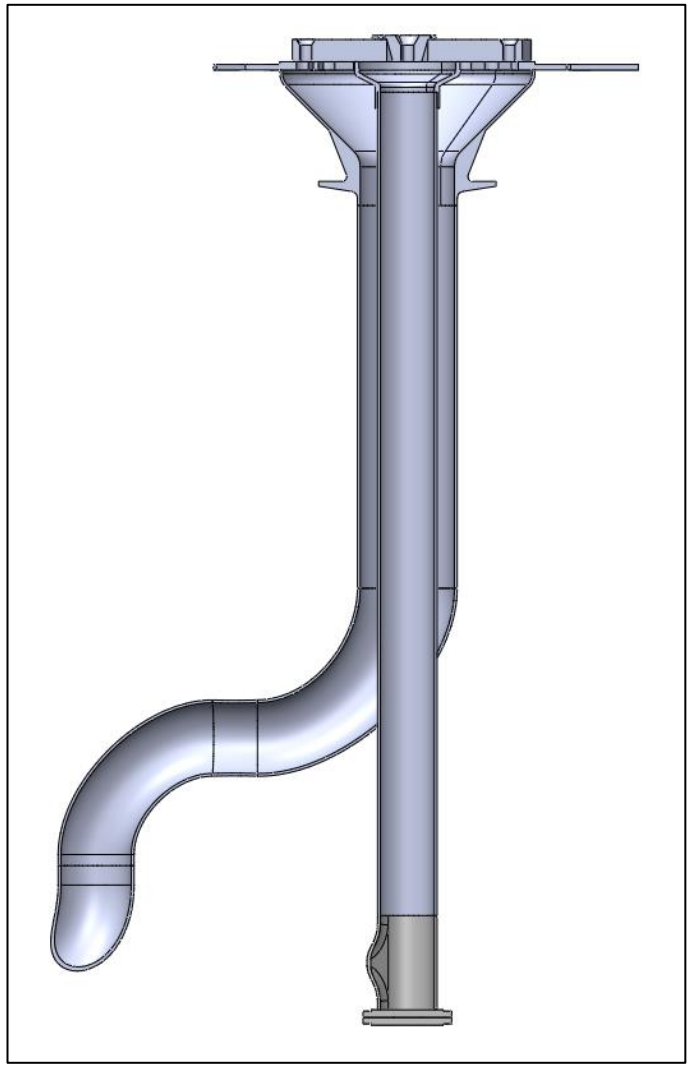


Process Room Side View Cross-Section

Reactor Inlet



Reactor Inlet Isometric View



Reactor Inlet Cross-Section

Level Control Pipe

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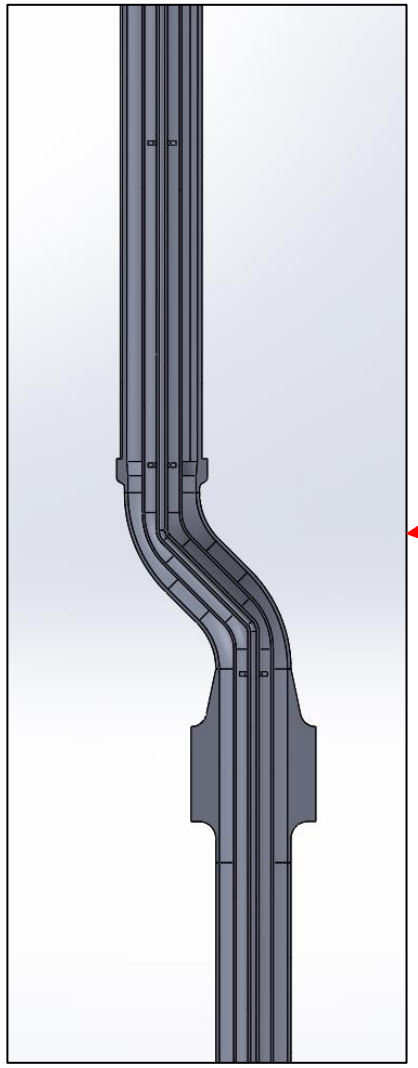
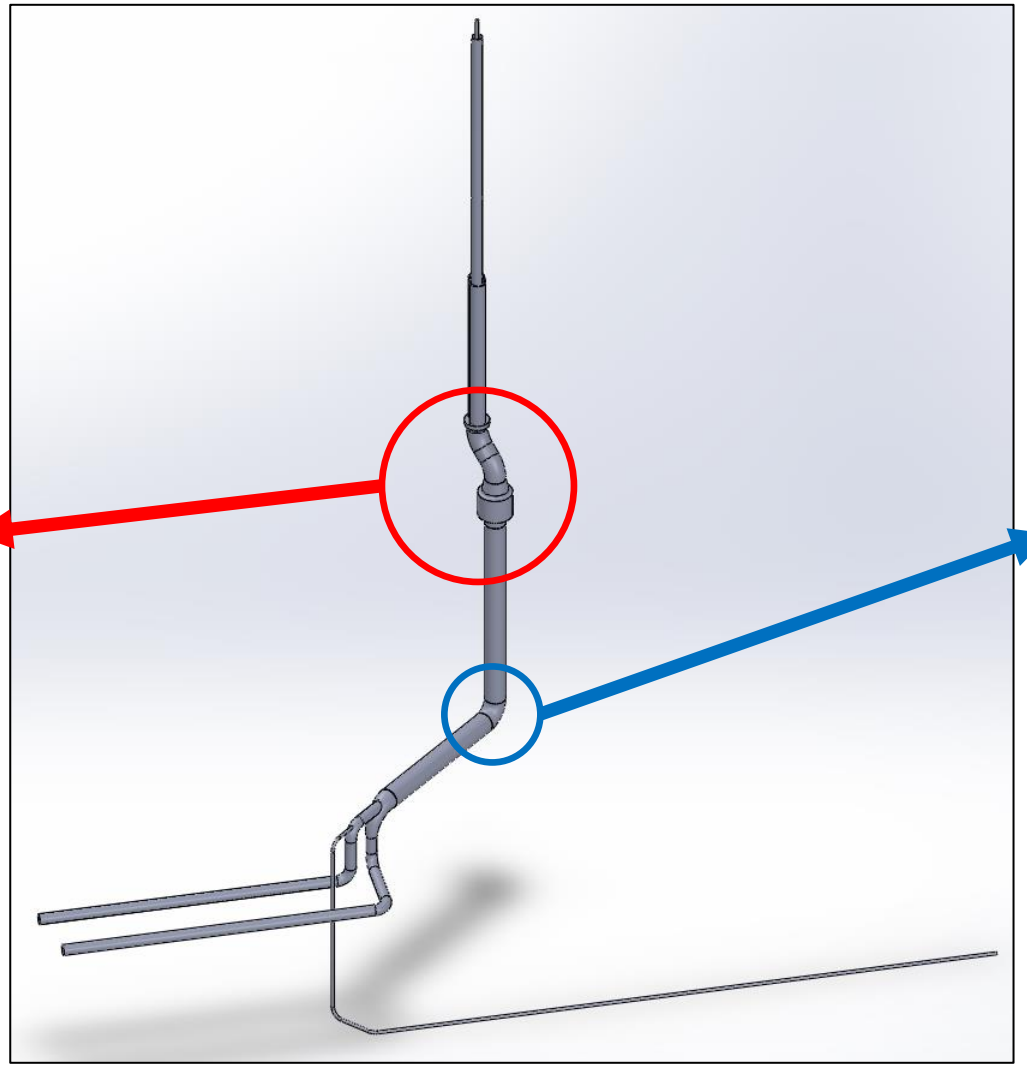
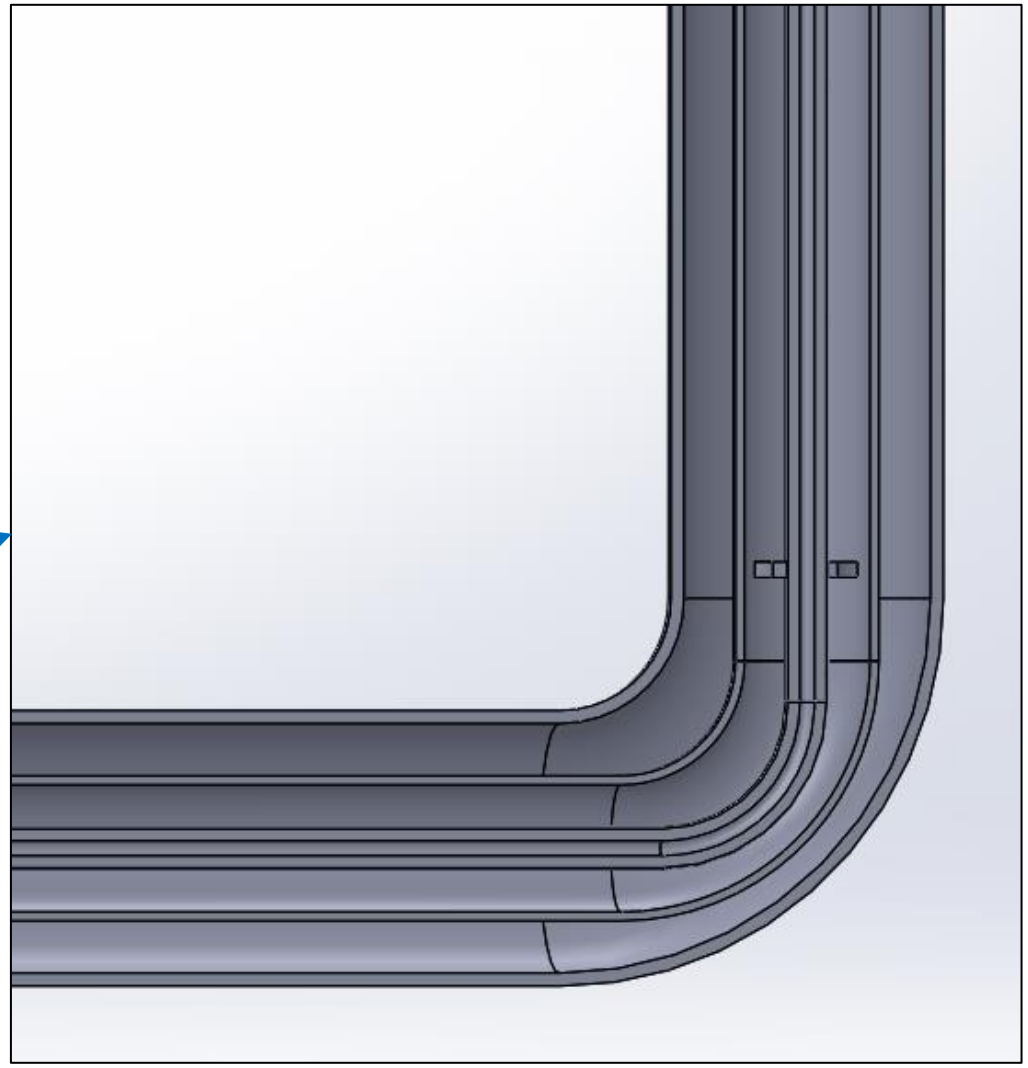


Pipe Transition

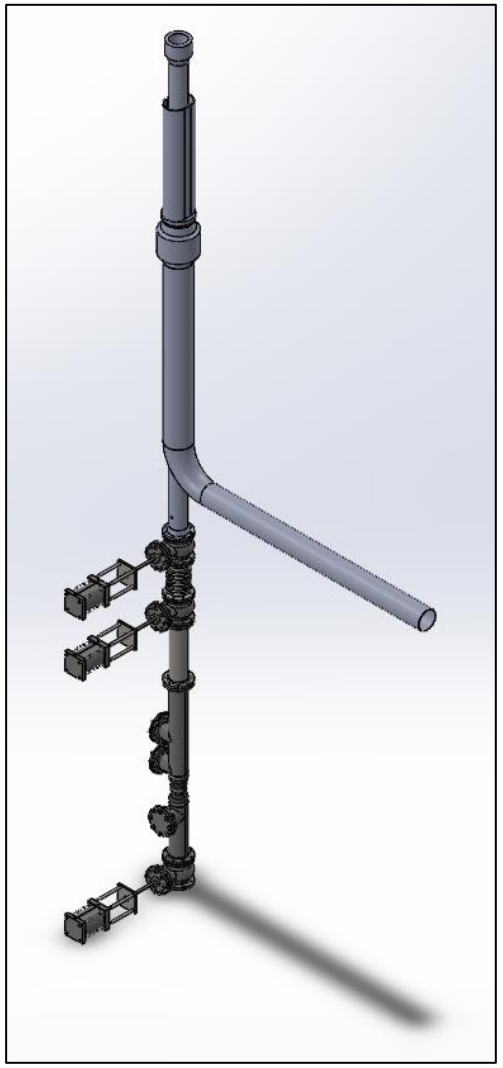


Level Control Pipe Isometric View

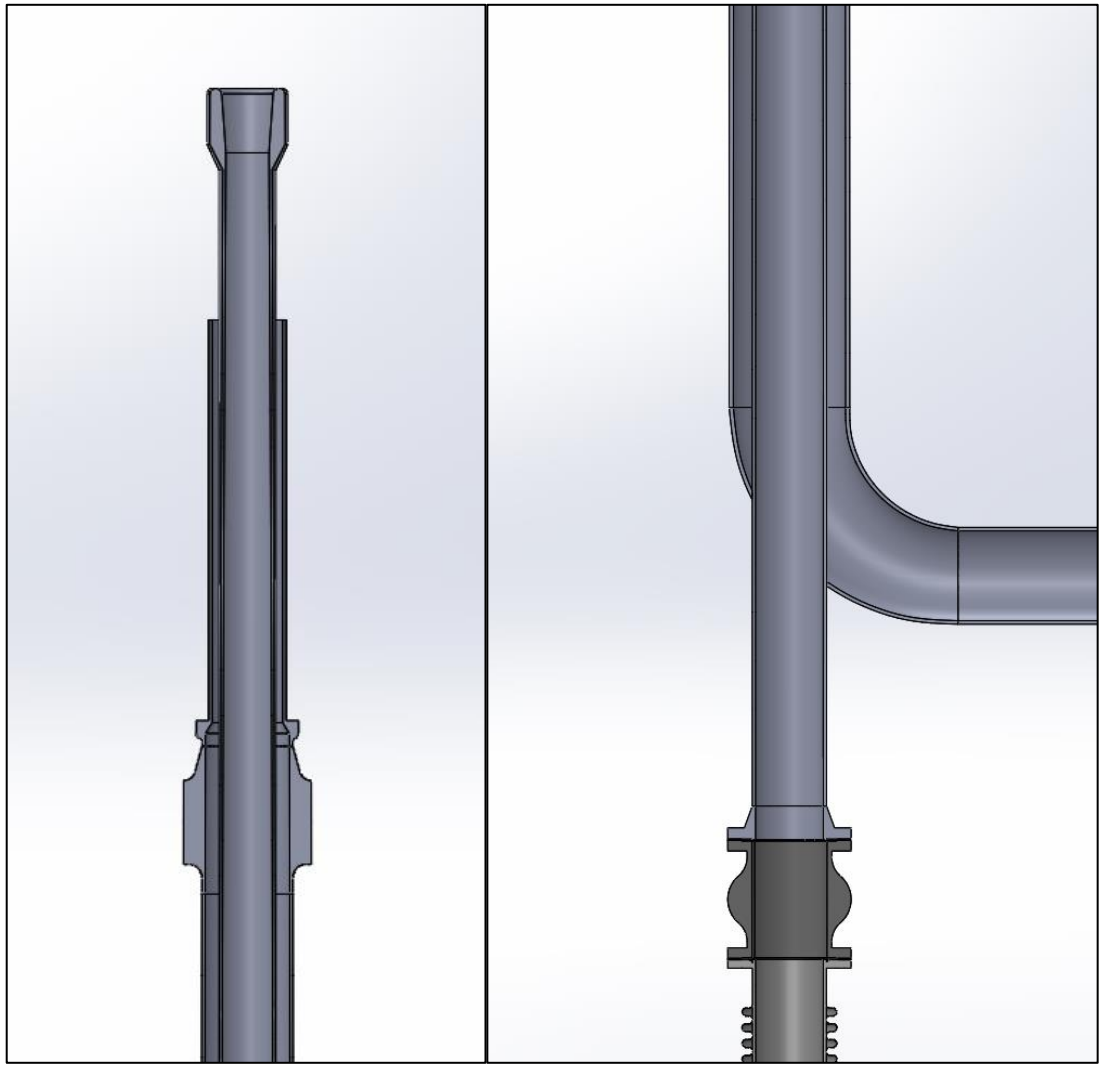


Pipe Elbow

Fuel Transfer System

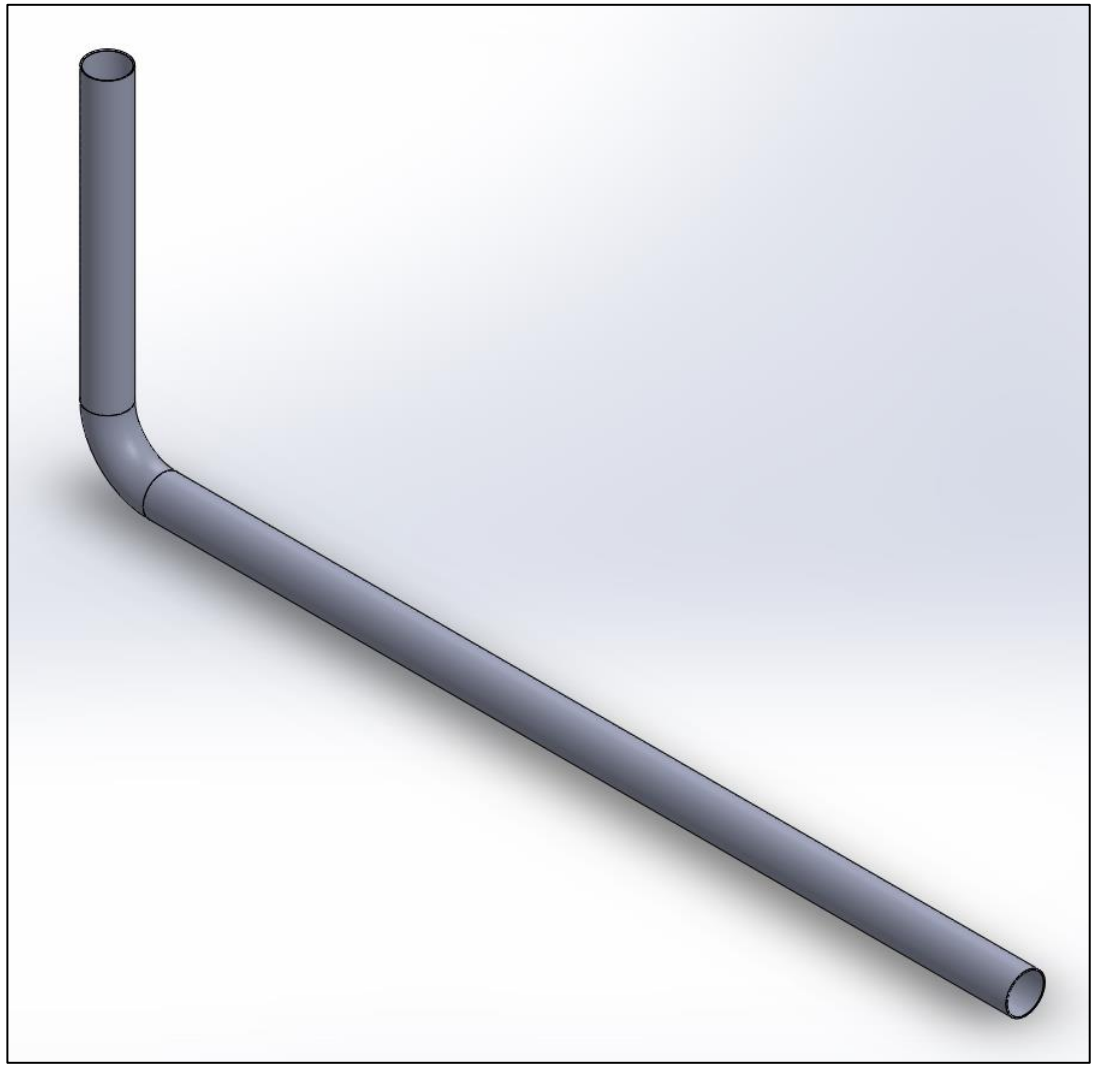


Fuel Transfer System Isometric View



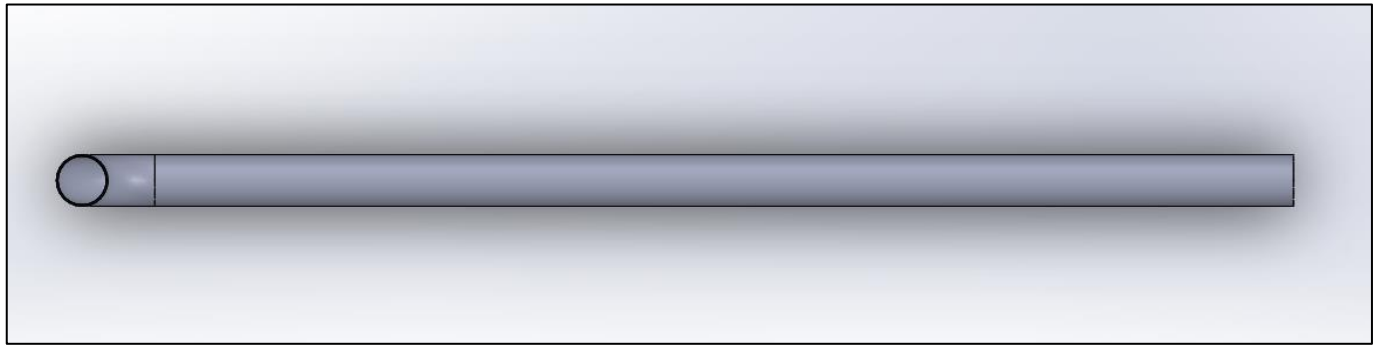
Fuel Transfer System Cross-Section

Coolant Outlets



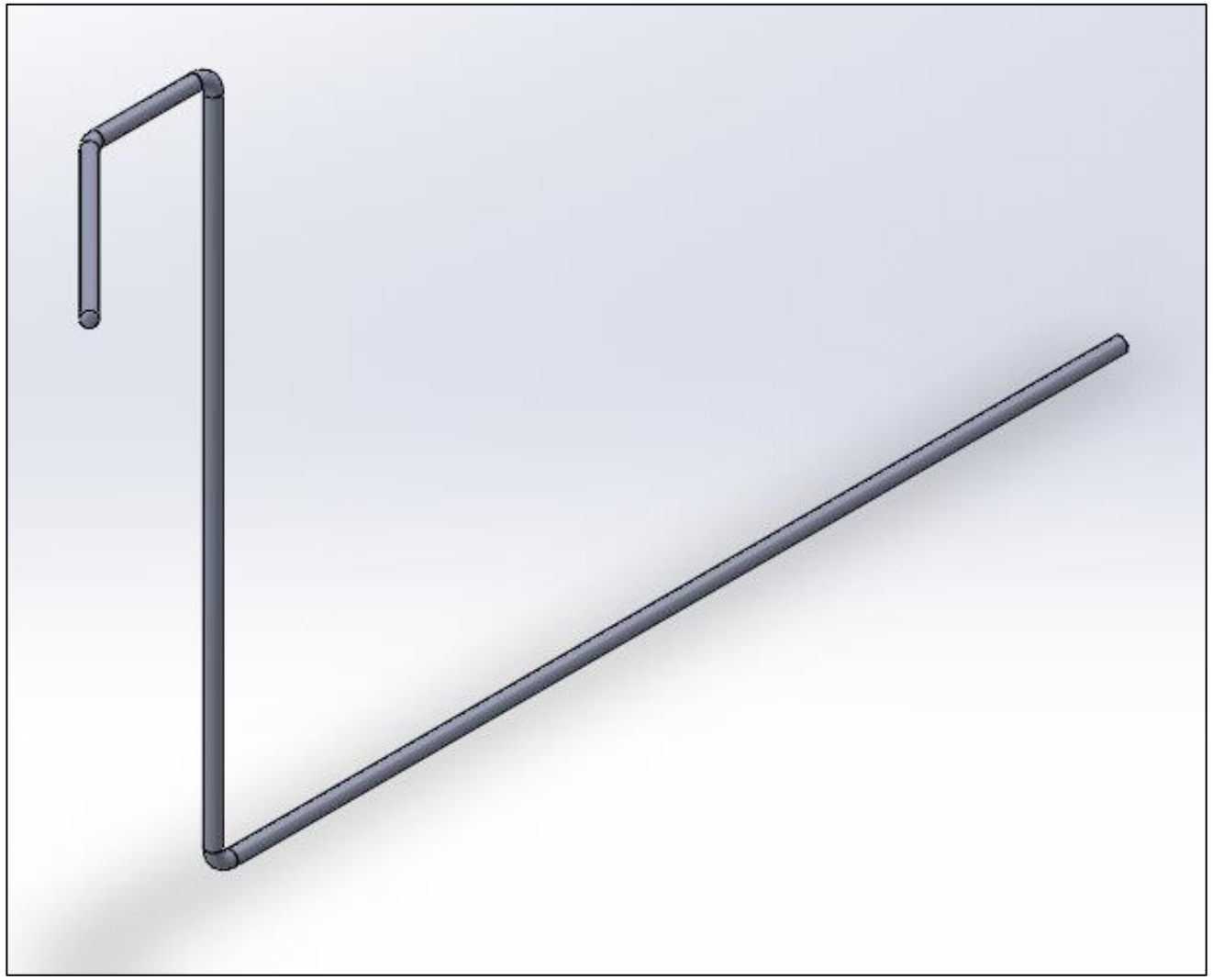
Coolant Outlet Isometric View

Coolant Outlet Side View



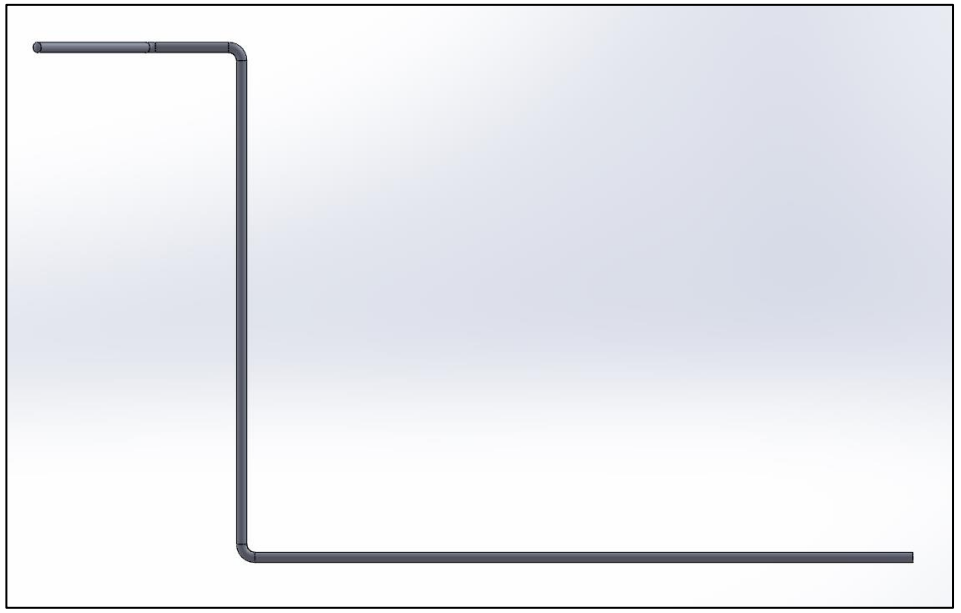
Coolant Outlet Top View

CO_2 Line



CO_2 Line Isometric View

CO_2 Line Top View



CO_2 Line Side View

Subpile Room Components

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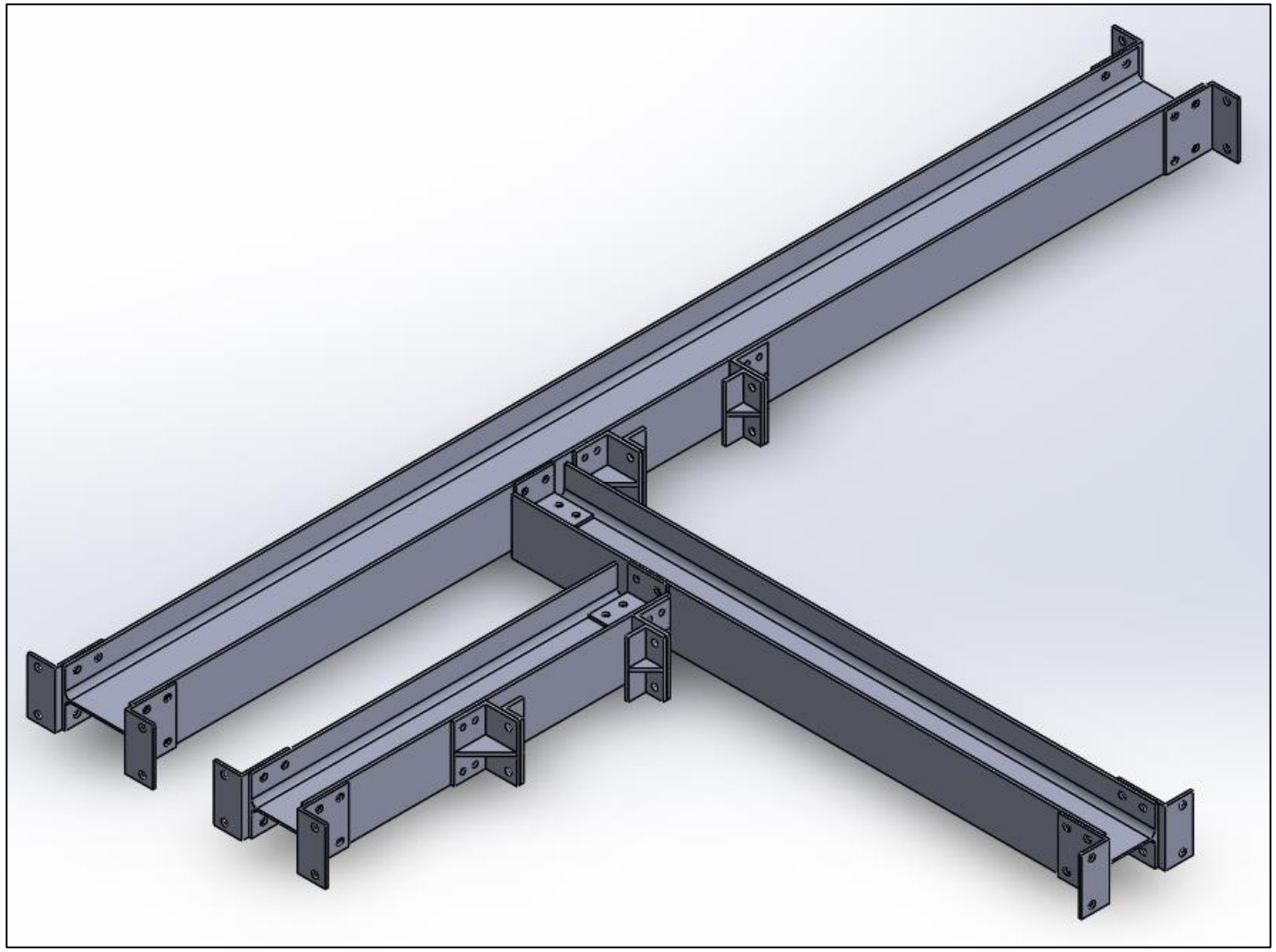
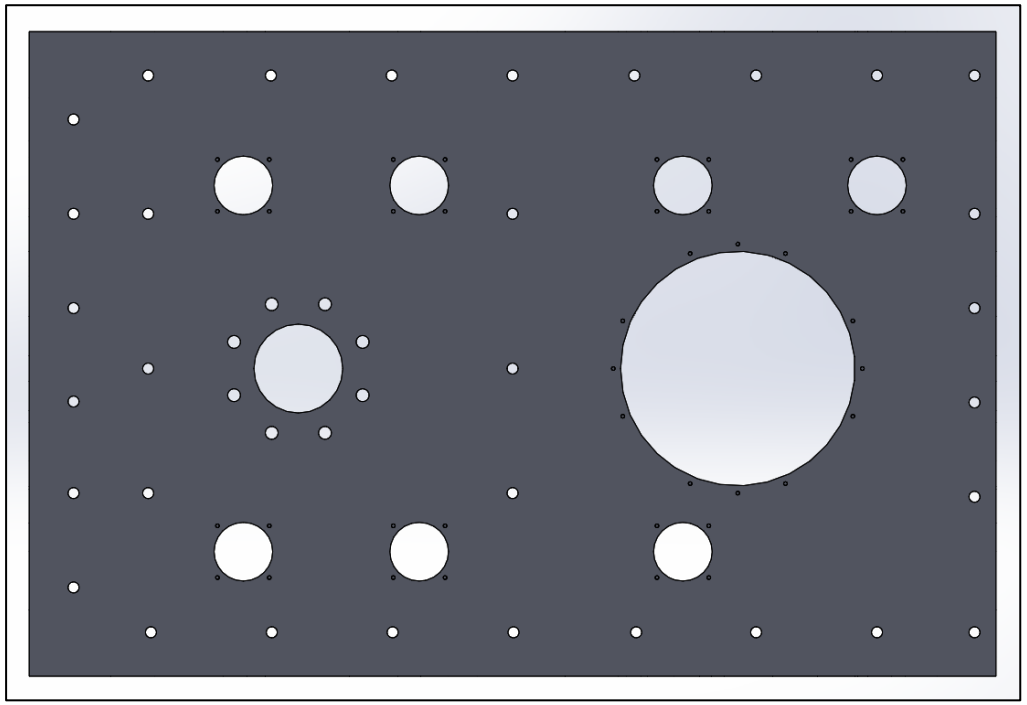
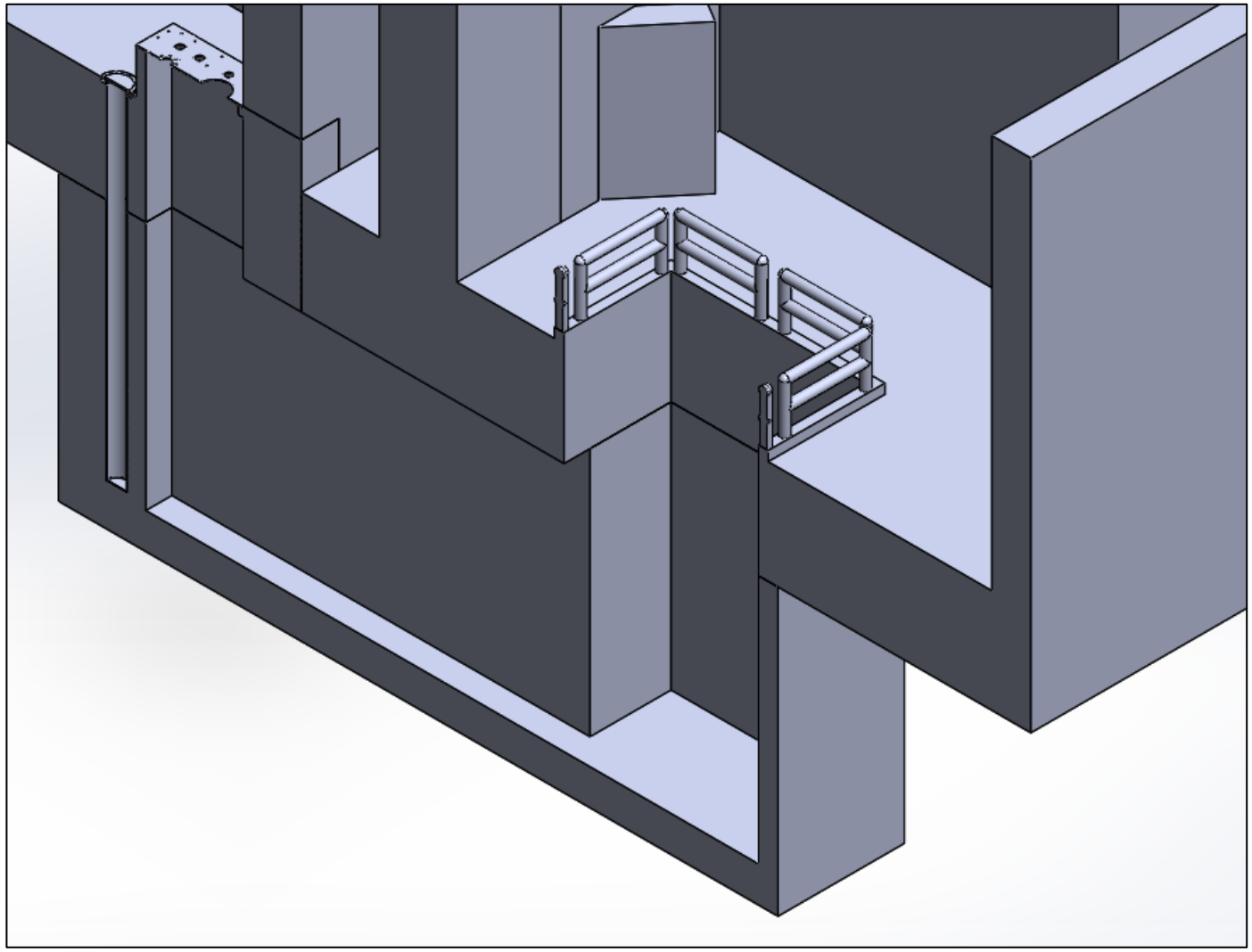


Subpile Room Support Beams Isometric View

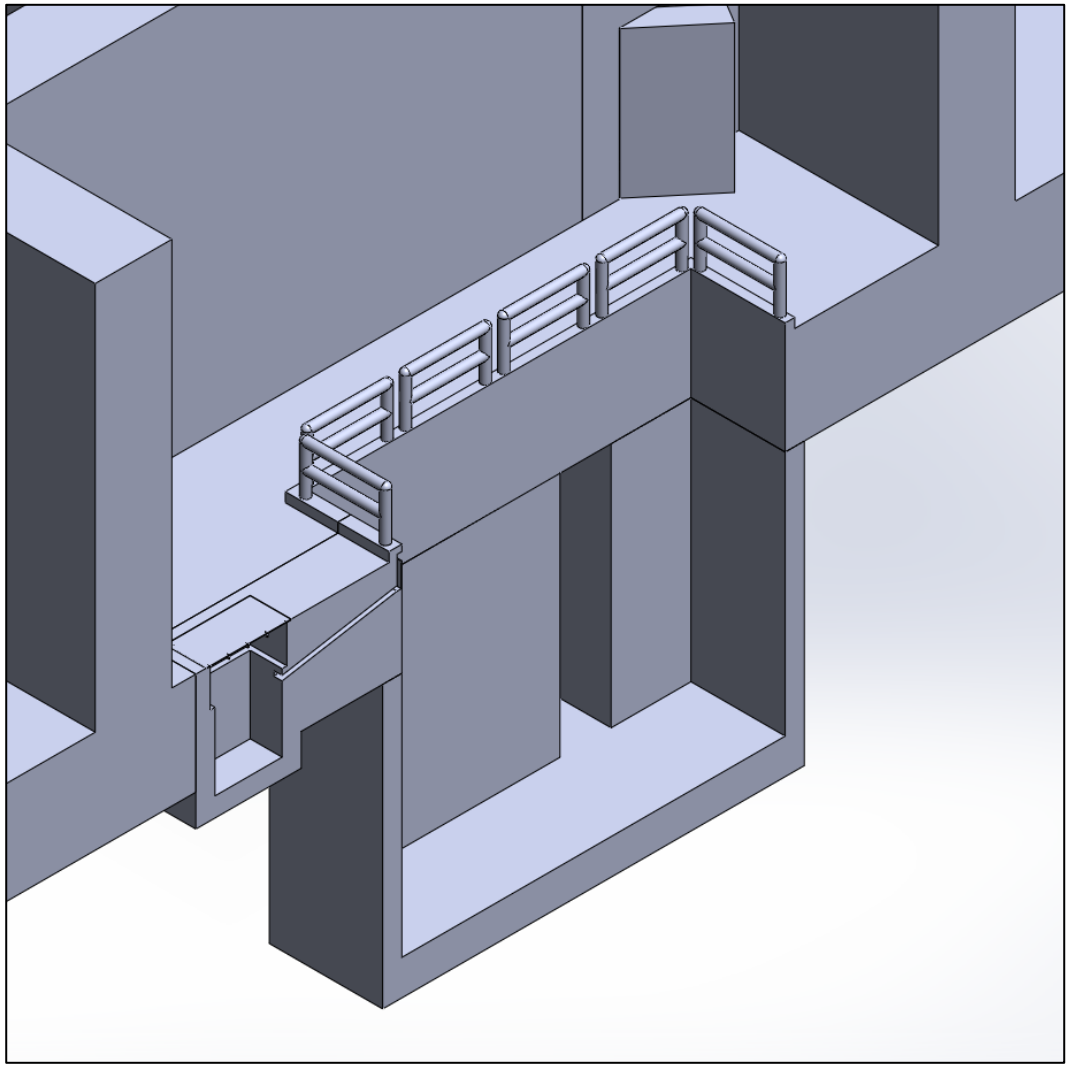


Subpile Room Cover Plate Top View

Subpile Room Canal



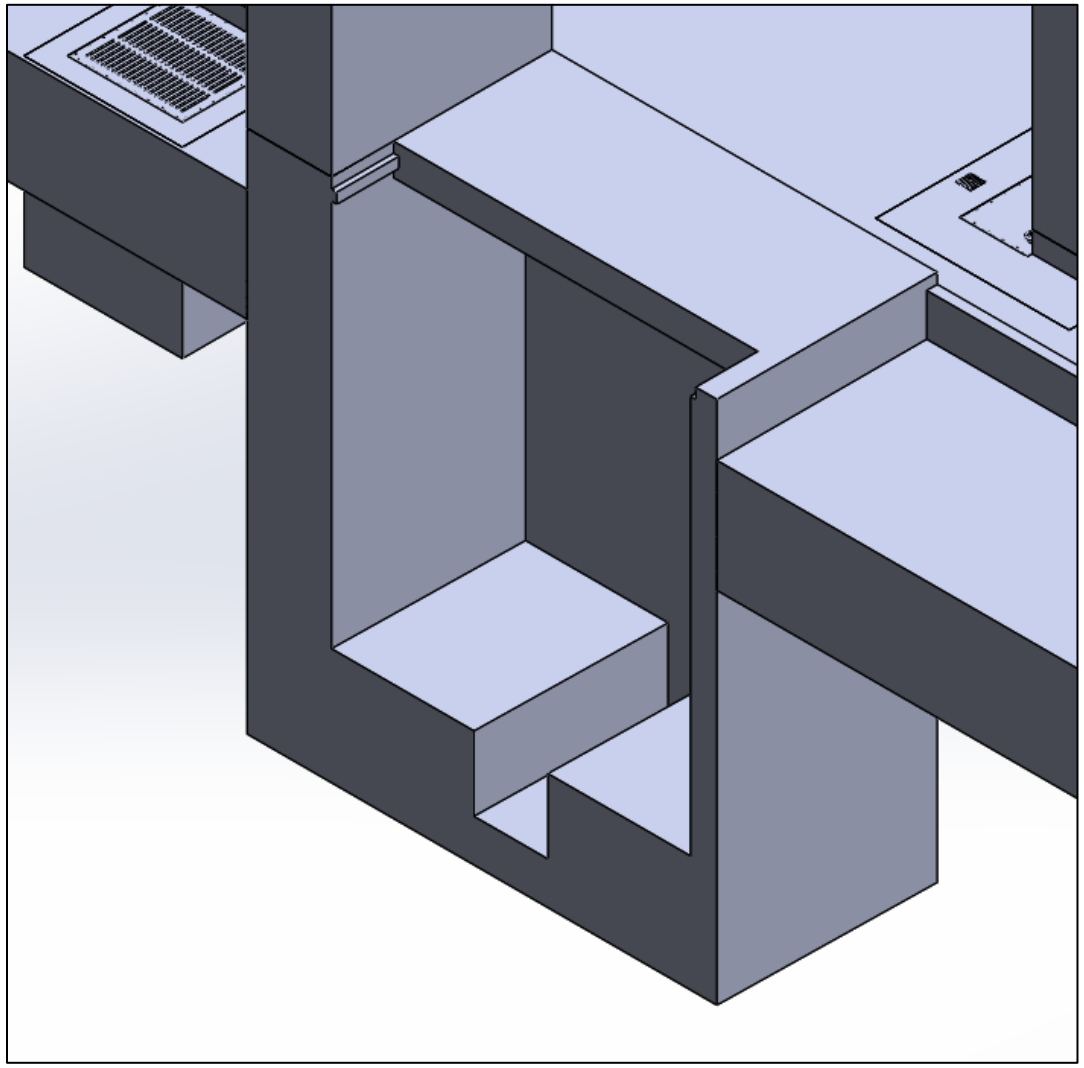
Subpile Room Canal N/S Cross-Section



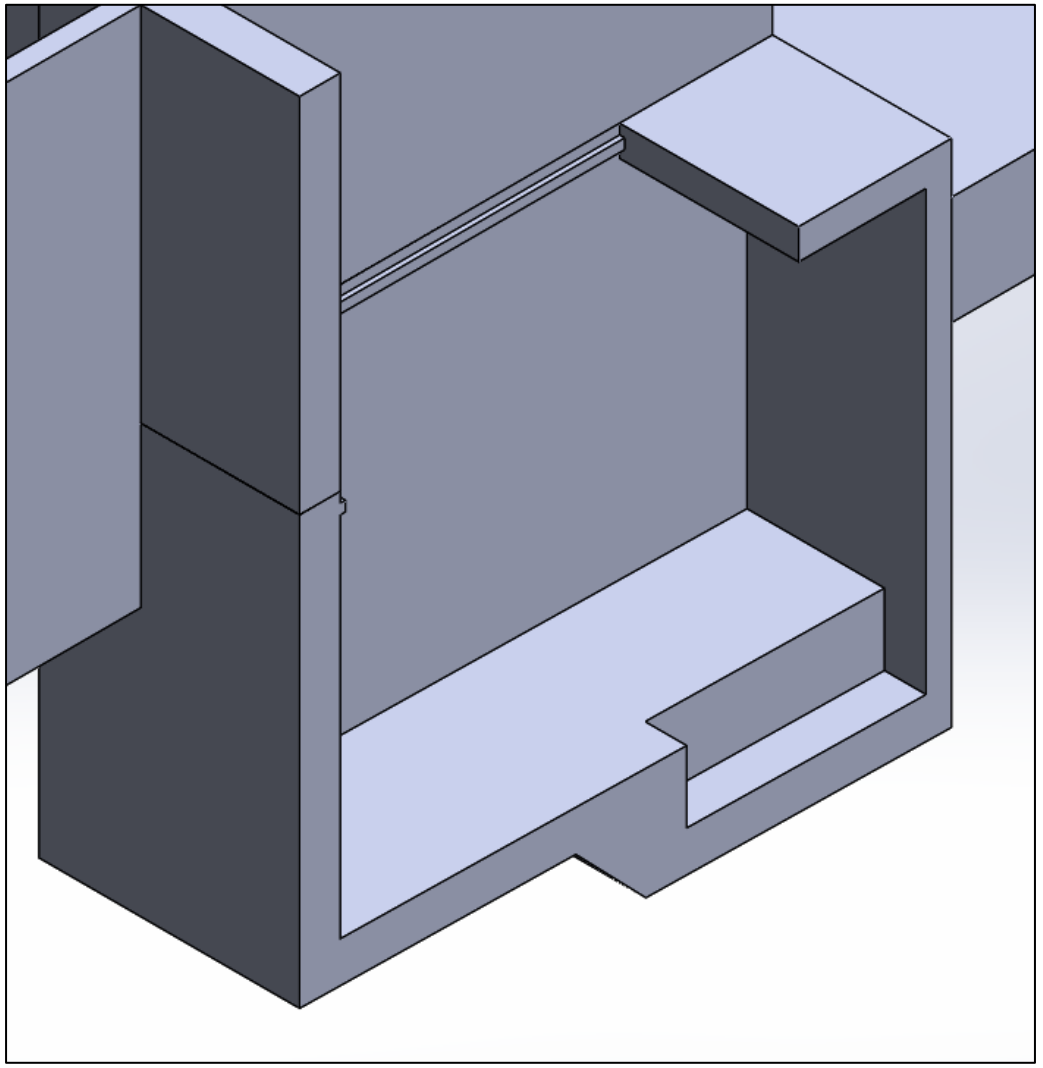
Subpile Room Canal E/W Cross-Section

Deuterium Tank

NIST CENTER FOR NEUTRON RESEARCH

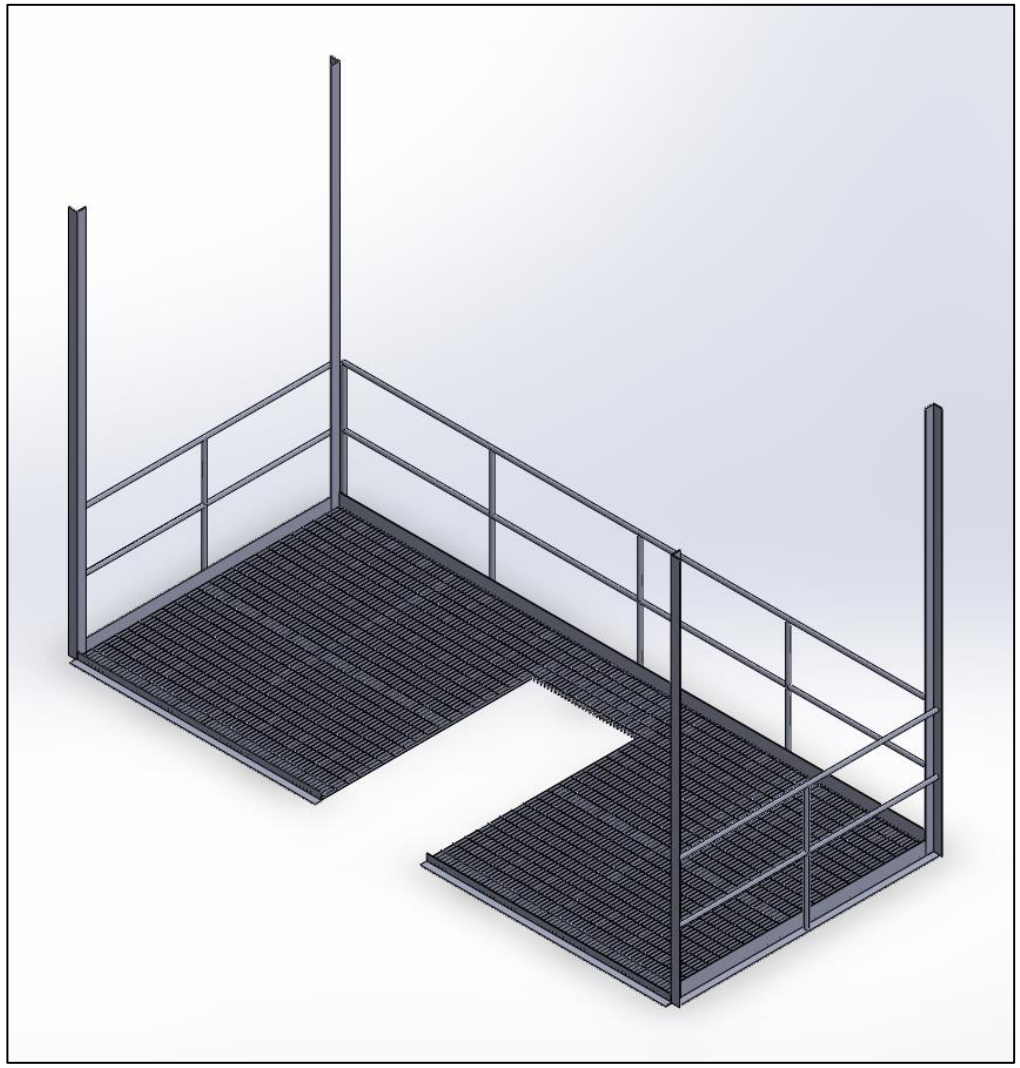


Deuterium Tank N/S Cross-Section

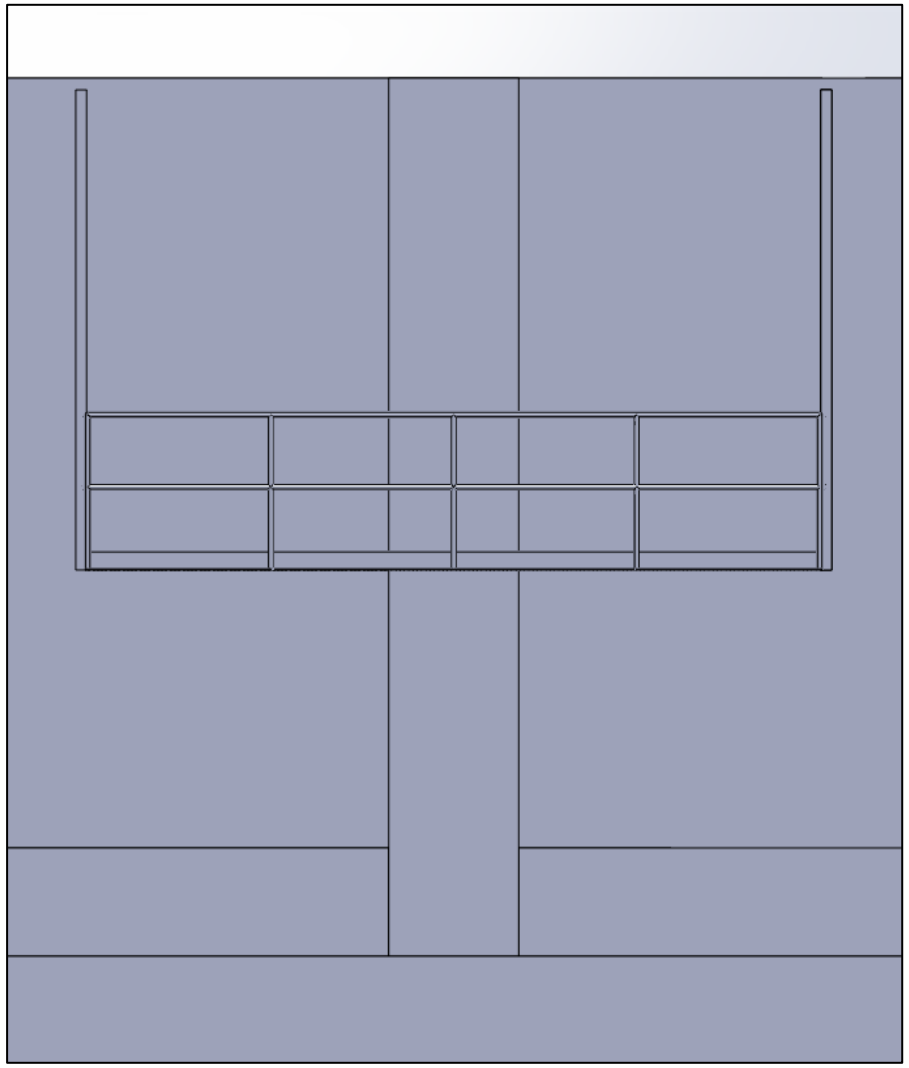


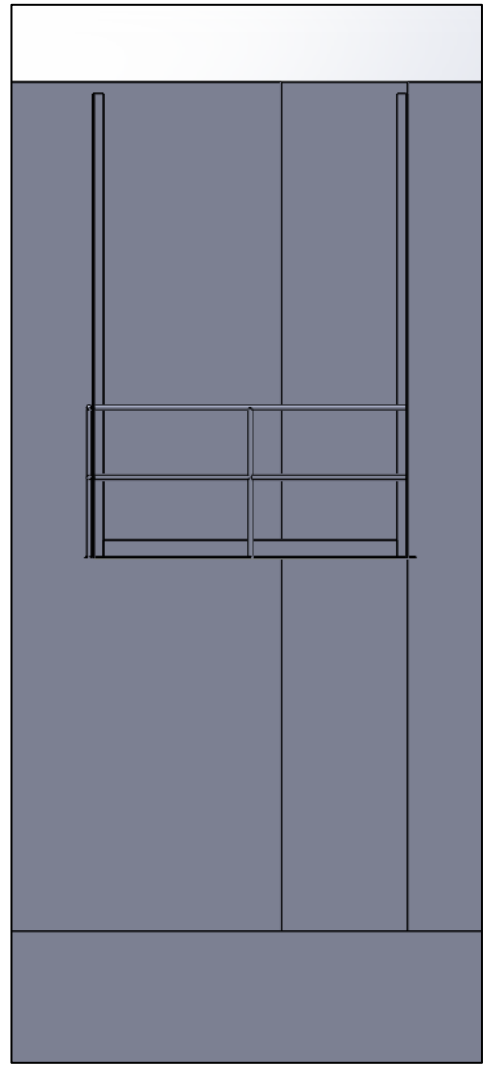
Deuterium Tank E/W Cross-Section

Gas Platform



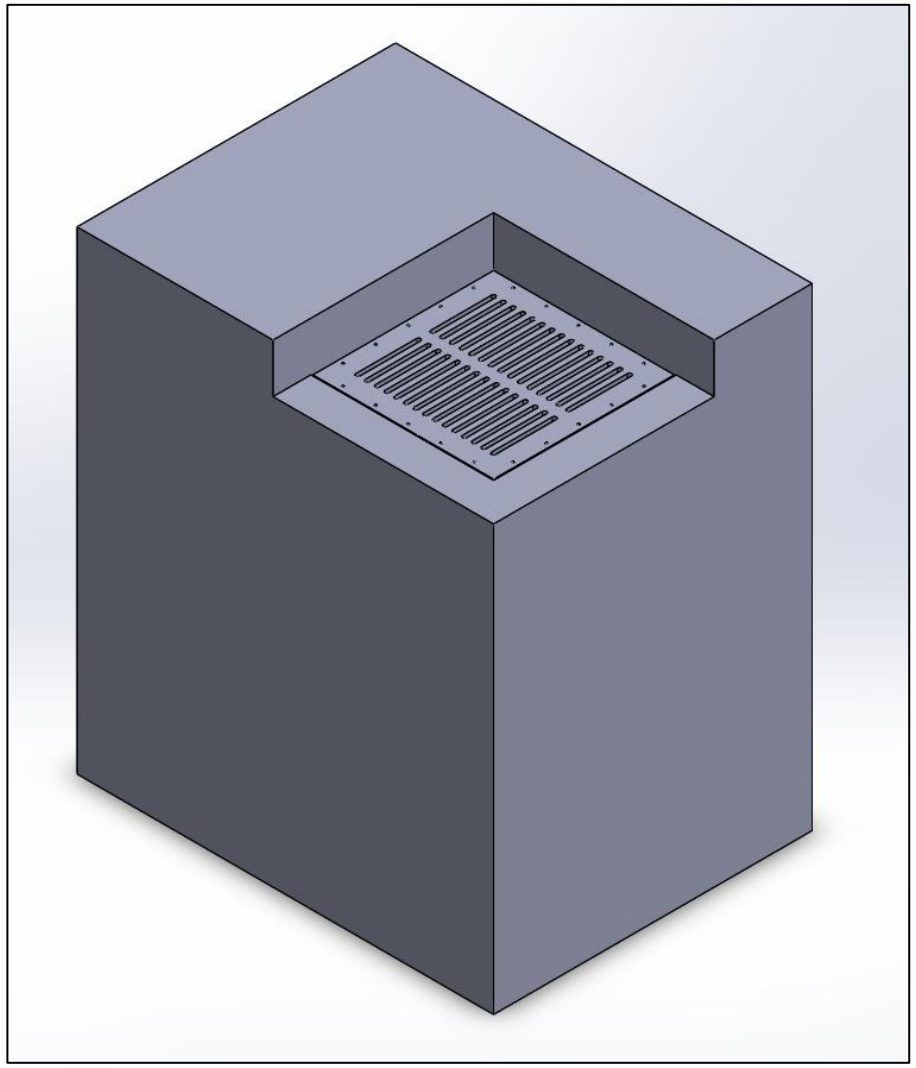
Gas Platform Isometric View



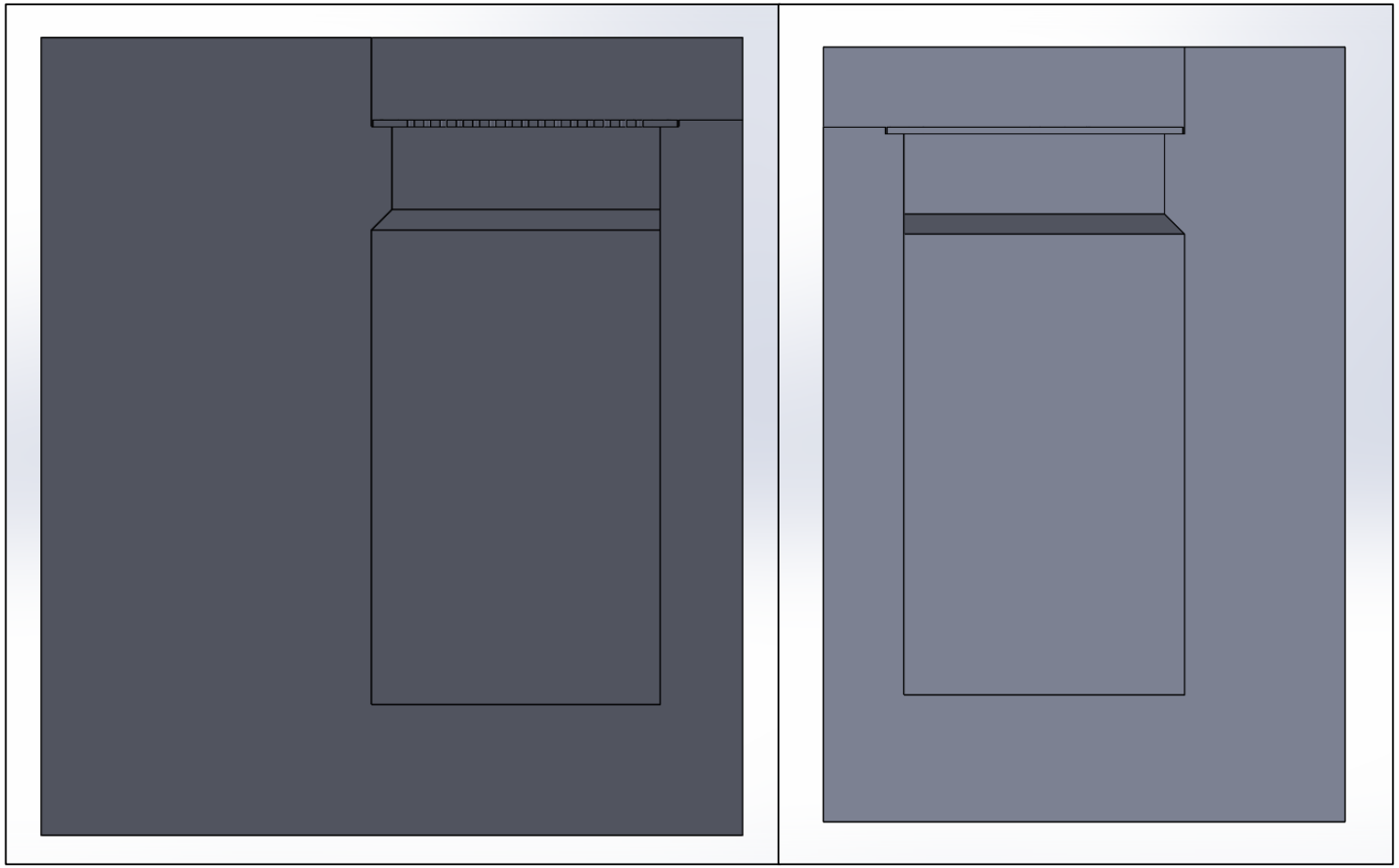


Gas Platform Front and Side View

Process Room Sump

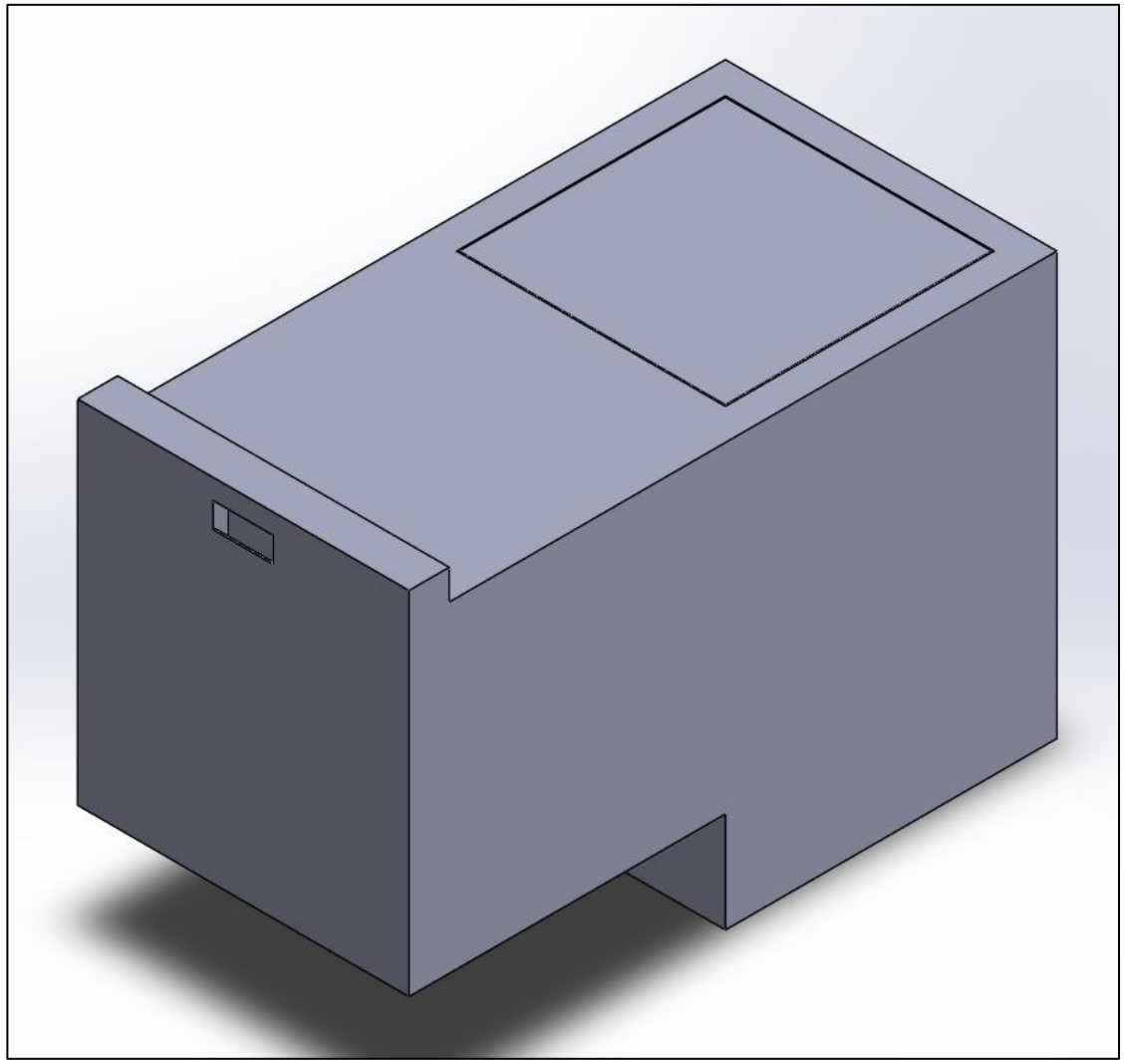


Process Room Sump Isometric View

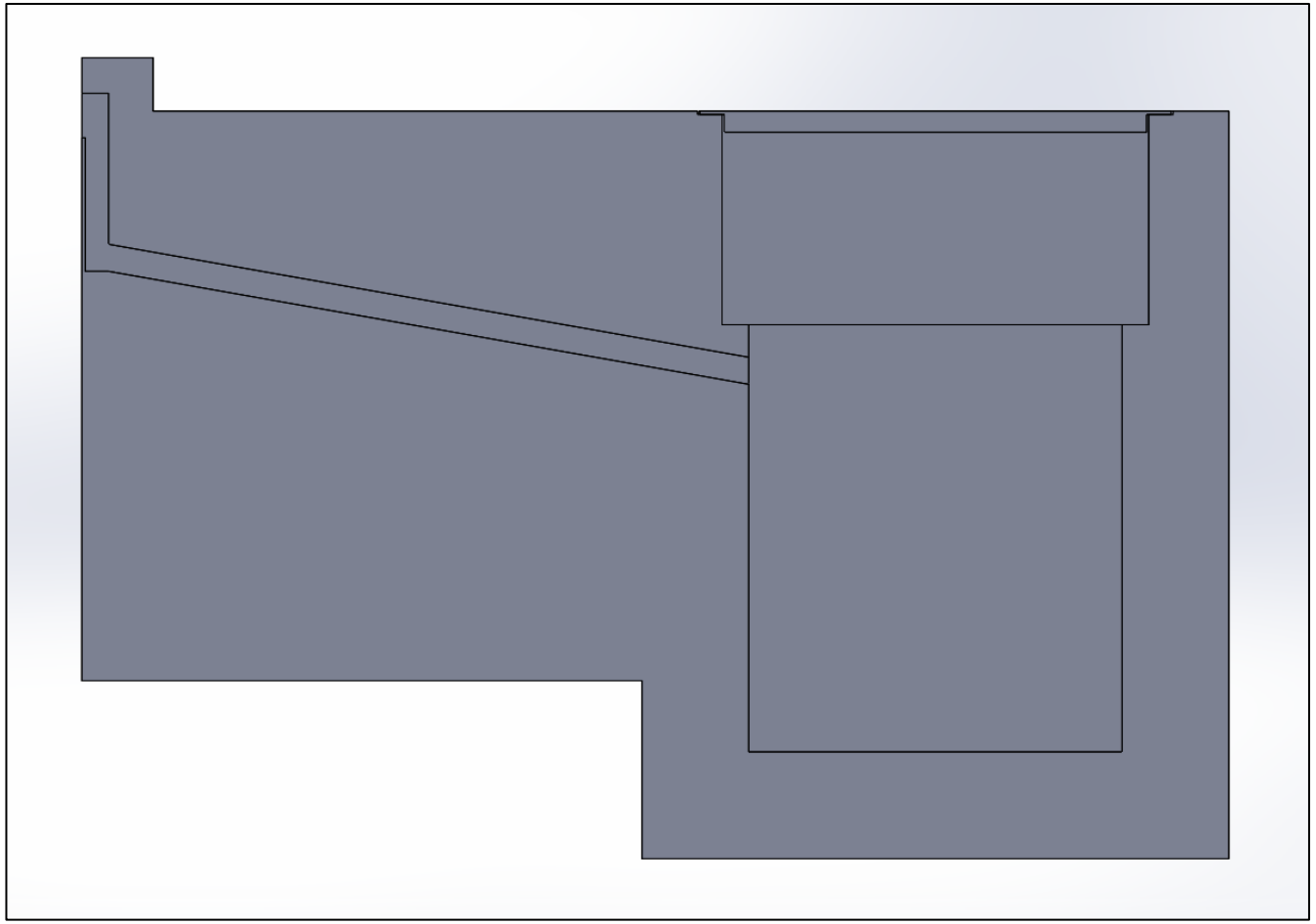


Process Room Sump Cross-Sections

Storage Pool Sump



Storage Pool Sump Isometric View



Storage Pool Sump Side View Cross-Section

Deuterium Equipment Sump

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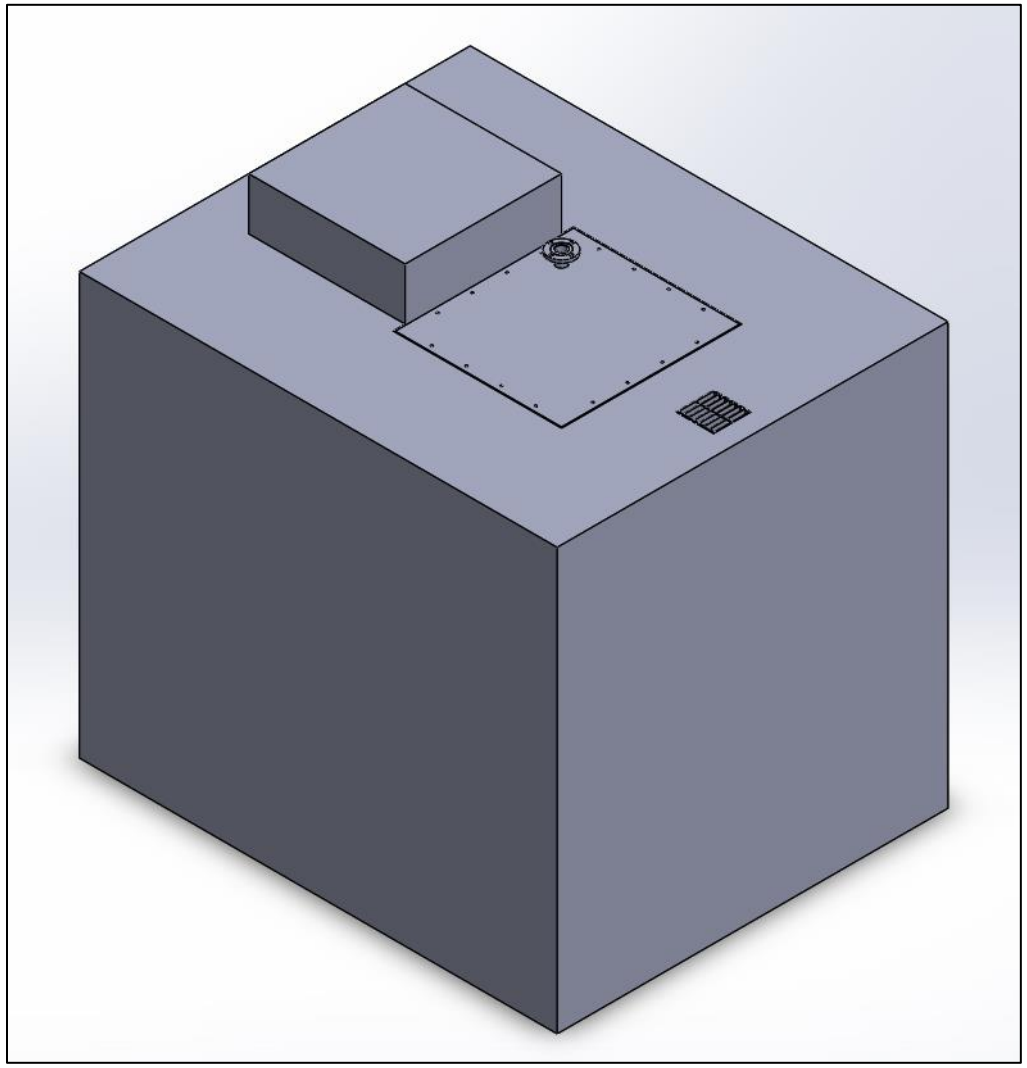
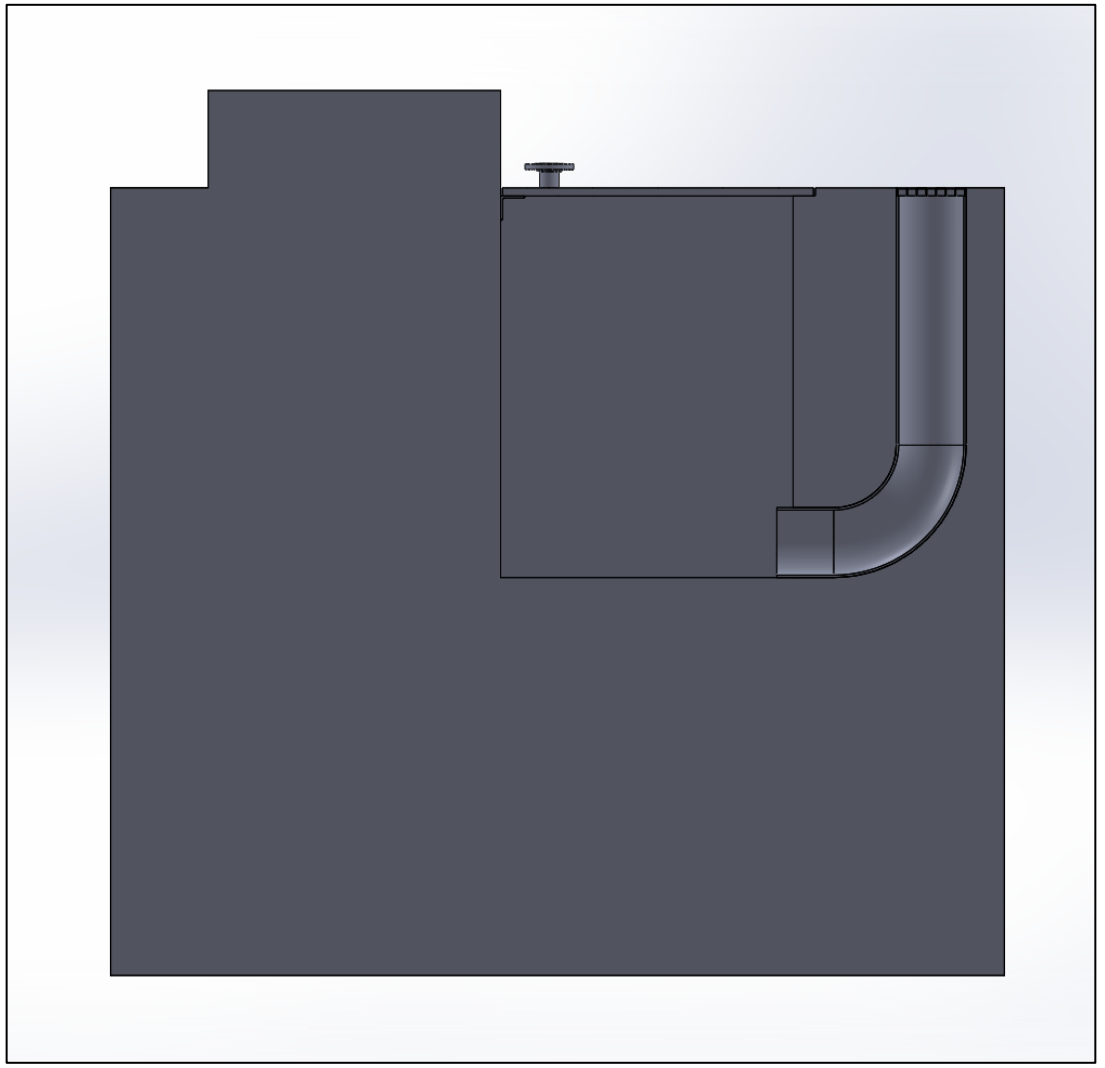
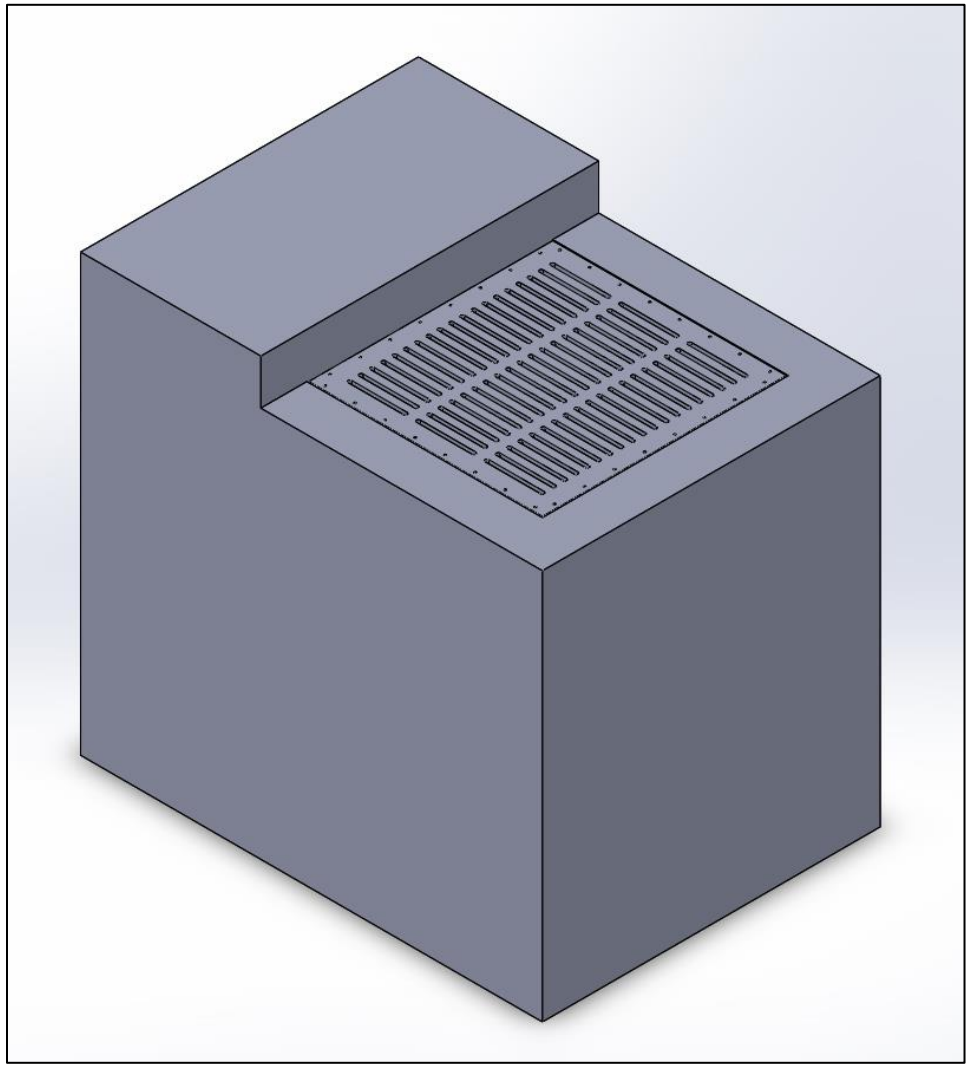


Deuterium Equipment Isometric View

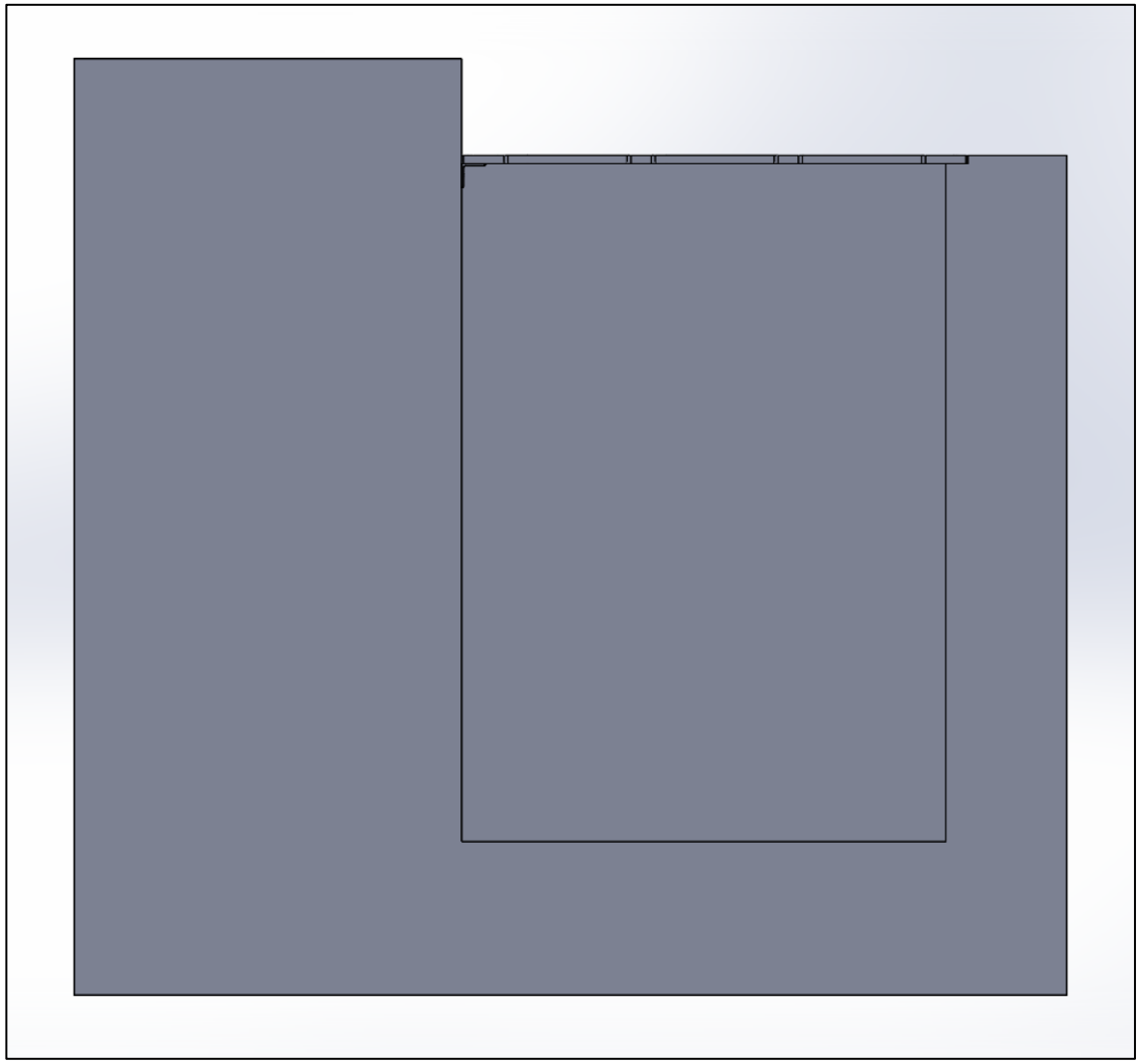


Deuterium Equipment Side View Cross-Section

Pump Room Sump



Deuterium Equipment Isometric View



Deuterium Equipment Side View Cross-Section

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