INL/EXT-17-41766-Revision-0

Hot Cell Design and Maintenance

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April 2017

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MFC Hot Cell Design and Maintenance

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MFC Facility Engineering

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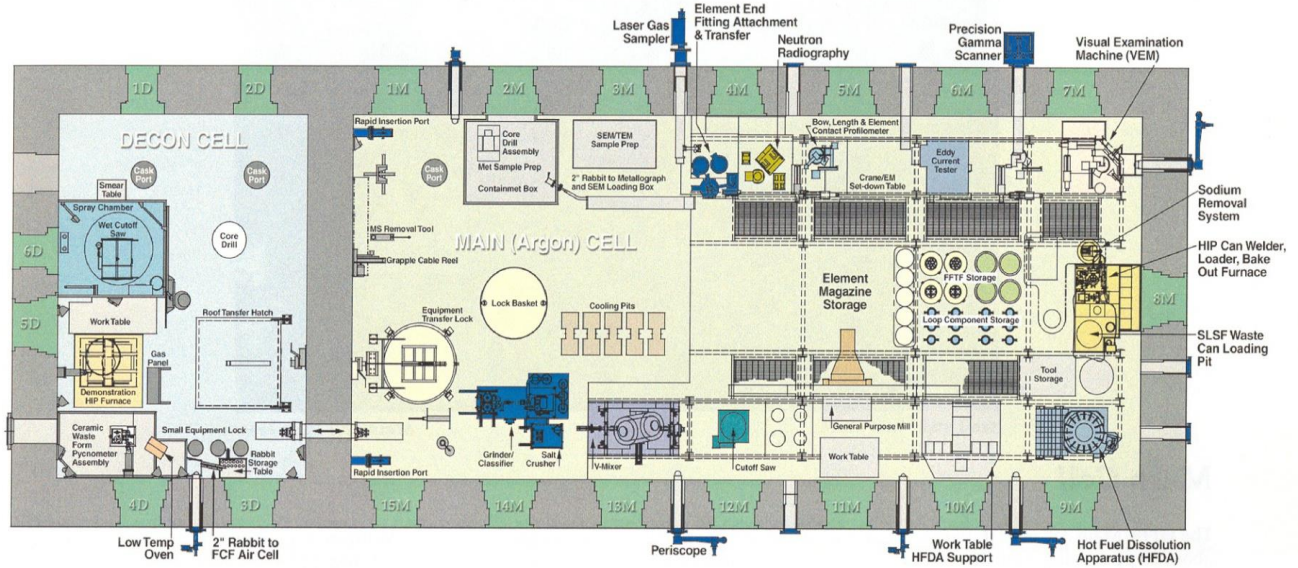
Presentation Outline

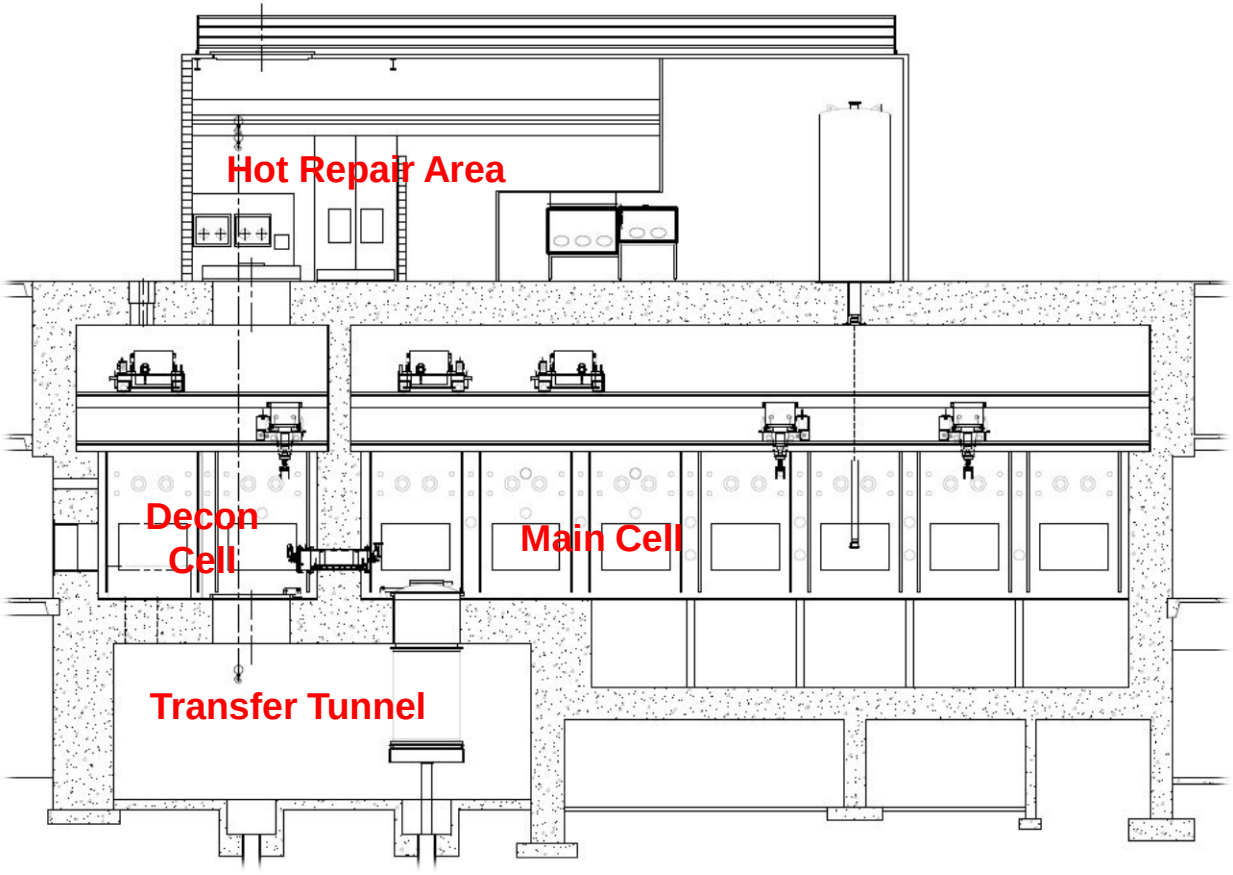
- Scope
- HFEF Atmosphere Control Systems
- Material Handling Systems Overview
  - Overhead Handling System
  - Thru Wall Manipulators
  - Transfer Systems
  - Cask Transfer Systems
- Overhead Handling System Design Features
- Maintenance Support Systems/Areas
- Summary

Hot Fuels Examination Facility (HFEF) Overview

- Main Cell (Argon Atmosphere)
  - Concrete shielded, gas tight, steel lined
  - 70 ft x 30 ft x 25 ft High (21.3 m x 9.1 m x 7.6 m high)
  - 8 ft (2.4 m) deep space with removable flooring
- Decon Cell (Air Atmosphere)
  - Concrete shielded, gas tight, steel lined
  - 20 ft x 30 ft x 25 ft High (6.1 m x 9.1 m x 7.6 m high)



Hot Fuel Examination Facility(HFEF)



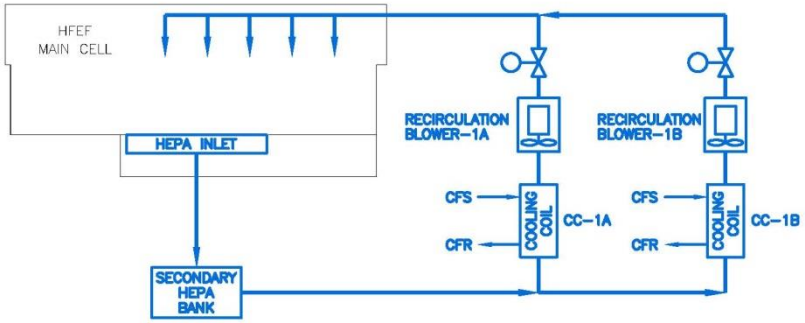
HFEF Main Cell Atmosphere Control

- Cell Pressure
  - Normal Range: -1 to -4 in. w.c.(-250 to -100 Pa)
  - Minimum: -22 in w.c. (-5.4 kPa)
  - Maximum: +3 in. w.c. (74 Pa)
- Temperature
  - Normal Range: 70 – 100 deg F (21 – 37 deg C)
  - Min 65 deg F (18 deg C)
  - Max 105 deg F (40 deg C)
- Oxygen: 25 – 100 ppm
- Moisture: 20 – 100 ppm

HFEF Main Cell Atmosphere Control (Continued)

- Main Cell Cooling System
  - Circulate and cool the cell gas
  - Removes the heat via cooling fluid and refrigeration system
  - Controls cell pressure
  - HEPA Filtered
- Vent System
  - Seal pot (No. 1) prevents back diffusion of air into the cell
- Argon Supply
  - Addition of clean argon
  - Addition of emergency argon for under pressure protection
- Pressure Relief
  - Seal Pot (No. 2) Over and under pressure protection
- Purification System
  - Removes moisture and oxygen from the cell atmosphere
- Atmosphere Monitoring

HFEF Main Cell Atmosphere Control (Continued)



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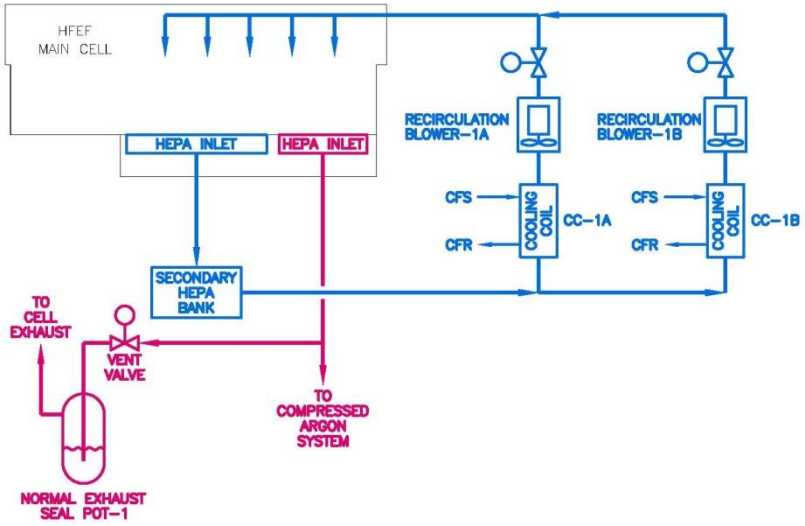
HFEF Main Cell Atmosphere Control (Continued)



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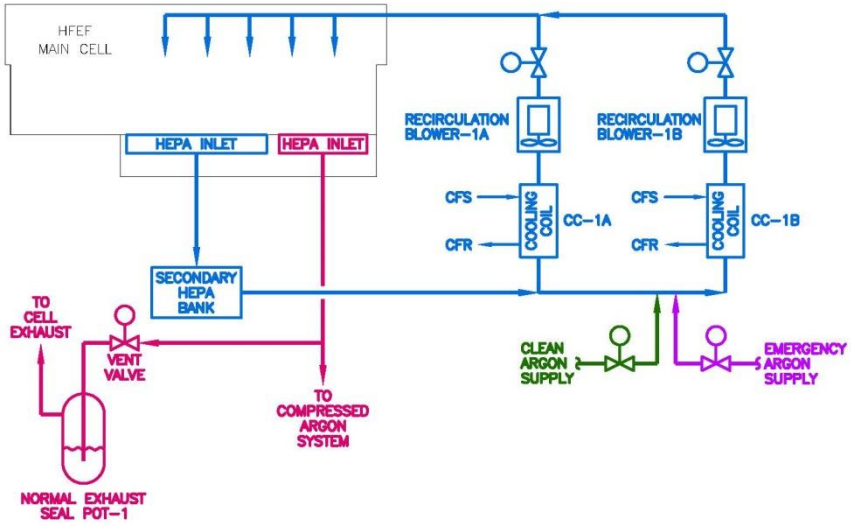
HFEF Main Cell Atmosphere Control (Continued)



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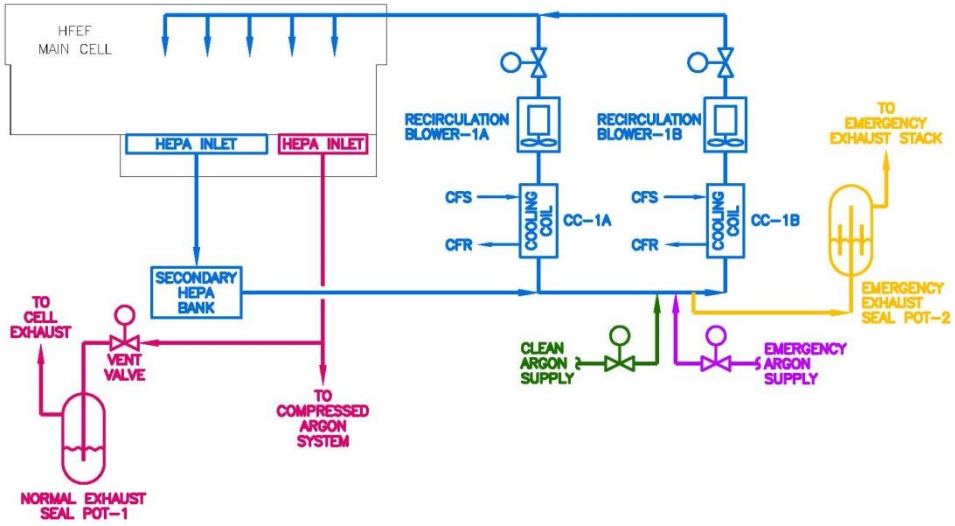
HFEF Main Cell Atmosphere Control (Continued)



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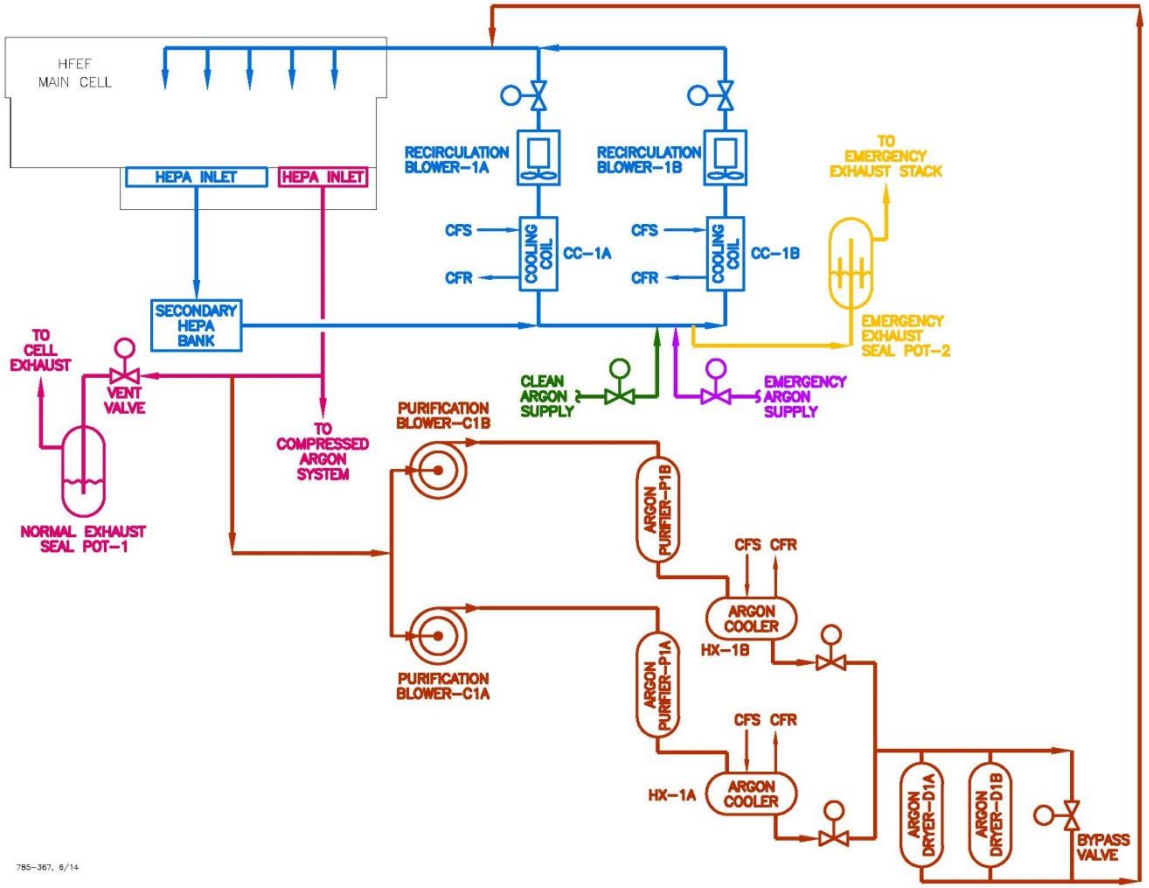
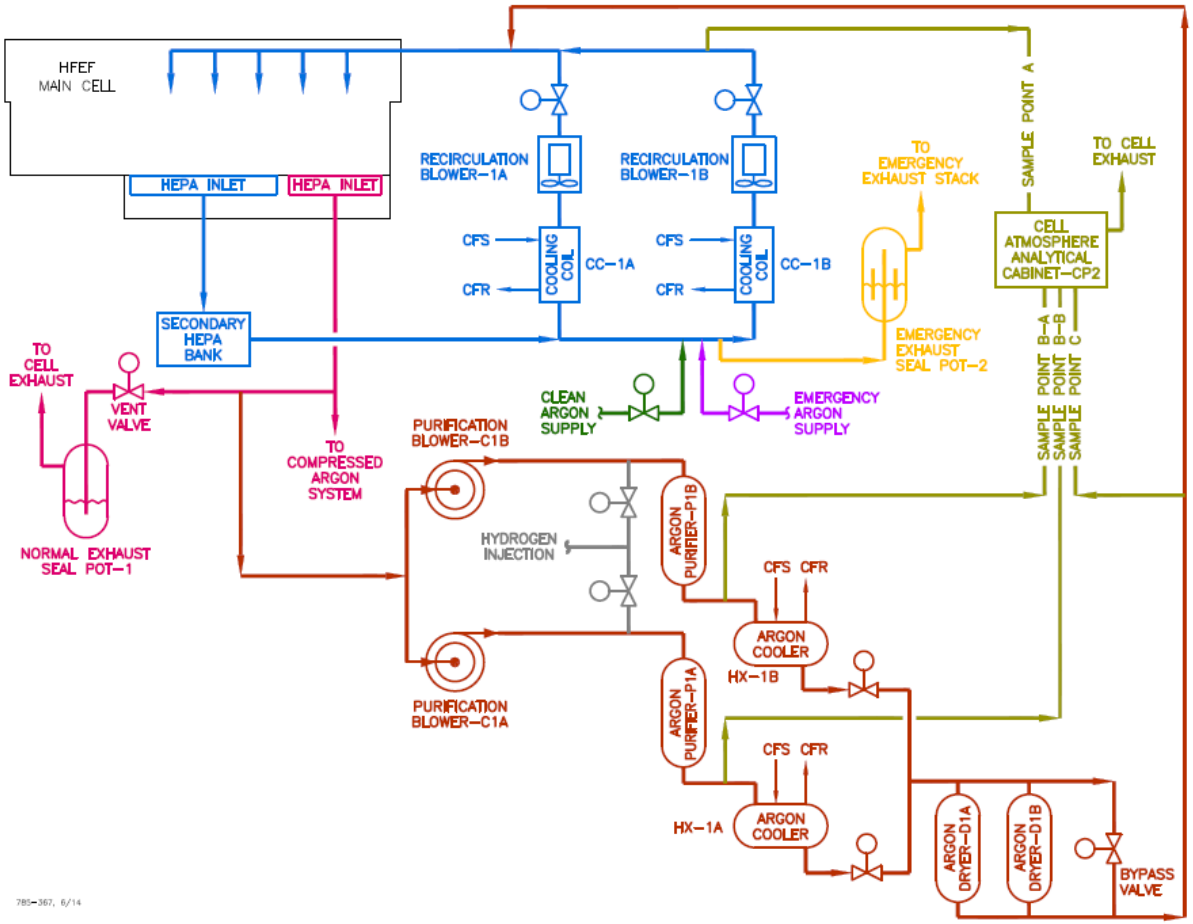
HFEF Main Cell Atmosphere Control (Continued)



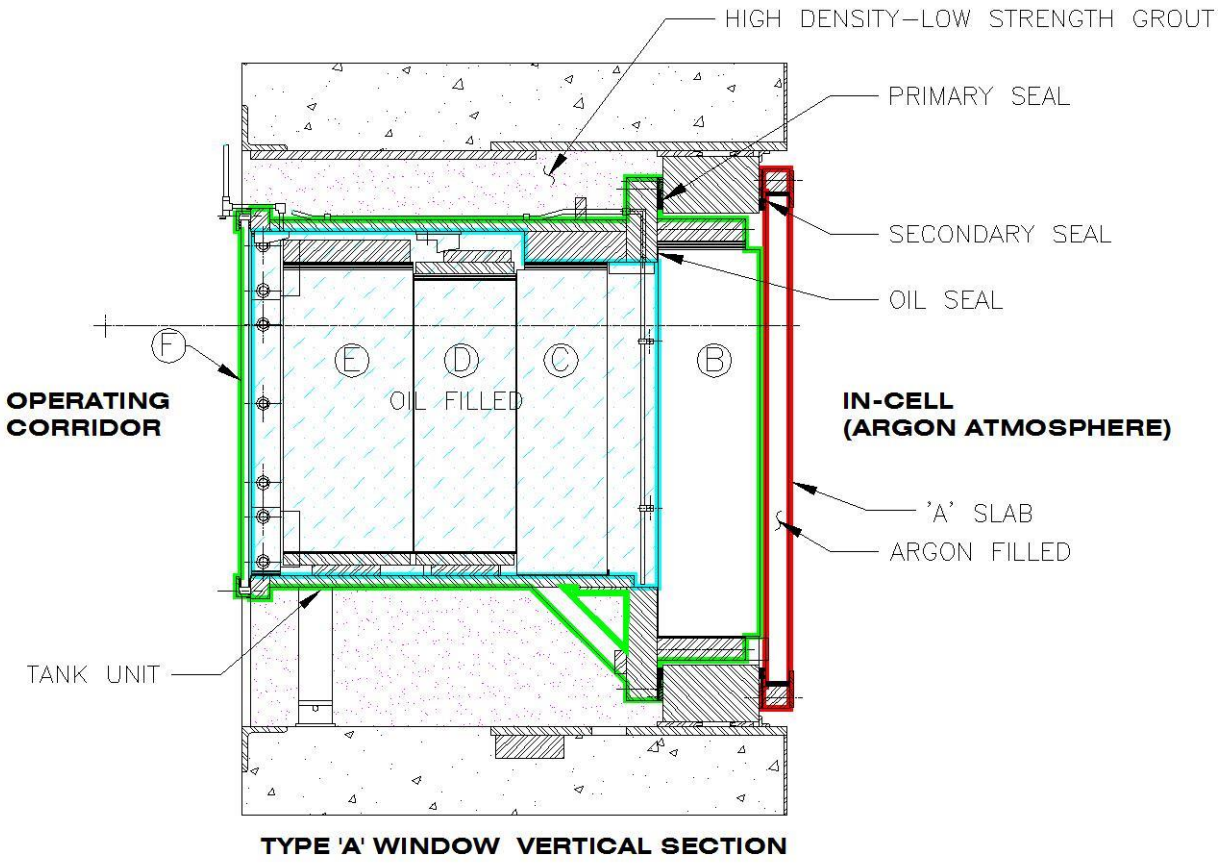
HFEF Main Cell Atmosphere Control (Continued)



HFEF Main Cell Shield Windows

- Oil-filled
- Leaded glass shielding windows
- Hinged protective cover plate (in-cell)
- Oil Expansion tank with argon cover gas
- Light Transmittance: 38%

HFEF Main Cell Shield Windows (Continued)



TYPE 'A' WINDOW VERTICAL SECTION

HFEF Main Cell Shield Windows (Continued)

- The tank assembly contains three heavy glass slabs, labeled C and D (cerium-stabilized), and E. The hot end is sealed with a 9 in. thick slab of cerium stabilized glass (B) and the cold end is sealed with a 20-mm-thick plate of the same type of glass (F) but with no cerium (total glass weight is 6734 lb/6734 kg). The glass schedule is as follows:

Slab	Density	Thickness	Composition Comments
A	2.53	5.1 cm (2 in.)	Cerium-stabilized
B	2.53	22.9 cm (9 in.)	Cerium-stabilized
C	3.23	20.3 cm (8 in.)	Cerium-stabilized
D	3.23	22.9 cm (9 in.)	Cerium-stabilized
E	5.20	29.2 cm (11.5 in.)	
F	2.53	1.9 cm (0.75 in.)	

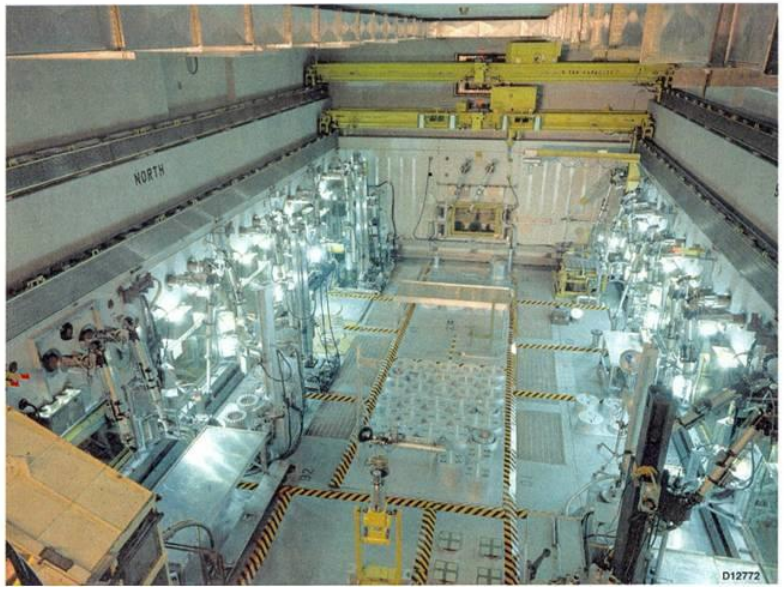
Material Handling System Overview

- Maximum Overall Equipment Handling Envelope (not including casks)
  - Capacity - 5 Ton (4,540 kg)
  - Max Height – 12 ft. 10 in. (3.91 m)
  - Max Diameter - 6 ft. (1.83 m)

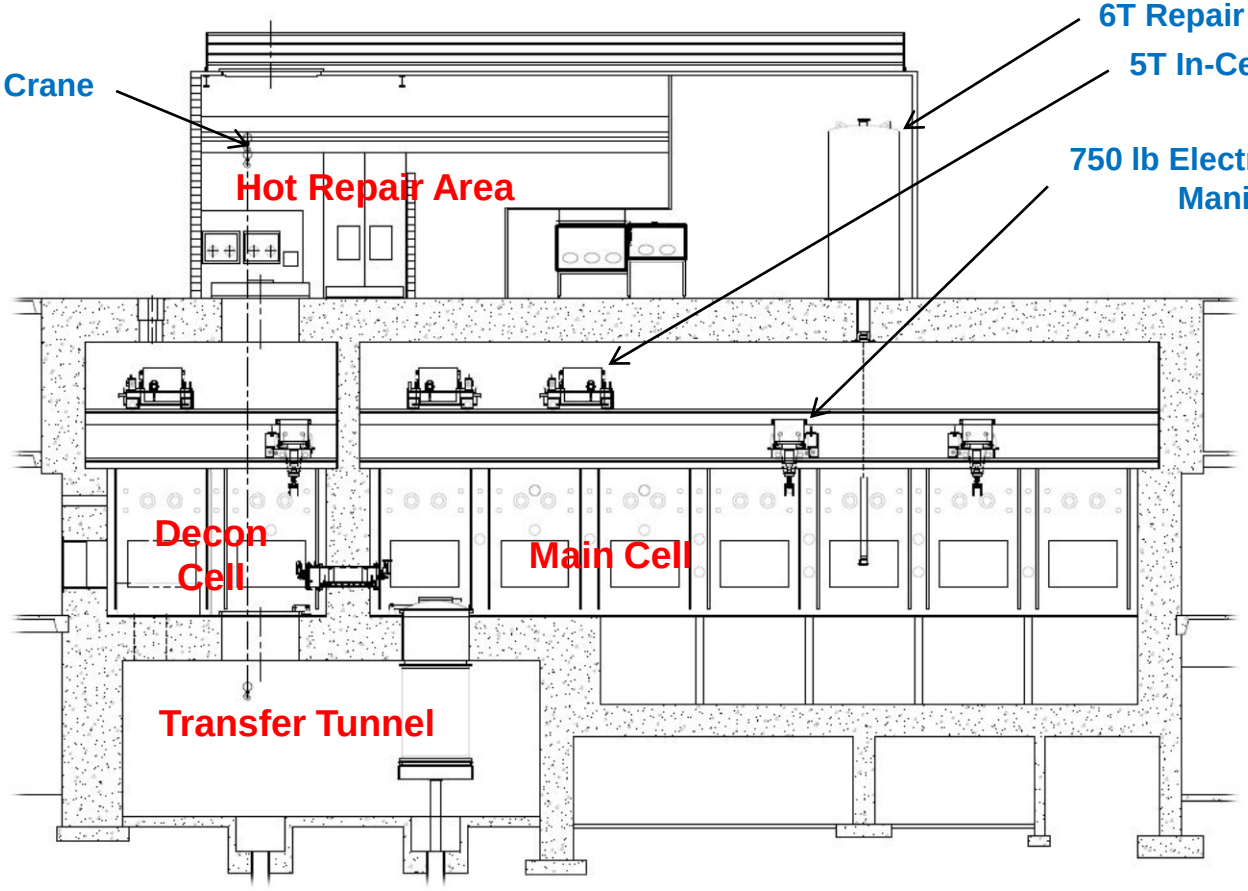
- In-Cell Overhead Handling (Three Levels)
  - Repair Hoist (Maintenance Use Only)
  - Cranes
  - Electro – Mechanical Manipulator (EM or EMM)

- Through the Wall Manipulators

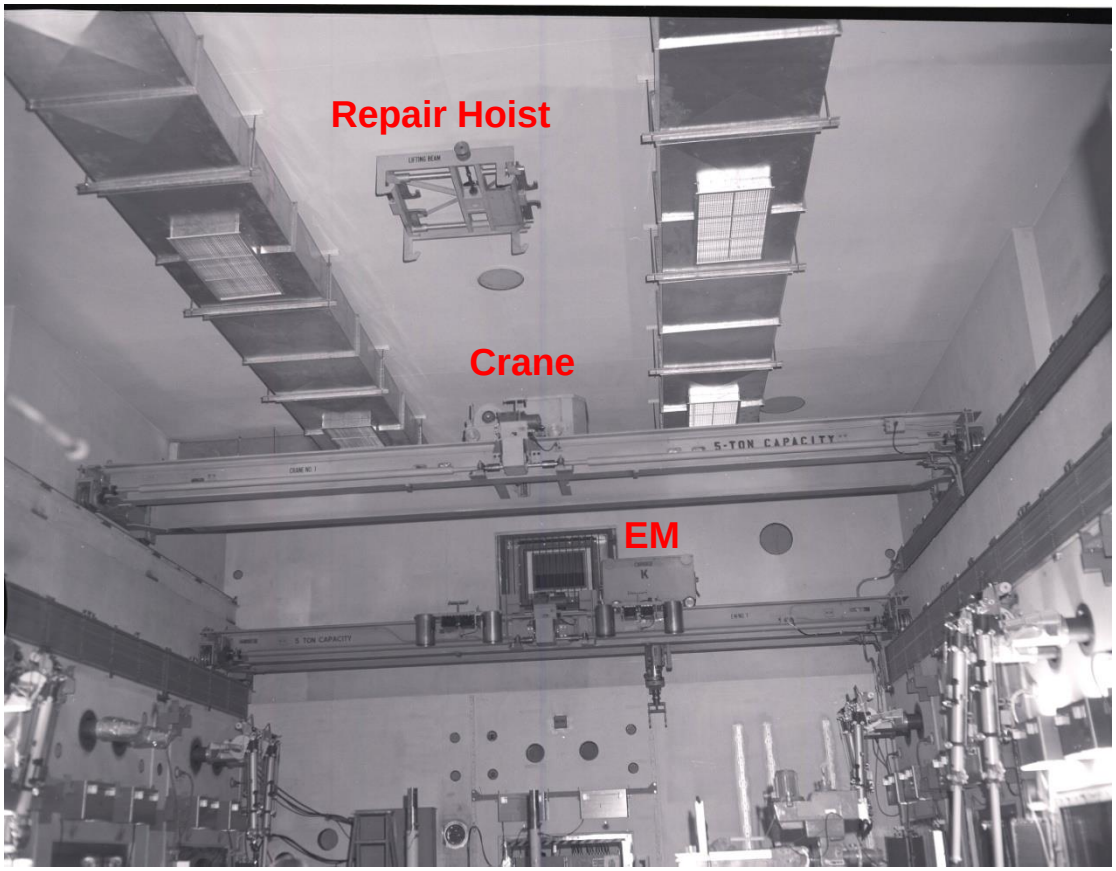
- Transfer Systems
  - Large Lock
  - Small Lock
  - Rapid Insertion Port



Hot Fuel Examination Facility(HFEF) Overhead Handling



Hot Fuel Examination Facility(HFEF) Overhead Handling (Continued)

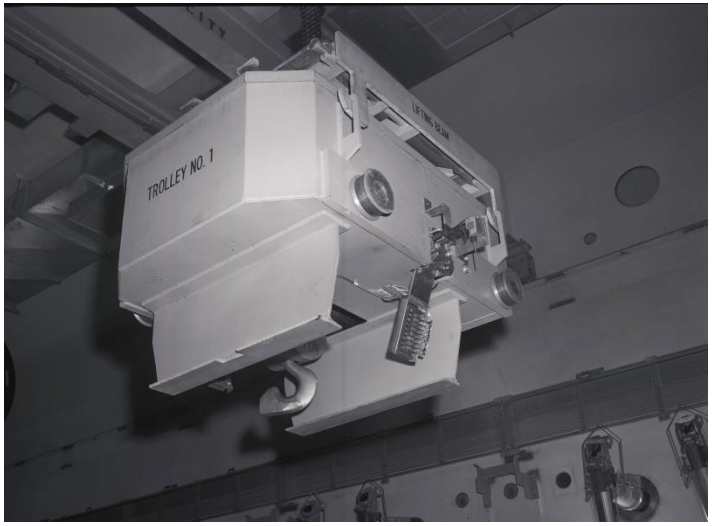


Hot Fuel Examination Facility(HFEF) Overhead Handling (Continued)

- Repair Hoist (Maintenance Use Only)
  - For removal of EM carriages, crane trolleys, bridge drive modules, bridge removal, and supports buss bar replacement
  - Capacity – 6 T (required for bridge removal)
  - Rotation for removing bridges and swapping carraiges/trolleys between bridges.
  - Rigid tube (10ft/3.05 m)) for rigid positioning for placing components on bridges. Hollow tube is only in affect at the bridge level and above.
  - Isolable and shielded from the main cell for entry into the repair hoist confinement.

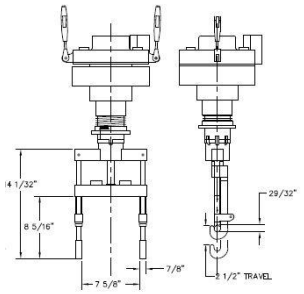
Hot Fuel Examination Facility(HFEF) Overhead Handling (Continued)

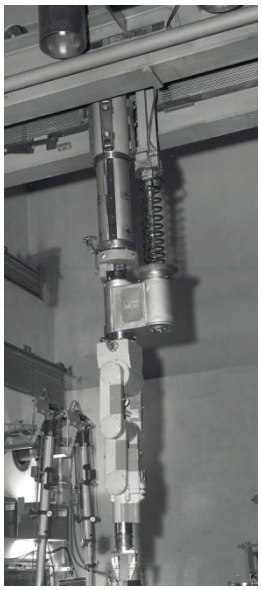
- In-Cell Crane
  - General lifting and handling
  - 5 T Capacity
  - Remotely removable components
    - Crane Trolley
    - Bridge Drive Module
    - Bridge
    - Wall Buss Bars

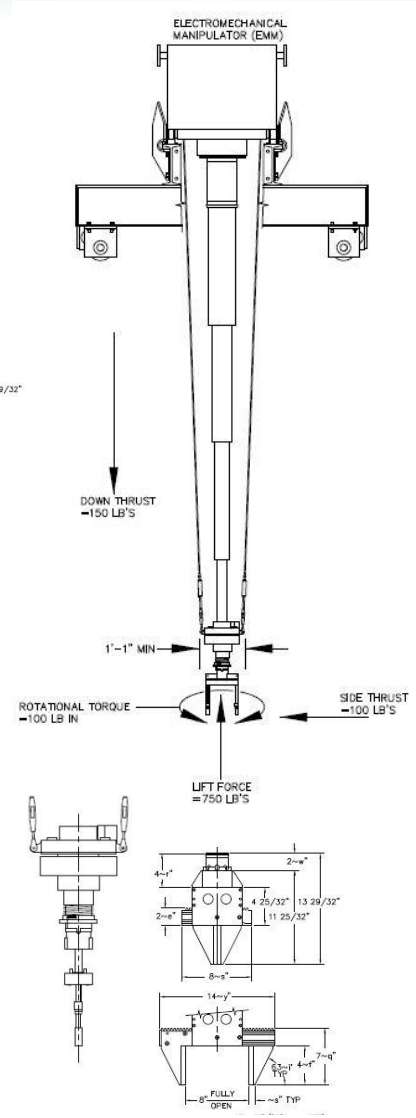


Hot Fuel Examination Facility(HFEF) Overhead Handling (Continued)

- Electro-Mechanical Manipulator (EM)
  - Majority of in-cell lifting and handling
    - Lift 750 lbs (340 kg)
    - Rotate 100 ft-lbs (135 N*m)
    - End Effectors
      - Dual Grip
      - Single Grip
      - Parallel Jaws
    - Off-Center Load
    - Articulated Arm (PaR 3000) (not currently used)
    - Bridge Cell Lighting



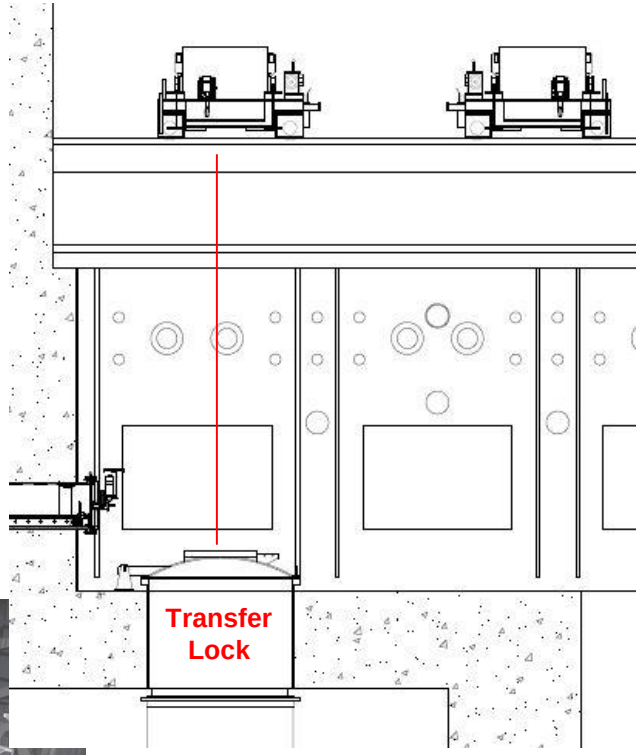


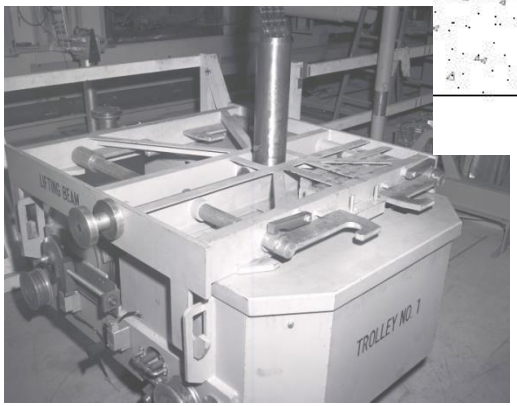


Hot Fuel Examination Facility(HFEF) Overhead Handling (Continued)

- Minimum Configuration (Main Cell)
  - One Crane with access to the transfer lock
  - **OR**, one EM for supporting repair hoist operations

  If one of the conditions is met, only handling operations to return the cell to full operations is permitted.

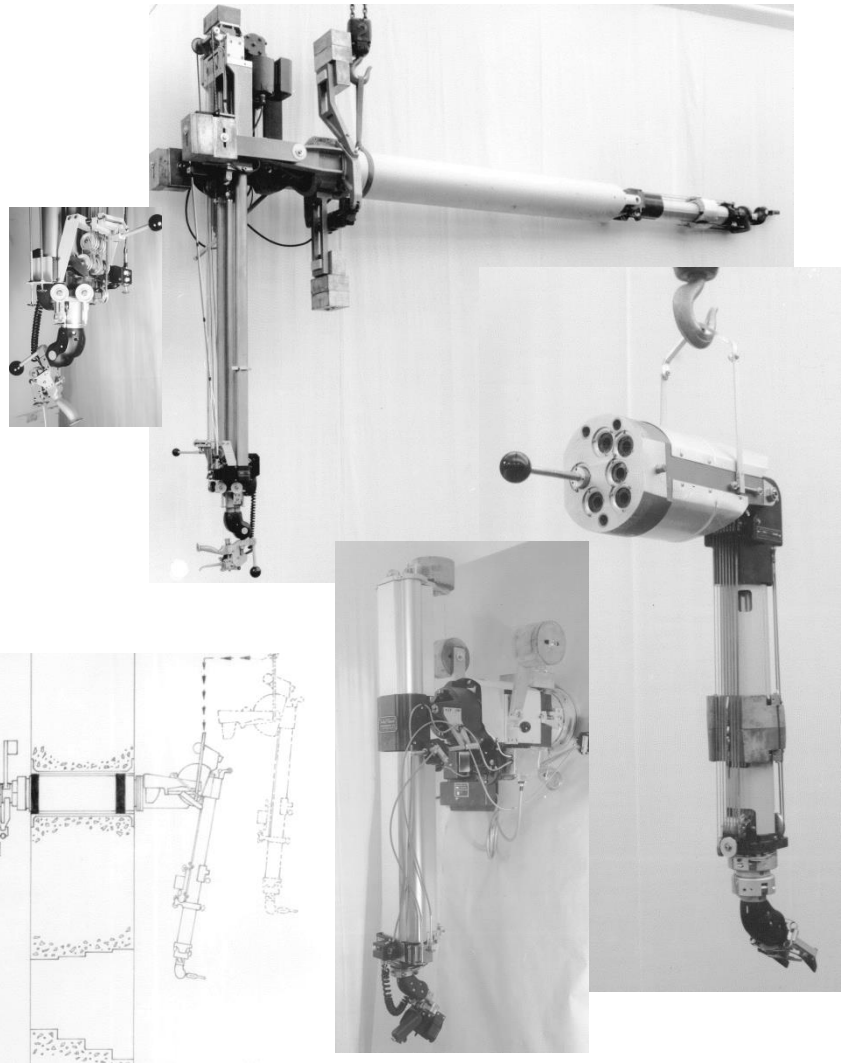


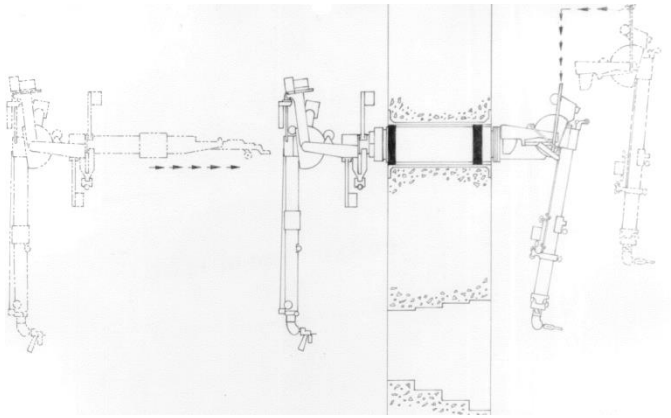


Hot Fuel Examination Facility(HFEF) Thru Wall Manipulators

- One piece manipulator is desirable due to reduced cost, simplicity, increased dexterity. In-cell boot for contamination control lowers dexterity.

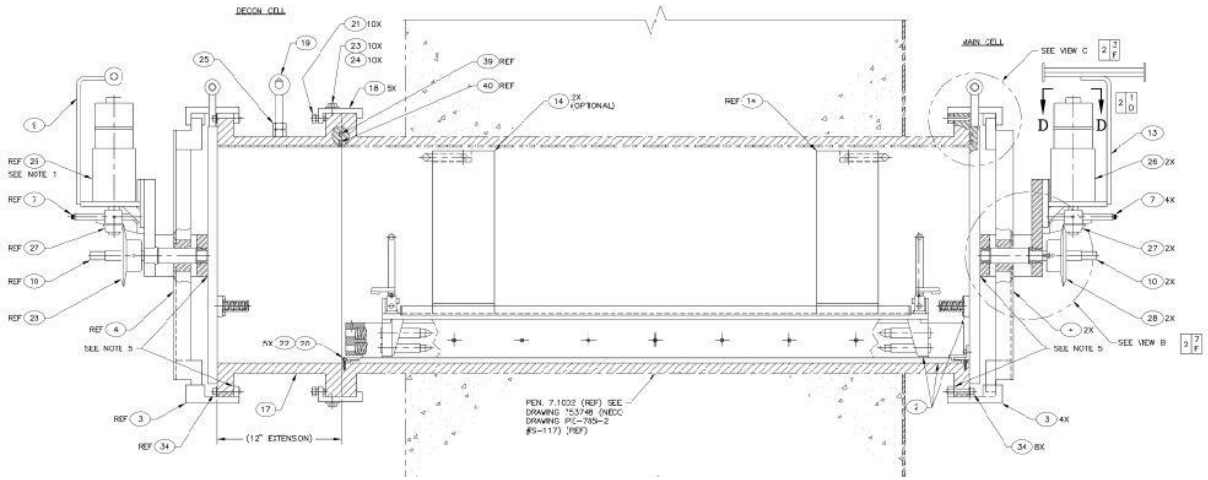
- Three piece manipulator (master arm, seal tube, slave arm) is required for negative inert atmospheres.



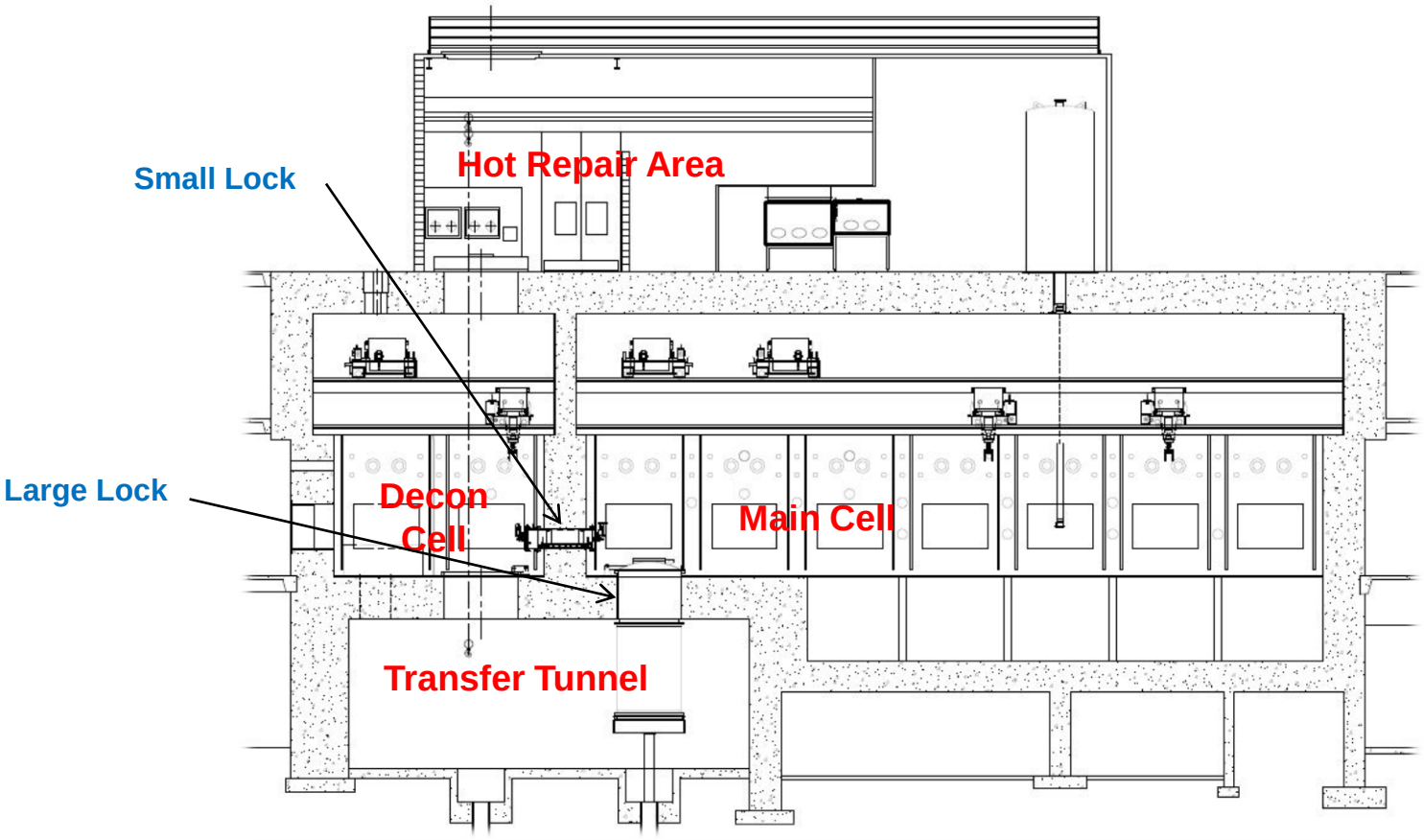


Hot Fuel Examination Facility(HFEF) Transfer Systems

- **Large Lock –** for the transfer of large objects (max transfer envelope) between the decon cell and the main cell while maintaining the cell atmosphere.
- **Small Lock** - for the transfer of small objects (max transfer envelope) between the decon cell and the main cell while maintaining the cell atmosphere.
- **Rapid Insertion Port (RIP)** – for the transfer of small objects (Approximately 5 in. dia x 18 in long/12.7 cm x 45.7 cm) directly into the main or decon cells while maintaining the cell atmosphere.



Hot Fuel Examination Facility(HFEF) Transfer Systems (Continued)

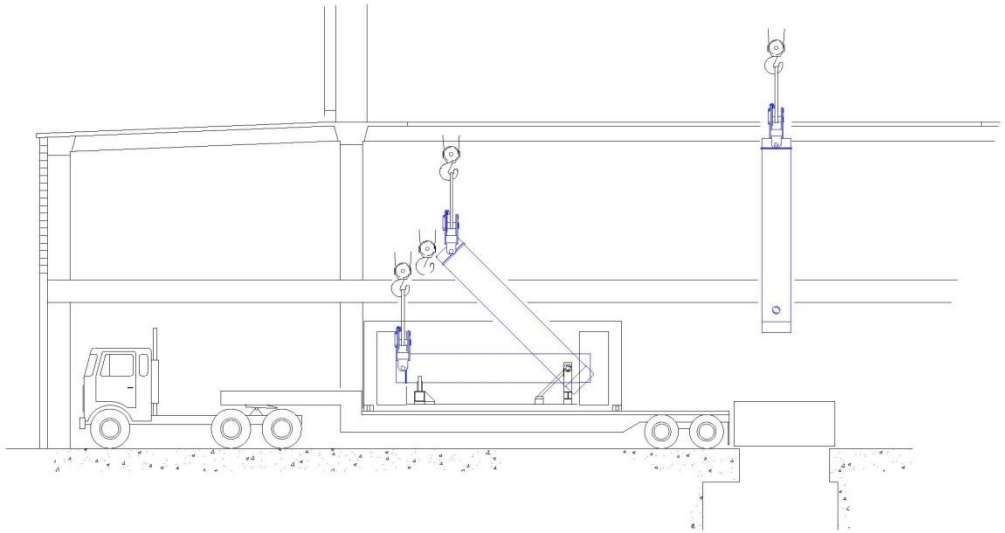


Hot Fuel Examination Facility(HFEF) Cask Transfer Systems

- Used for vertical transfers of cask payloads into and out of the cells
- Cask Tunnel Penetrations
  - Two penetrations in the Decon Cell
  - One penetration in the Main Cell
- Cask Cart - 30 Ton Capacity

Hot Fuel Examination Facility(HFEF) Cask Transfer Systems (Continued)

- Cask Transfer to/from truck.



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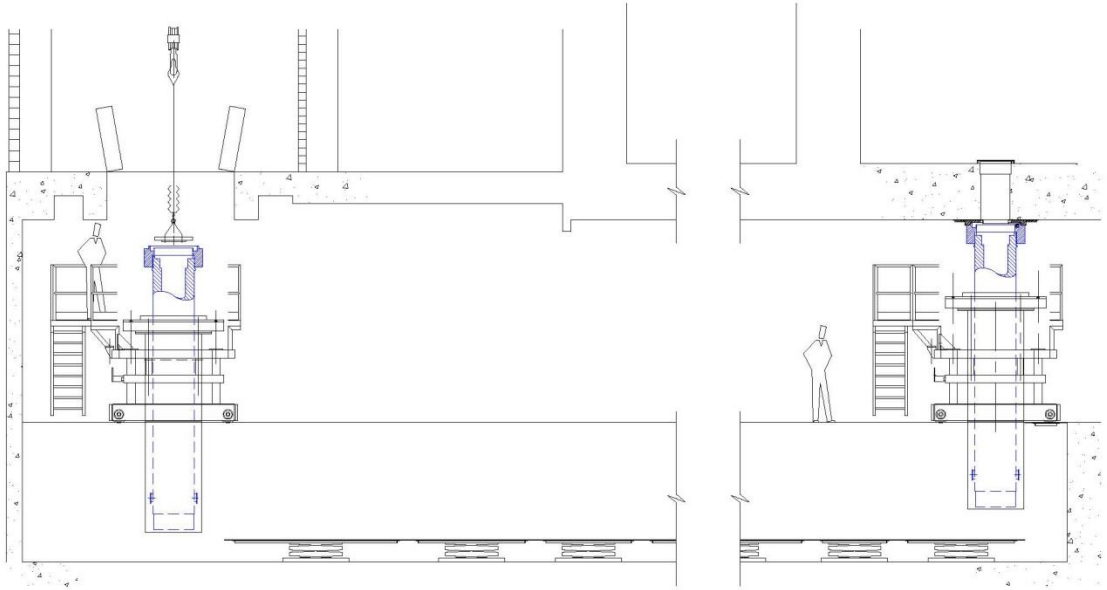
Hot Fuel Examination Facility(HFEF) Cask Transfer Systems (Continued)

- Cask Tunnel Transfer



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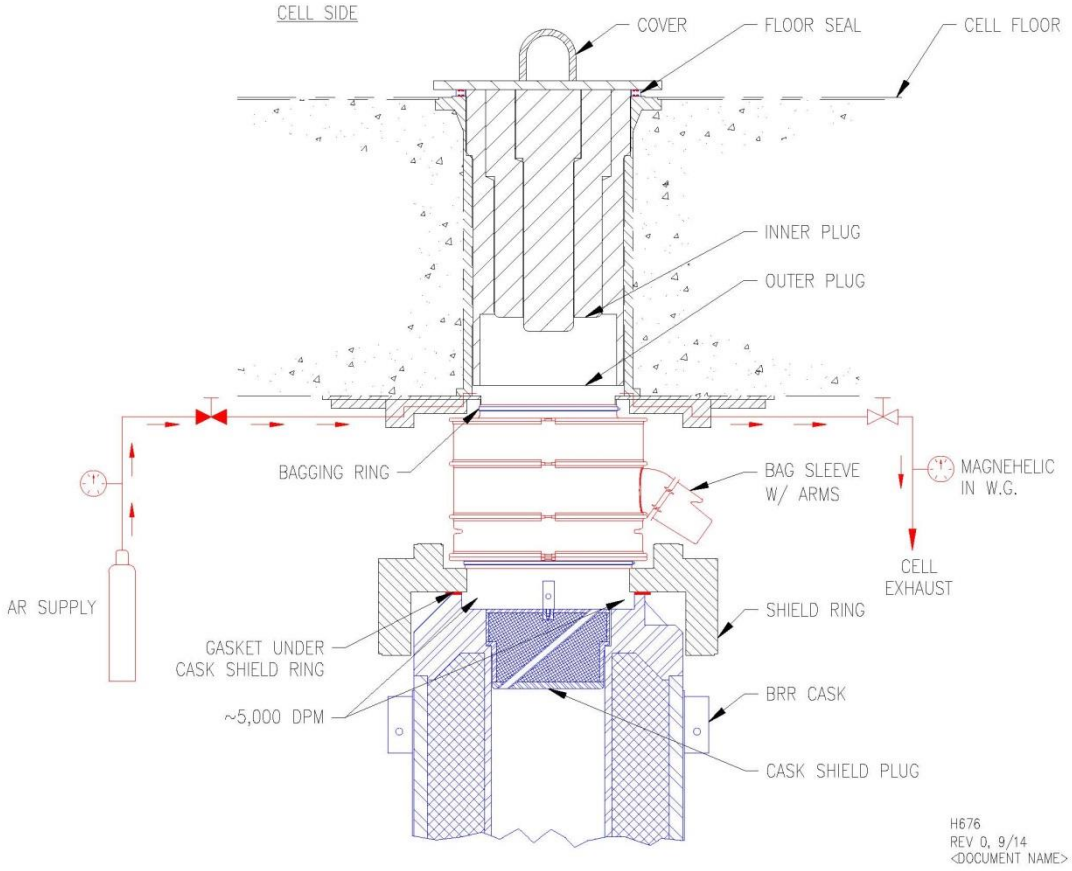
Hot Fuel Examination Facility(HFEF) Cask Transfer Systems (Continued)

- Cask Bagging Operations



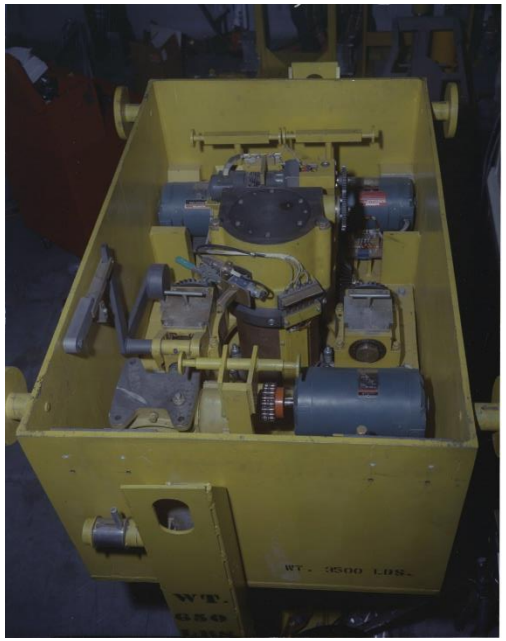
Hot Fuel Examination Facility(HFEF) Cask Transfer Systems (Continued)

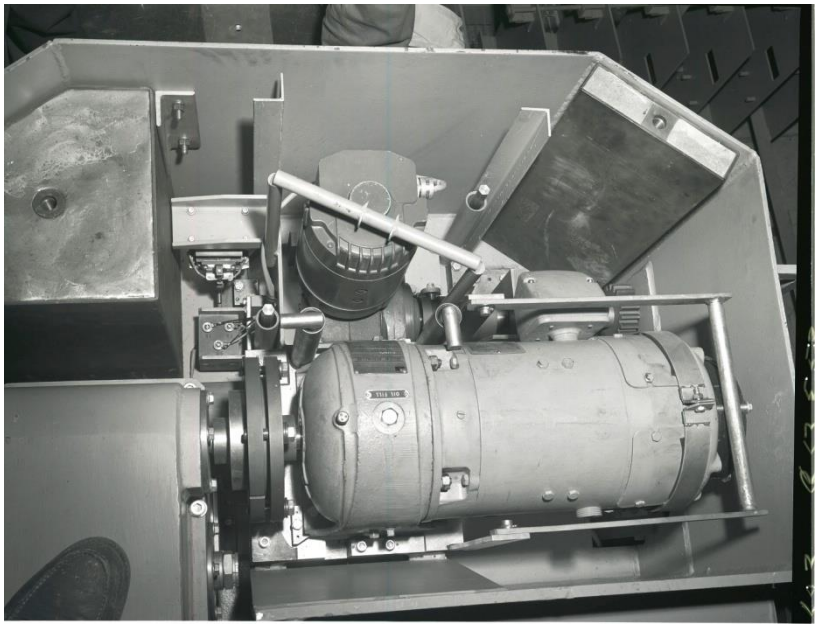
Overhead Handling System Design Features

- Modular major component design. Frequent major component mechanical and electrical connections integrated into a single operation installation and removal. Major components are normally removed from the cell and transferred to the HRA for contact maintenance.
  - Crane trolley or EM carriage (Interchangeable between like bridges)
  - Bridge drive module (BDM) for crane bridge and EM bridge (Interchangeable between all bridges)
  - EM Bridge Lighting.

Overhead Handling System Design Features (Continued)

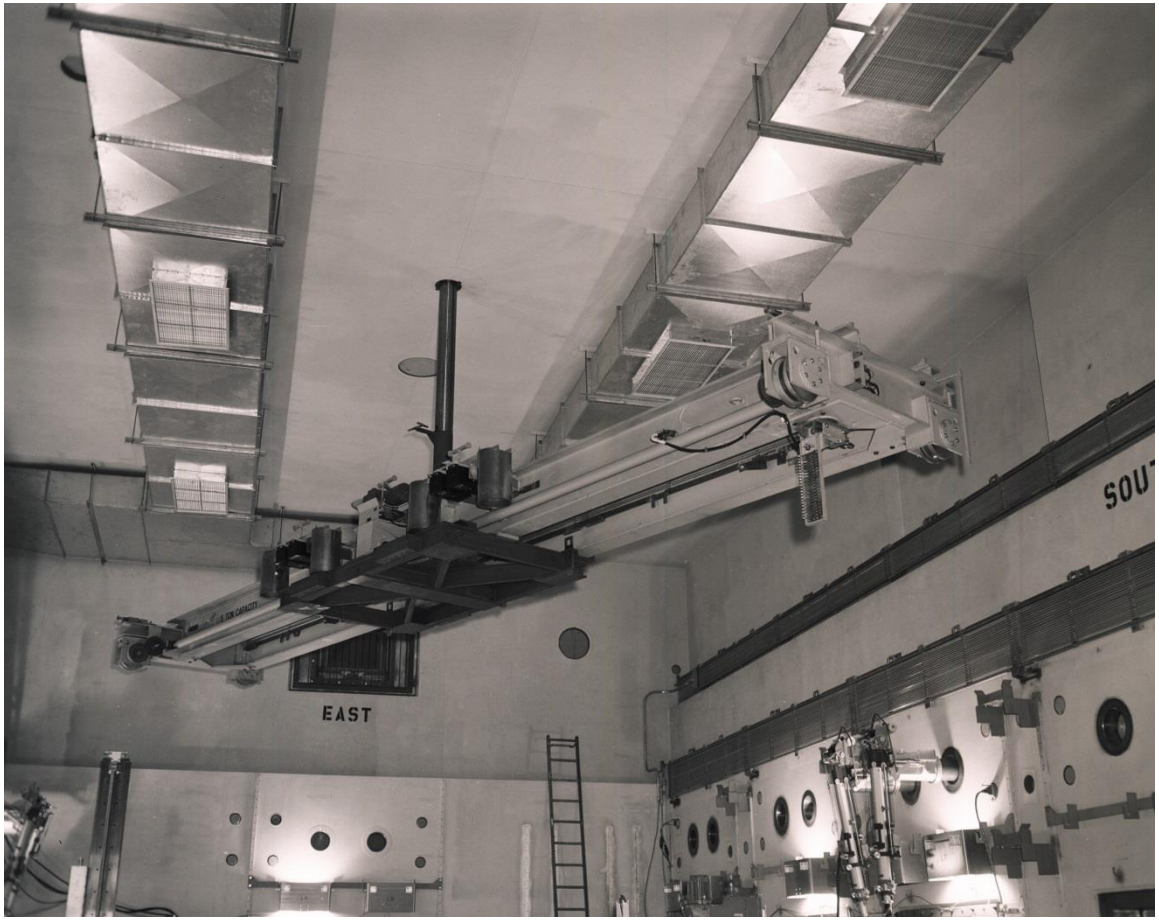
- Modular component design for motor assemblies within the crane trolley and EM carriage.
  - The design allows for remote motor assembly replacement (not practiced).
  - Improves access to components and lowers dose associated with repairs.





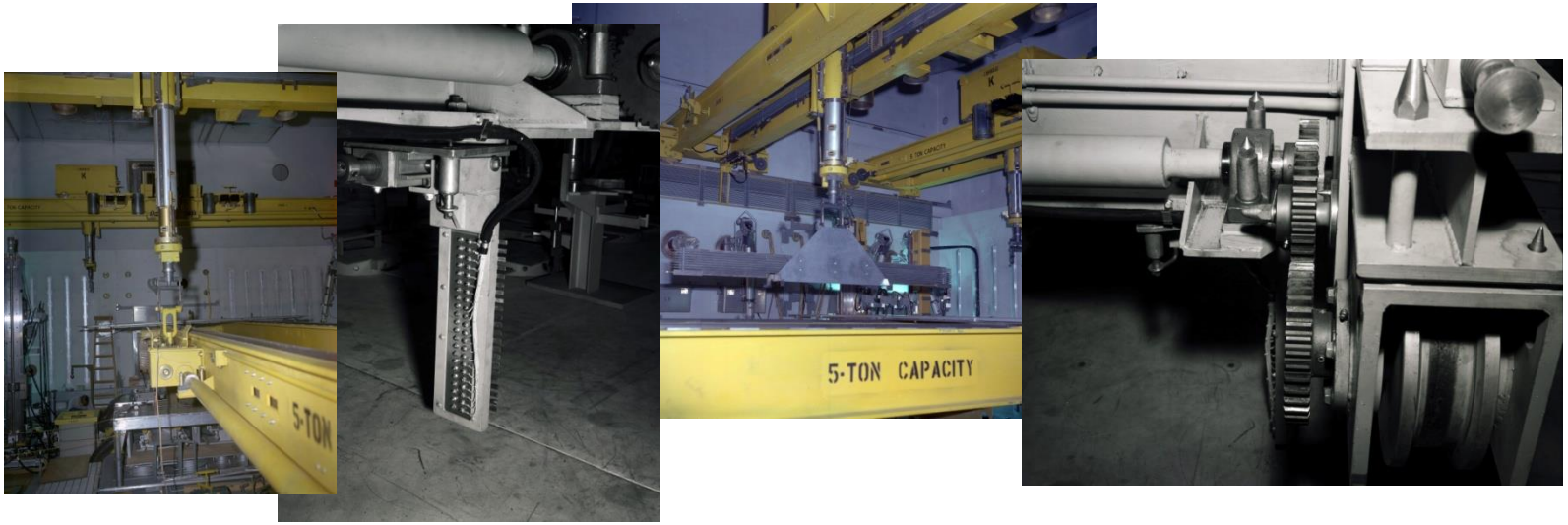
Overhead Handling System Design Features (Continued)

- Bridge Removal



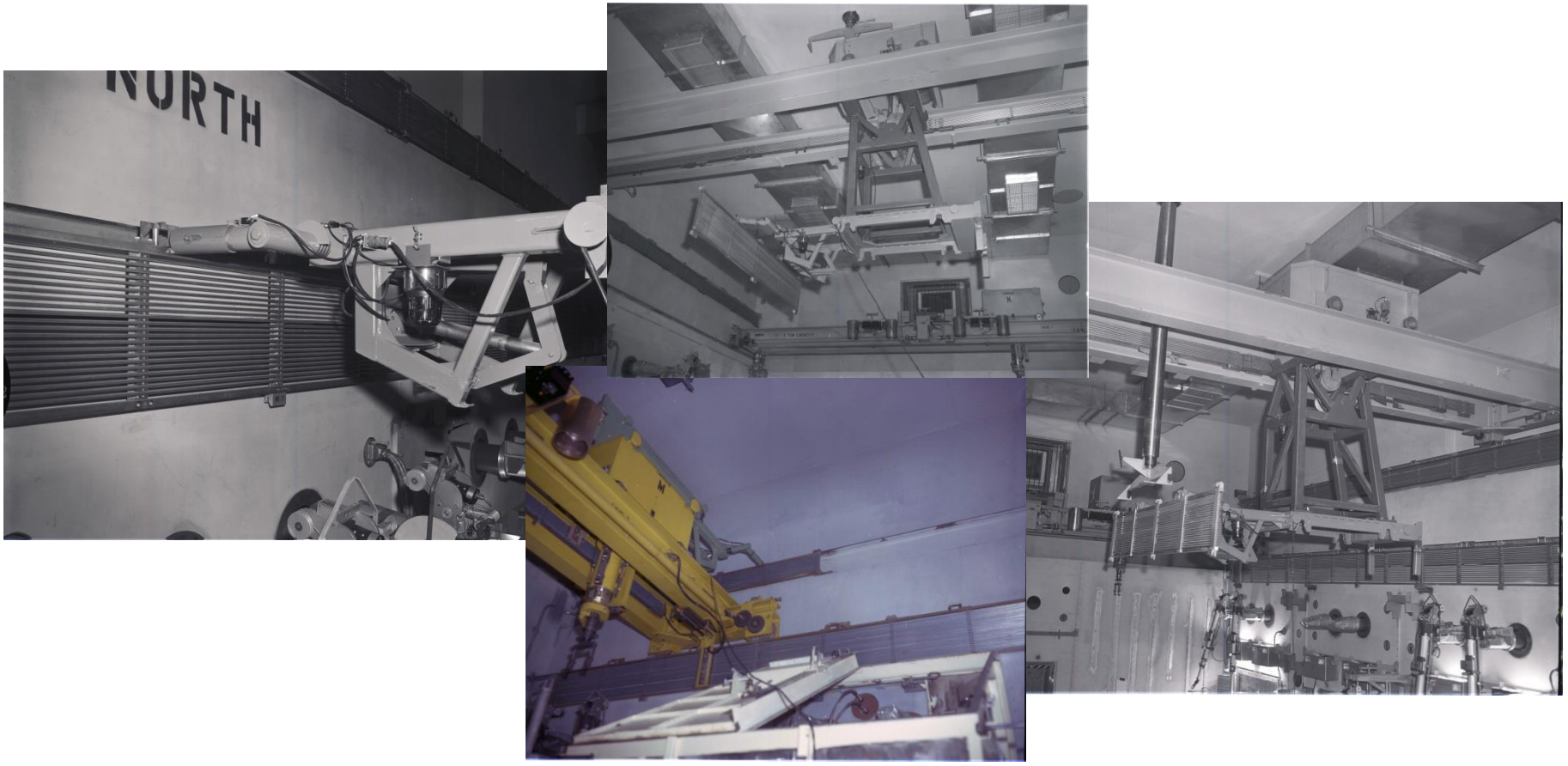
Overhead Handling System Design Features (Continued)

- Crane and EM Bridge Removal Capability(Main Cell Only)
  - Requires bridge lifting beam and stands for supporting the bridge.
  - Requires a large area for crane bridge trolley/carriage and staging area.
  - Modular design for remote removal of the following:
    - Wheel Modules
    - Drive Shafts
    - Buss Bars
    - Brush Pickup Assembly
    - Bridge Drive Gearbox

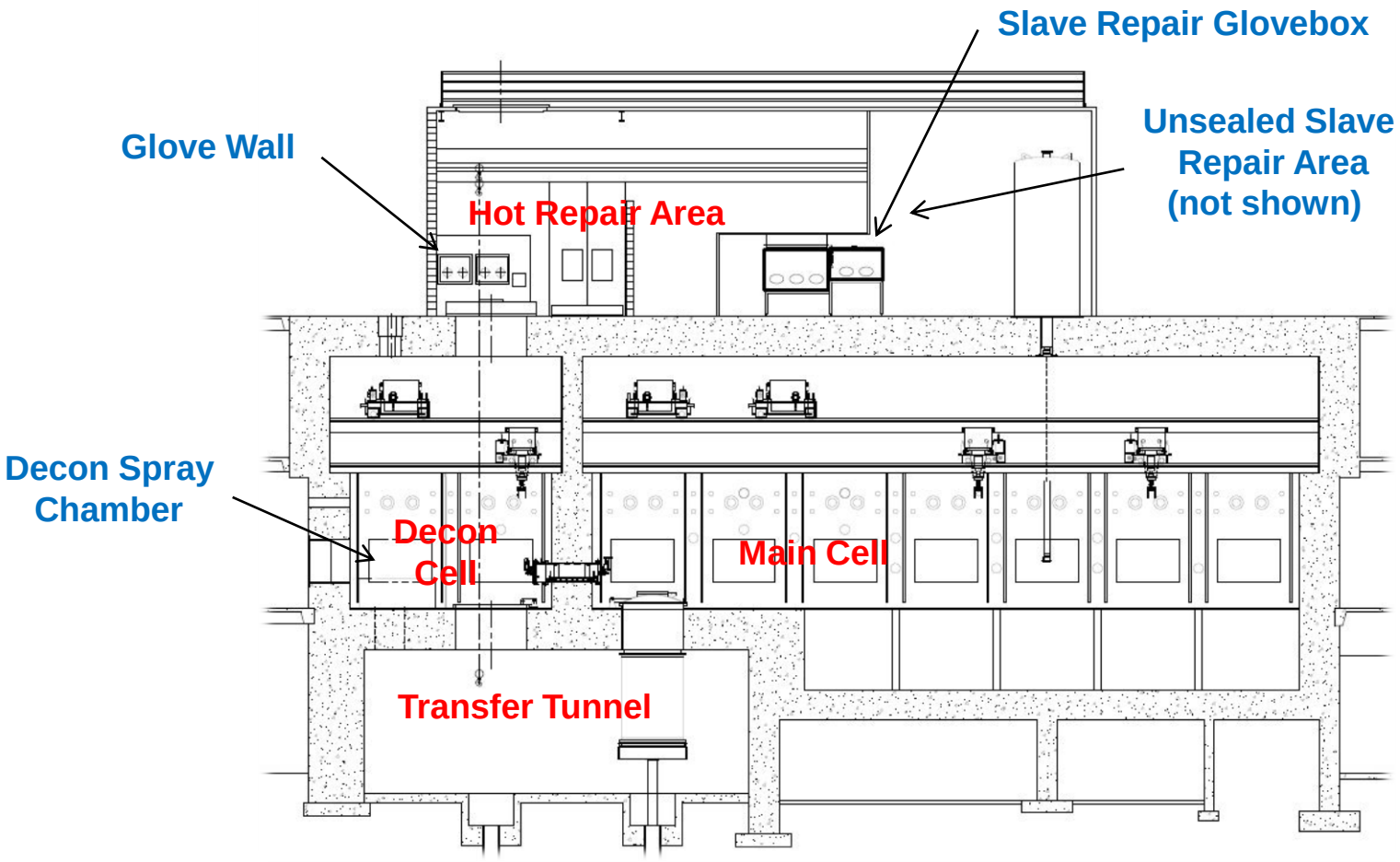


Overhead Handling System Design Features (Continued)

- Wall Buss Bar Replacement Capability

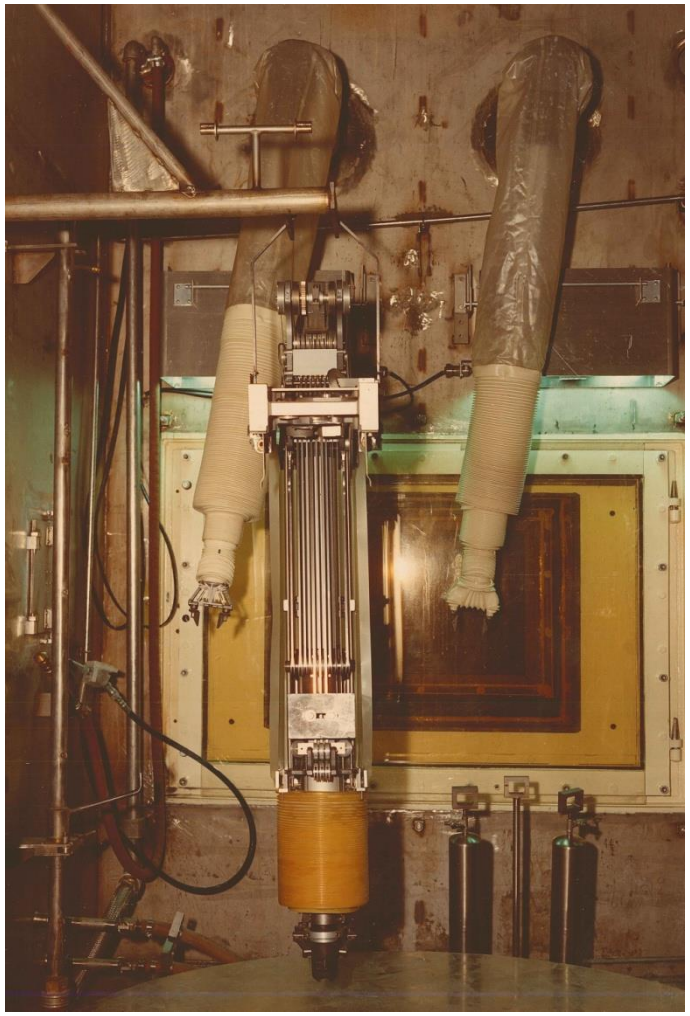


Maintenance Support Systems/Areas



Maintenance Support Systems/Areas (Continued)

- Decon Spray Chamber (DCS)
  - High pressure spray system to decontaminate slave arms.
  - Has a rotating platform for accessing entire item.
  - Slave arms are decontaminated using the DSC.
  - Crane and EM carriages and trolleys are not typically washed. Remote wipe-down and contact decon on the HRA are usually employed.

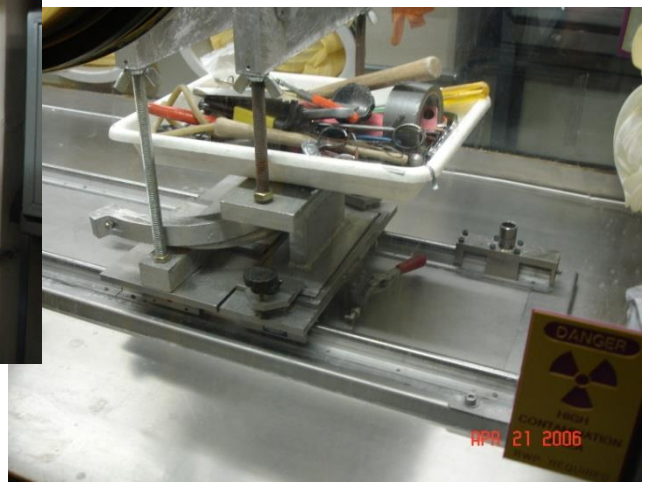


Maintenance Support Systems/Areas (Continued)

- Repair Areas
  - Suited Repair Areas/Hot Repair Areas for contact maintenance
    - Located near the decon cell. Allows for checkout of equipment for integrated testing
    - Glove walls for repair of small components after removal from the equipment
    - Operation of equipment for checkout prior to returning the component to the cell.
    - Test manipulator seal tubes for checkout of manipulators prior to returning to service.
    - Storage of manipulator slave arms for repair in the glove box and staging prior to transfer into the cell.

Maintenance Support Systems/Areas (Continued)

- Slave Repair Glove Box
  - Connected to the HRA for loading and unloading
  - Fixtures for holding slave arm in position for repairs

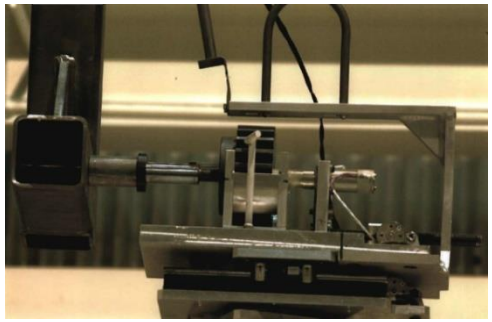


Maintenance Support Systems/Areas (Continued)

- Unsealed Slave Repair Room
  - Room which the manipulator is loaded similar to the normal installation
  - Room is entered as a suited repair area for hands on repairs to the slave end.

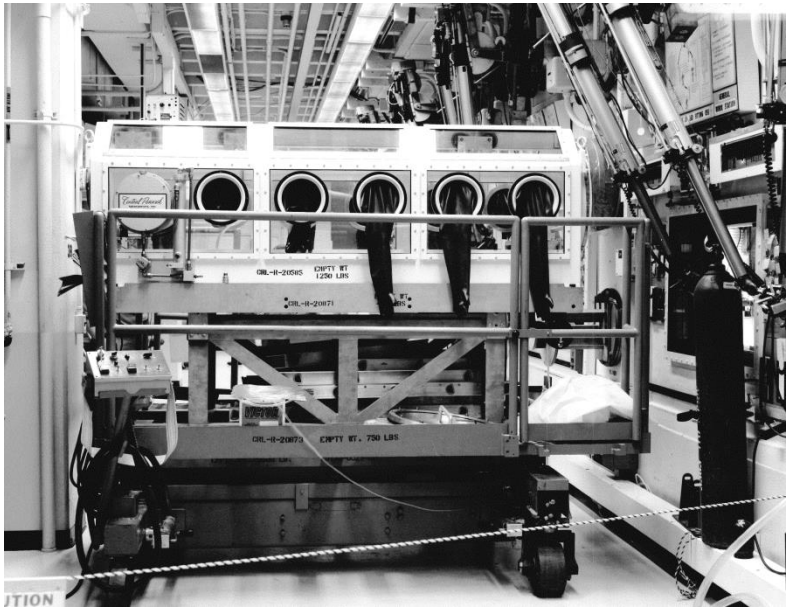
Maintenance Support Systems/Areas (Continued)

- Mockup Area
  - Specialized tool development for maintenance and recovery
  - Qualification of tooling prior to deployment
  - Operator/Technician Training
  - Qualification/Testing of modifications to handing equipment.



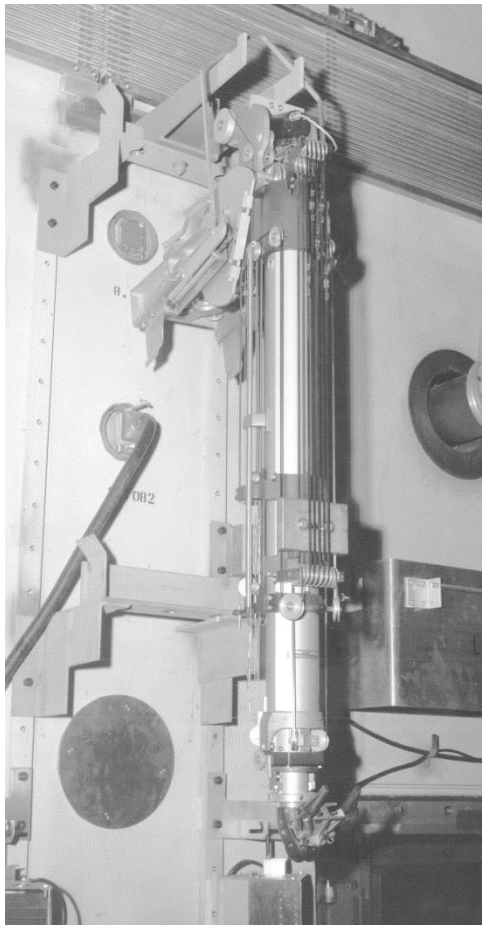
Maintenance Support Systems/Areas (Continued)

- Repair Equipment
  - Seal Tube/Feed-through change-out
  - The glove box is coupled to the wall via sleeving bagging ring. The sleeving and glove box provides a barrier for contamination control and cell atmosphere.
  - Maintenance and repair of the seal tube is normally performed in another location.



Maintenance Support Systems/Areas (Continued)

- Miscellaneous
  - Spare master arm slave arms and unsealed manipulators.
  - Manipulator Storage for spare master arms and unsealed manipulators.
  - In-cell storage for slave arms.
  - Hot Repair Area storage for slave arms (glove box staging)
  - Spare Parts- Manipulator and overhead handling equipment spares are essential to timely corrective maintenance
  - Preventative Maintenance for early detection of repairs/problems



Summary

- Modular concept is important for reduction of facility downtime from equipment failures
- A robust spare system and sufficient number of spare units reduces delays in equipment repairs.
- Design for efficient decontamination of equipment is important for the reduction of worker dose and equipment repair time.
- A considerable amount of space dedicated for maintenance is necessary.
- Suited worker accessibility must be considered in design.