Reactor and Reactor System/ Component Level Compliance with NRC Regulations

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Overview

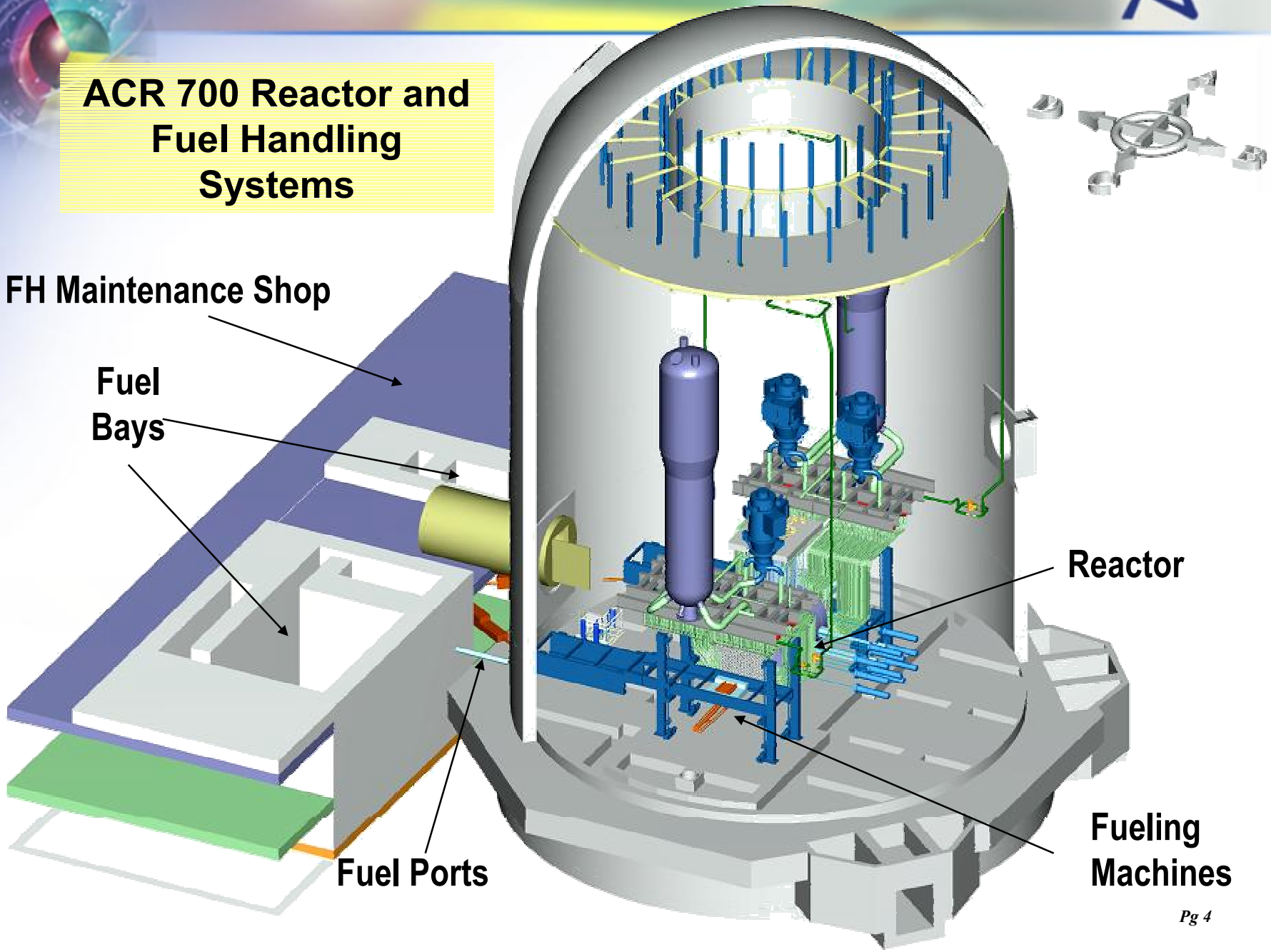
Contents:

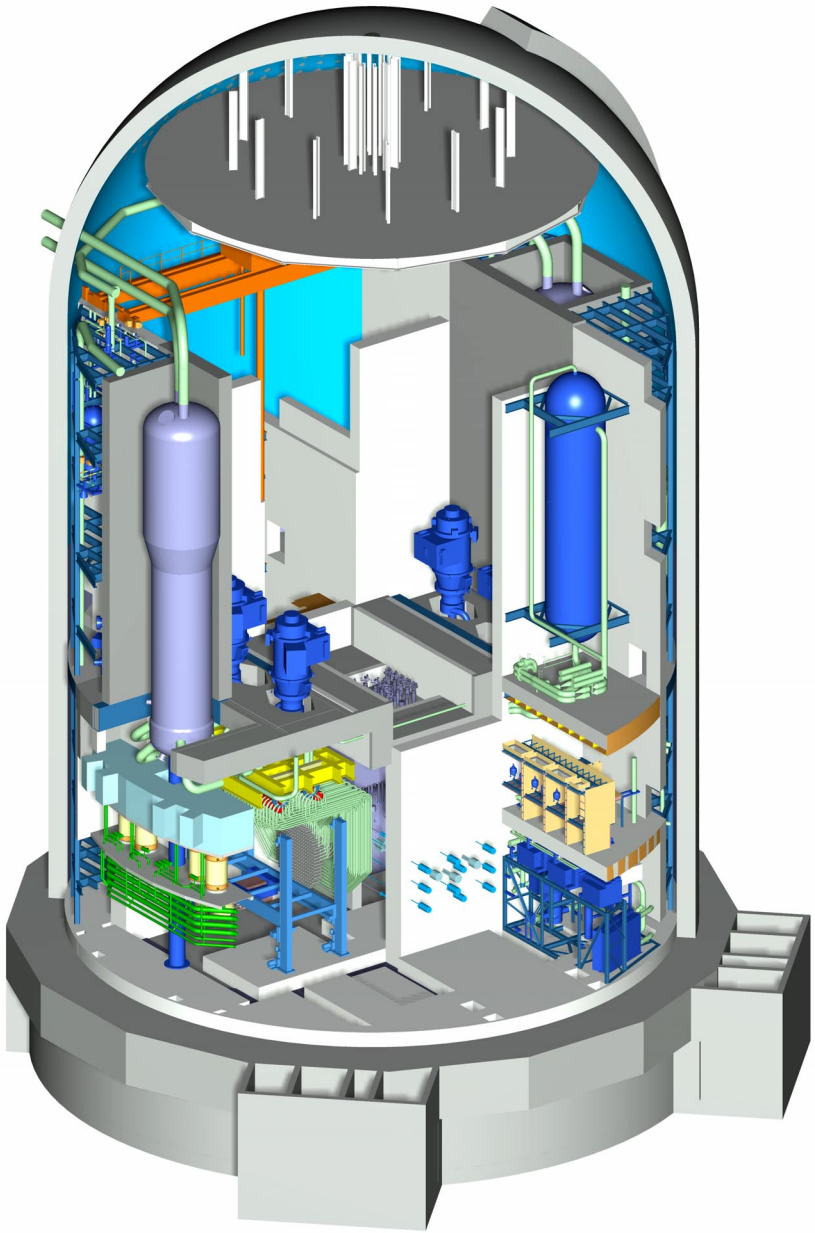
- Major pressure boundary components of RCS
- Fuel Channel
- Fueling Machine
- Conclusions

Reactor System Compliance

- CANDU designs have historically complied with ASME
- Pressure Boundary uses ASME B&PV Code Section III
- Section III written for pressure vessel reactors and directly applied for related parts
- Additional requirements to Section III using same principles and margins (see next presentations)
- ASME In-Service Inspection supplemented (e.g., PT material)
- EQ is performed on safety related systems/ components

ACR 700 Reactor and Fuel Handling Systems

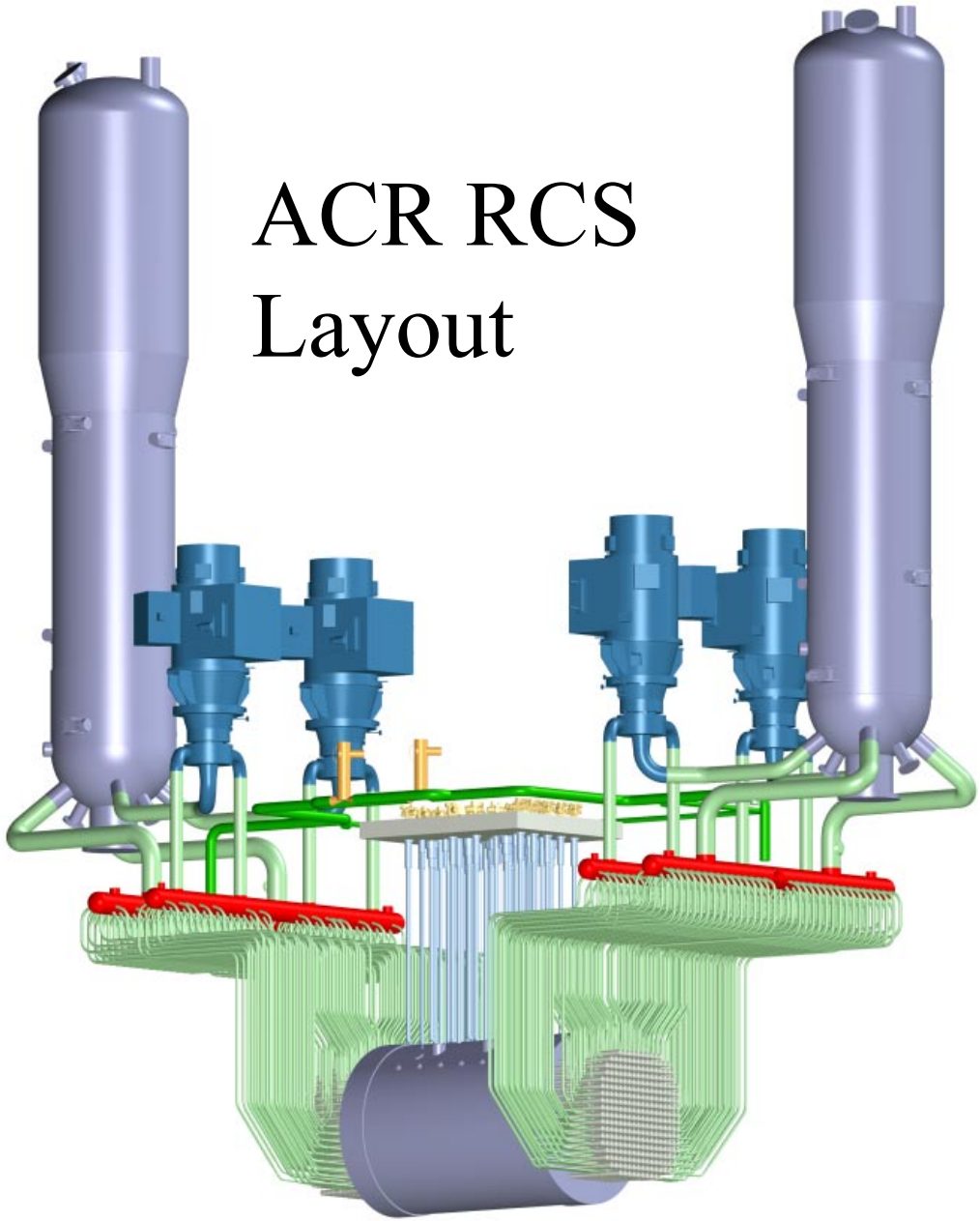




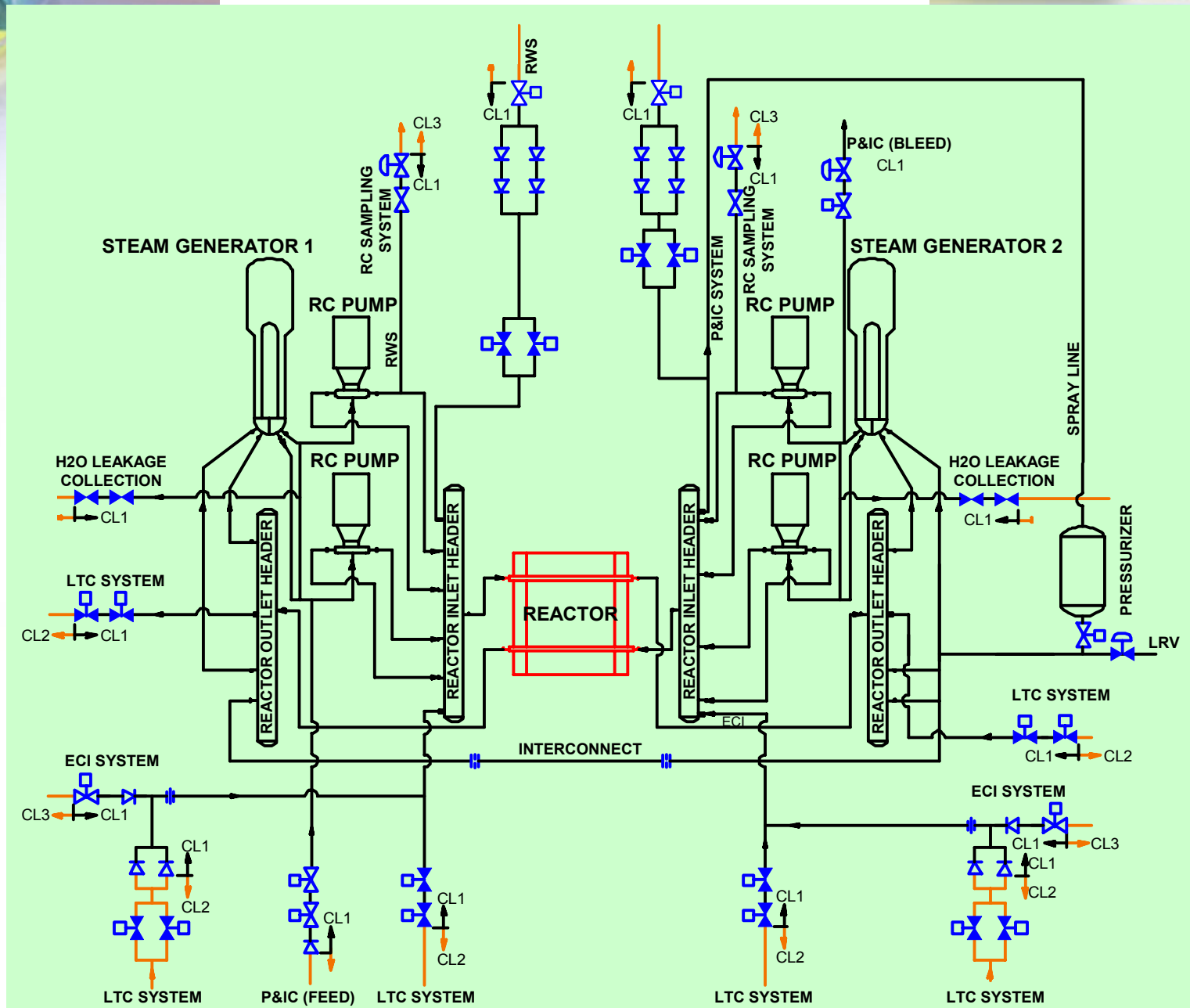
ACR Reactor Layout

- The ACR-700 reactor is an evolutionary design building on past CANDU designs
- The ACR-700 uses slightly enriched fuel in a 292 channel horizontal pressure tube reactor

ACR RCS Layout



RCS Pressure Boundary



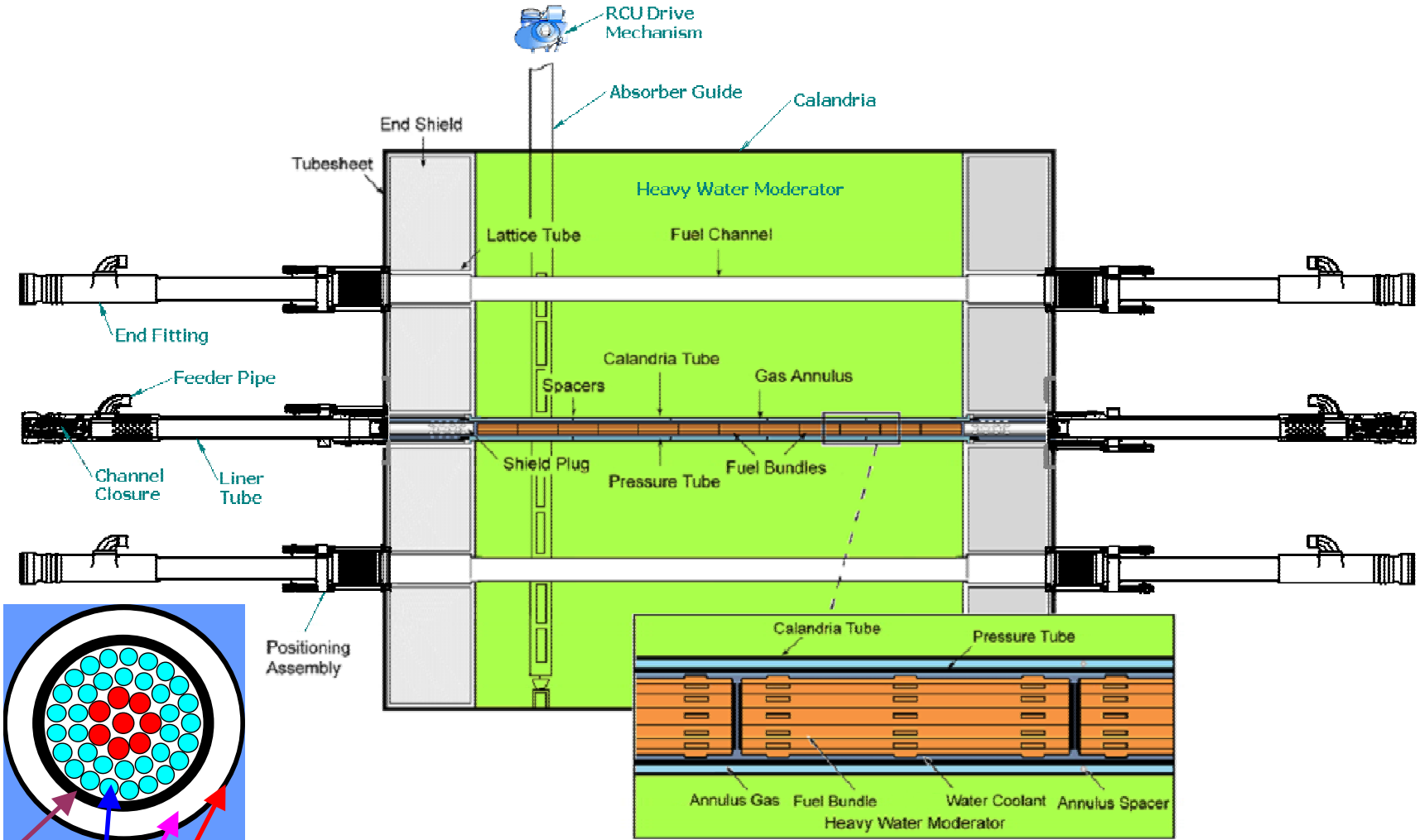
RCPB Components

- Principal Pressure Boundary Components are designed to Class 1 (Gr. A) using ASME Section III including:
  - Steam generators,
  - Pressurizer,
  - RC pumps,
  - Piping (including feeders),
  - Headers.
- Other components (e.g., fuel channels) designed using ASME III rules as discussed in rest of meeting

RCS Operating/Design Conditions

Component	Operating		Design	
	Pressure psig (MPa(g))	Temp. °F (°C)	Pressure psig (MPa(g))	Temp. °F (°C)
RC Pump Suction	1682 (11.6)	533.3 (278.5)	1871 (12.9)	561.2 (294)
RC Pumps	1900 (13.1)	533.3 (278.5)	2161 (14.9)	561.2 (294)
Pump Discharge	1900 (13.1)	533.3 (278.5)	2161 (14.9)	561.2 (294)
RIH	1900 (13.1)	533.3 (278.5)	2161 (14.9)	561.2 (294)
ROH	1726 (11.9)	617 (325)	1871 (12.9)	627.8 (331)
SG inlet pipe	1726 (11.9)	617 (325)	1871 (12.9)	627.8 (331)
Steam Generators	1726 (11.9)	617 (325)	1871 (12.9)	627.8 (331)
Pressurizer	1726 (11.9)	617 (325)	1871 (12.9)	627.8 (331)

Fuel Channel Arrangement



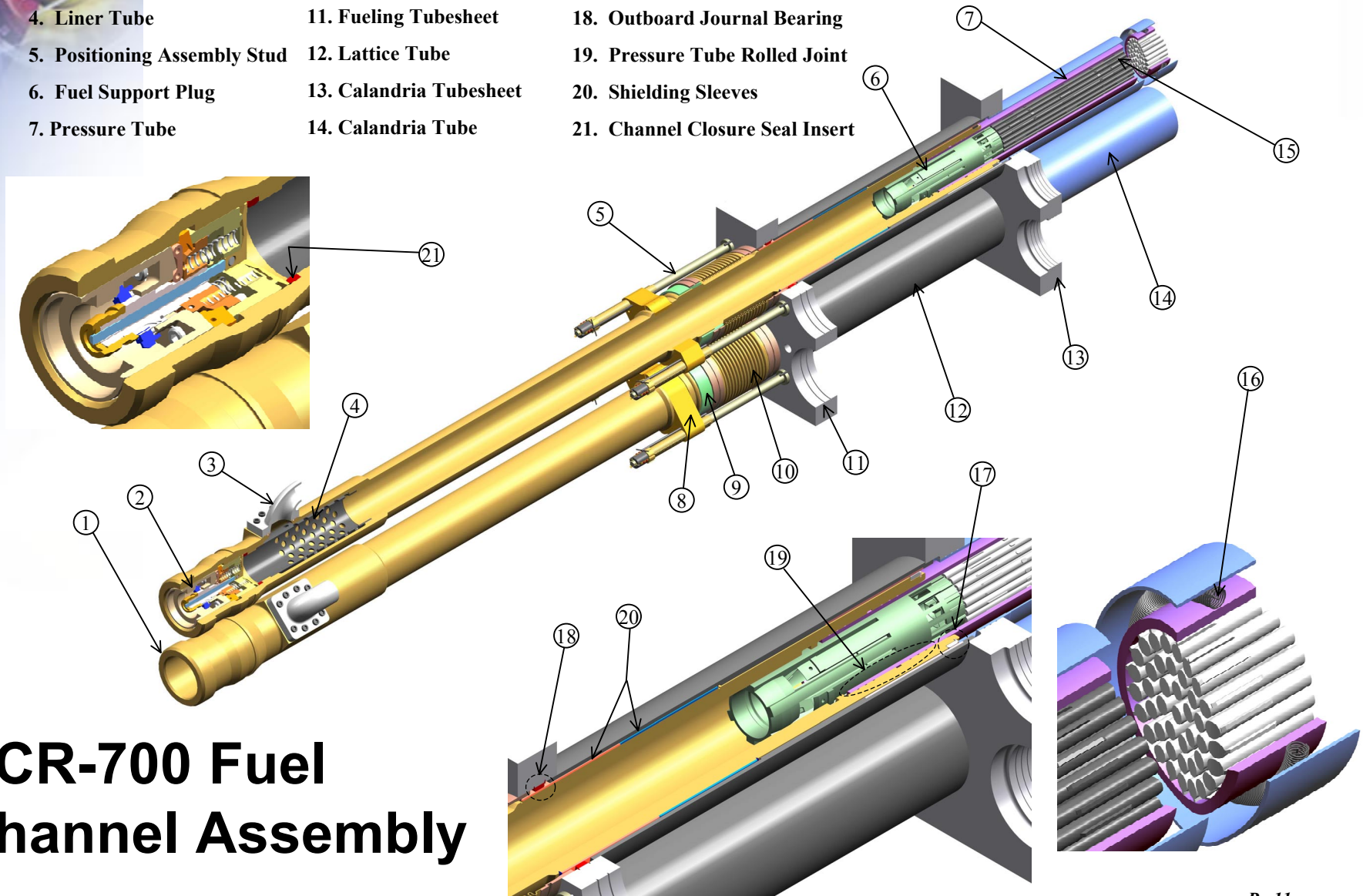
Pressure tube

Calandria tube

Annulus gap

Fuel elements

1. End Fitting
2. Channel Closure
3. Feeder Connection
4. Liner Tube
5. Positioning Assembly Stud
6. Fuel Support Plug
7. Pressure Tube
8. Position Assembly Yoke
9. Bellows Attachment Ring
10. Bellows Assembly
11. Fueling Tubesheet
12. Lattice Tube
13. Calandria Tubesheet
14. Calandria Tube
15. Fuel Bundle
16. Channel Annulus Spacer
17. Inboard Journal Bearing
18. Outboard Journal Bearing
19. Pressure Tube Rolled Joint
20. Shielding Sleeves
21. Channel Closure Seal Insert



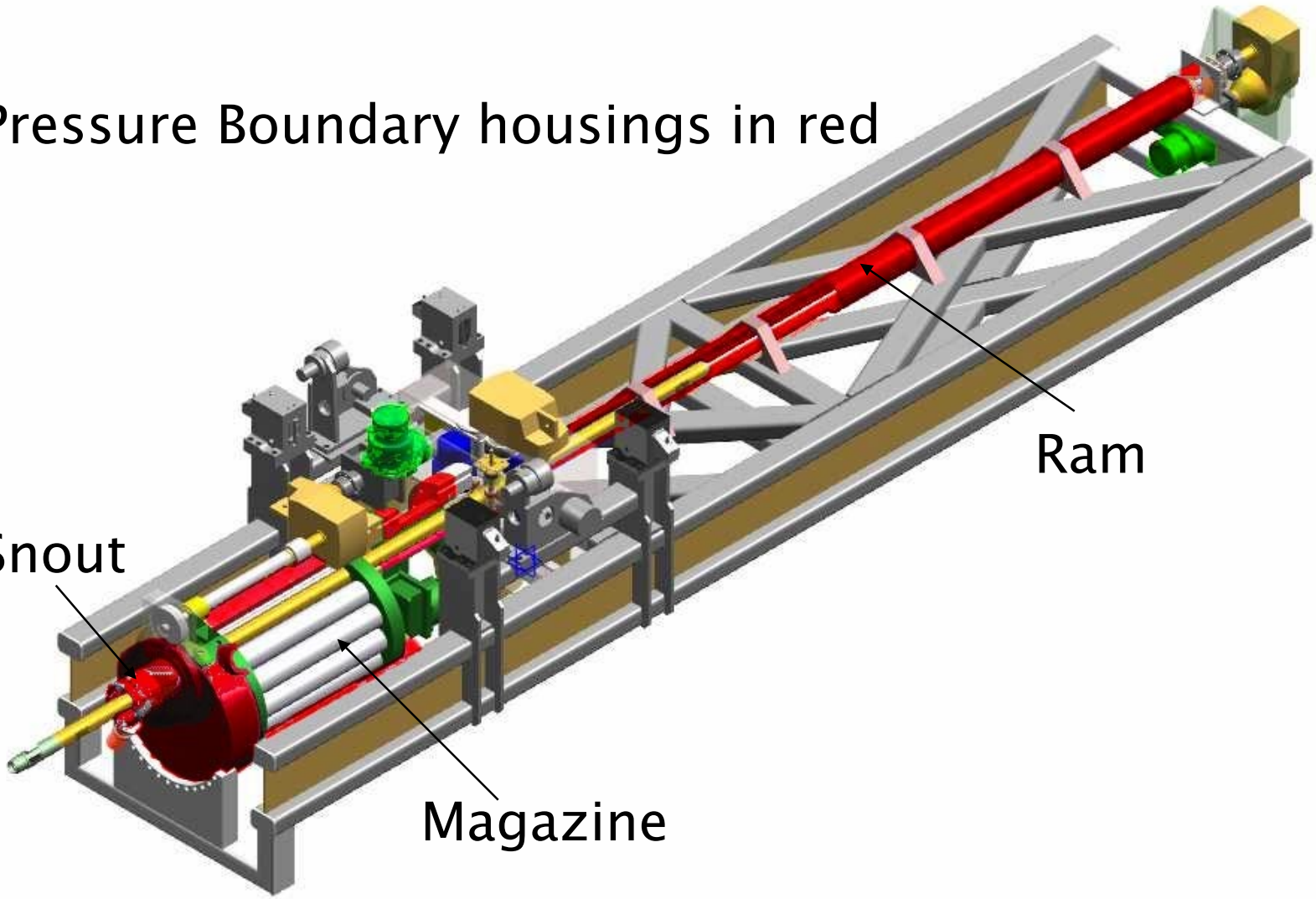
ACR-700 Fuel Channel Assembly

Fuel Channel Parts

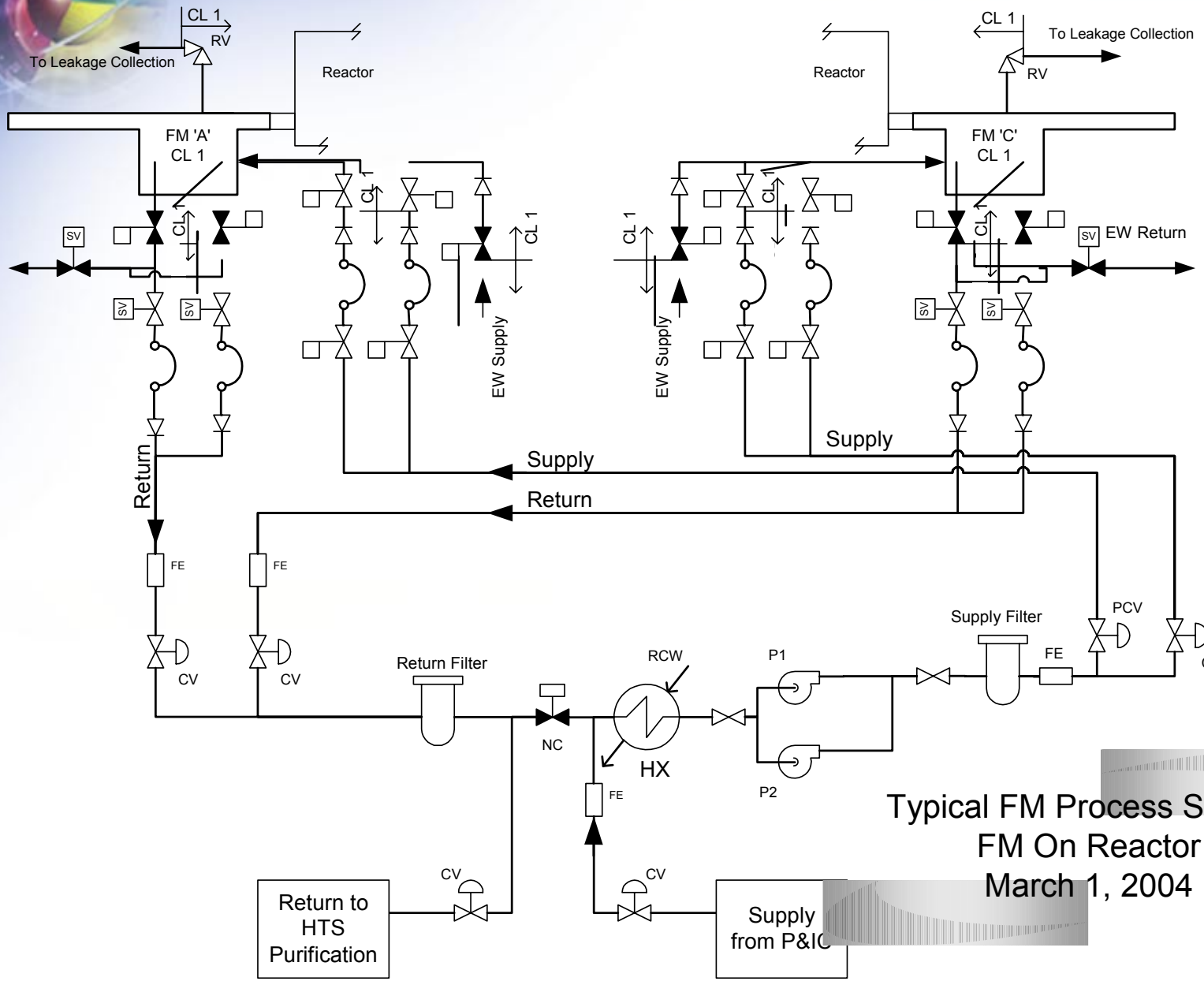
	Features	Notes
Feeder Connection	Stainless Steel Casting bolted with gasket	Design meets ASME III
End Fitting	Forged, modified 403 stainless	Design to ASME III except for material
Rolled Joint	PT material roll formed in to grooves in end fitting	ASME III stress limits
Pressure Tubes	Zirconium Niobium alloy	See later presentation
Closure Plug	Seal latched and locked in place (see next presentation)	Design to ASME III with extra features not covered by ASME (latched jaws)

ACR Fueling Machine Head

Pressure Boundary housings in red



Fueling Machine



Typical FM Process System
FM On Reactor
March 1, 2004

Fueling Machine

Head Parts	Features	Notes
Pressure boundary shell	Conventional shell	Design to ASME III
Nozzle connections	Small diameter penetrations in boundary	Class I boundary at second isolation valve Screw thread for small dia fittings under assessment
Tubing	Small Bore tubing	Tube to ASME III, Swagelock fittings qualified
Catenaries / hoses	B31.1 equivalent reinforced elastomer hose	Qualified by manufacturing and design controls
Connection Lock	Mechanical pressure / spring activated	Extra feature to cover connection safety

Prevention of Inadvertent Release of FM from Reactor Channel

- FM snout-to-end-fitting clamping mechanism
- FM snout safety lock – engaged / locked by channel pressure
- Check for integrity of seal between FM snout and channel end fitting prior to removal of channel closure
- FM snout clamp interlocks on pressure and status of snout safety lock
- FM bridge drive / brake safety interlocks
- Limited force of carriage drives
- Check for partial blockage of channel prior to installing channel closures
- Check for integrity of seal between channel closure end fitting prior to unclamping of FM snout

Design Features to Enhance Safety During Fueling - Summary

- The principal safety features related to CANDU fueling are well proven and are designed according to recognized standards
- Pressure boundary components are designed to established piping and pressure vessel codes
- Additional interlocks, mechanical locks and backup systems are incorporated to enhance safety and operability
- Inherent benefit in reduction of reactor coolant system (RCS) activity from defective fuel bundles due to early detection / removal

Design Features to Enhance Safety During Fueling - Summary

- Latching snout connection mechanism and additional safety locks to prevent unintentional or unsafe release from a fuel channel
- Controls and instrumentation that are required to function properly during and following a Safe Shutdown Earthquake (SSE), LOCA or MSLB are seismically and environmentally qualified
- A seismically and environmentally qualified emergency water system is included to maintain fuel cooling when the FM is off reactor during and following a SSE, LOCA or MSLB or if the normal system becomes unavailable
- Stainless steel tubes and baskets guarantee sub-criticality of the fuel in all mediums

Fuel Transfer Ports

- See video

CANDU Specific Features of the ACR-700 Design

(Discussed in Next Presentation)

- **Fuel Channel**
  - Rolled Joints
  - Pressure tubes
  - Channel Closure interfaces
- **Calandria**
  - Rolled Joints
  - Lattice tubes
- **Reactivity Control Units**
  - Low pressure boundary
- **Fuel Handling Equipment**
  - Hoses
  - Channel closure locks/ interlocks
  - Channel connection locks/ interlocks
  - Supports
  - Threaded Connections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