ACR Reactor and Fuel Handling

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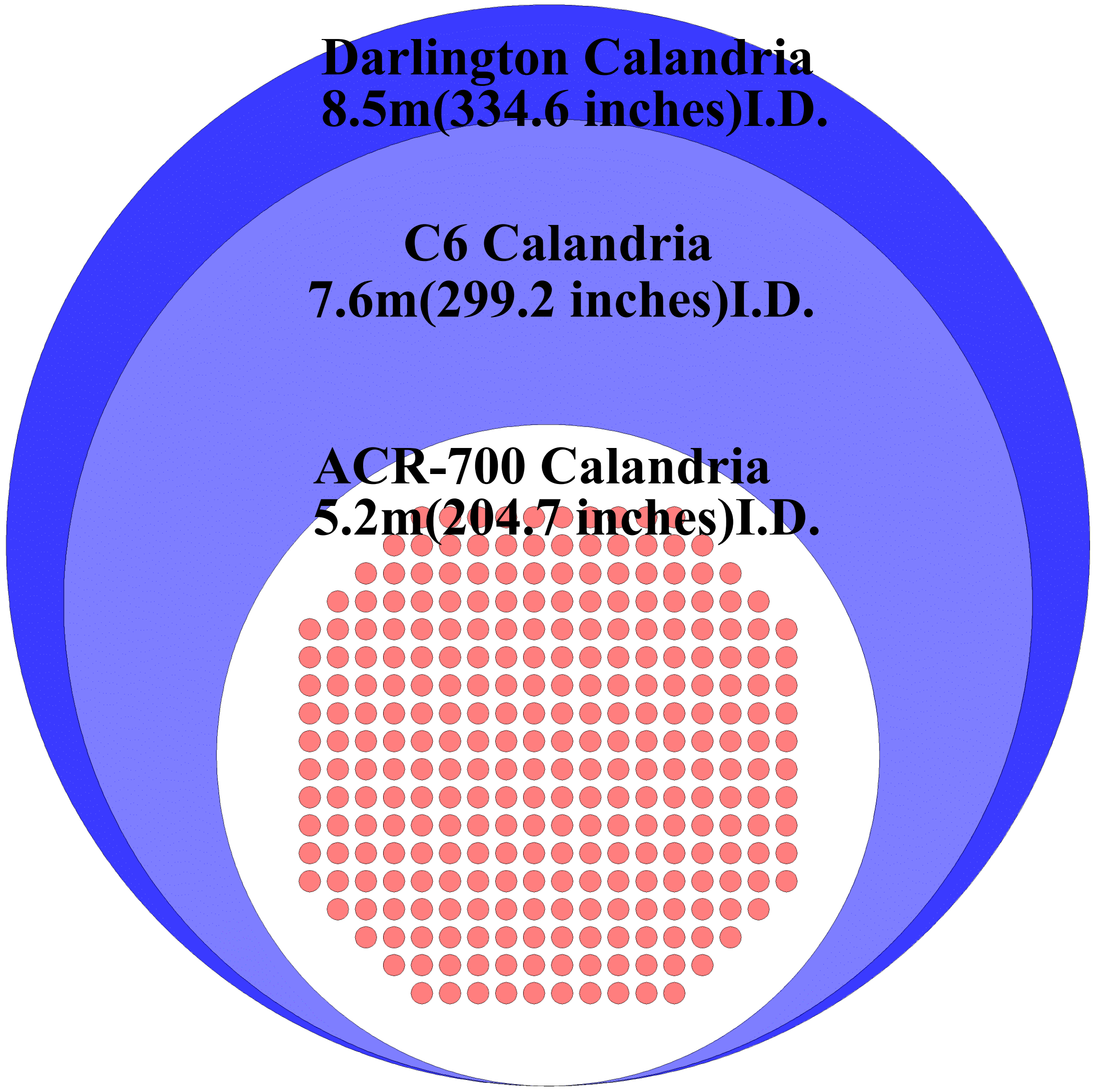
AECL TECHNOLOGIES INC.

Reactor Design Basis

- The ACR reactor is based on a typical CANDU design
- Features an array of fuel channels passing horizontally through calandria containing the moderator heavy water
- Calandria is a horizontal cylindrical vessel closed at each end by circular flat plates (calandria tube sheets)
- The calandria tubes pass horizontally through the calandria and restrain the calandria tube sheets
- The calandria is enclosed by end shields
- The shield tank encloses and supports the calandria and end shields

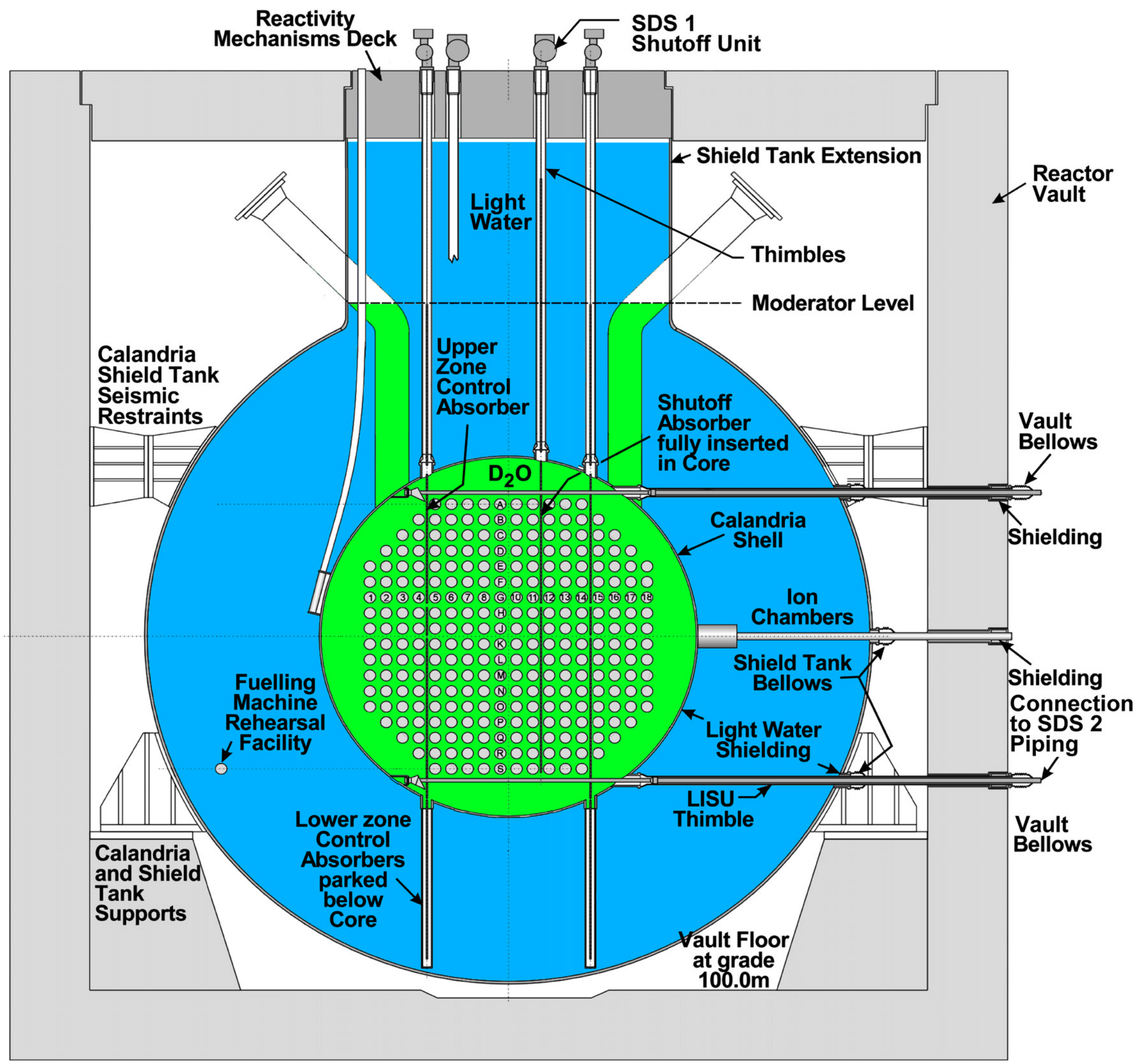
ACR-700 Reactor Size



ACR Reactor Design utilizes proven features of CANDU

- The calandria contains heavy water moderator
- The end shields contain light water and shielding balls.
- The shield tank contains light water, which serves as both a thermal and a biological shield
- The cool moderator is independent of the hot, pressurized light water coolant in the fuel channels

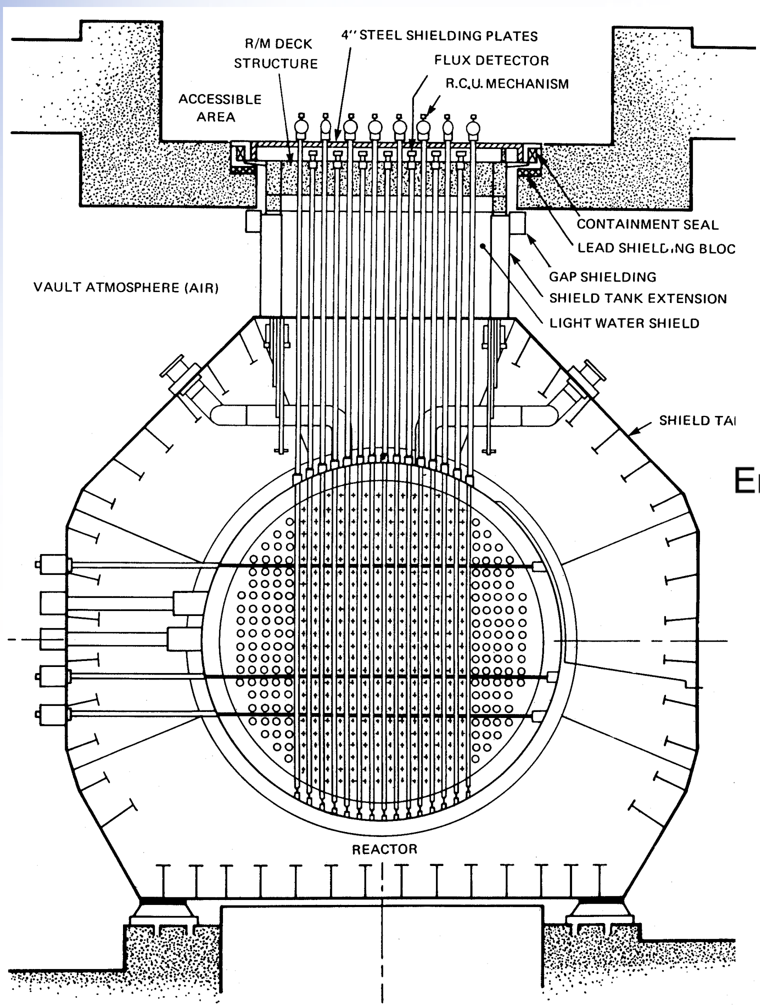
ACR Calandria & Shield Tank Assembly



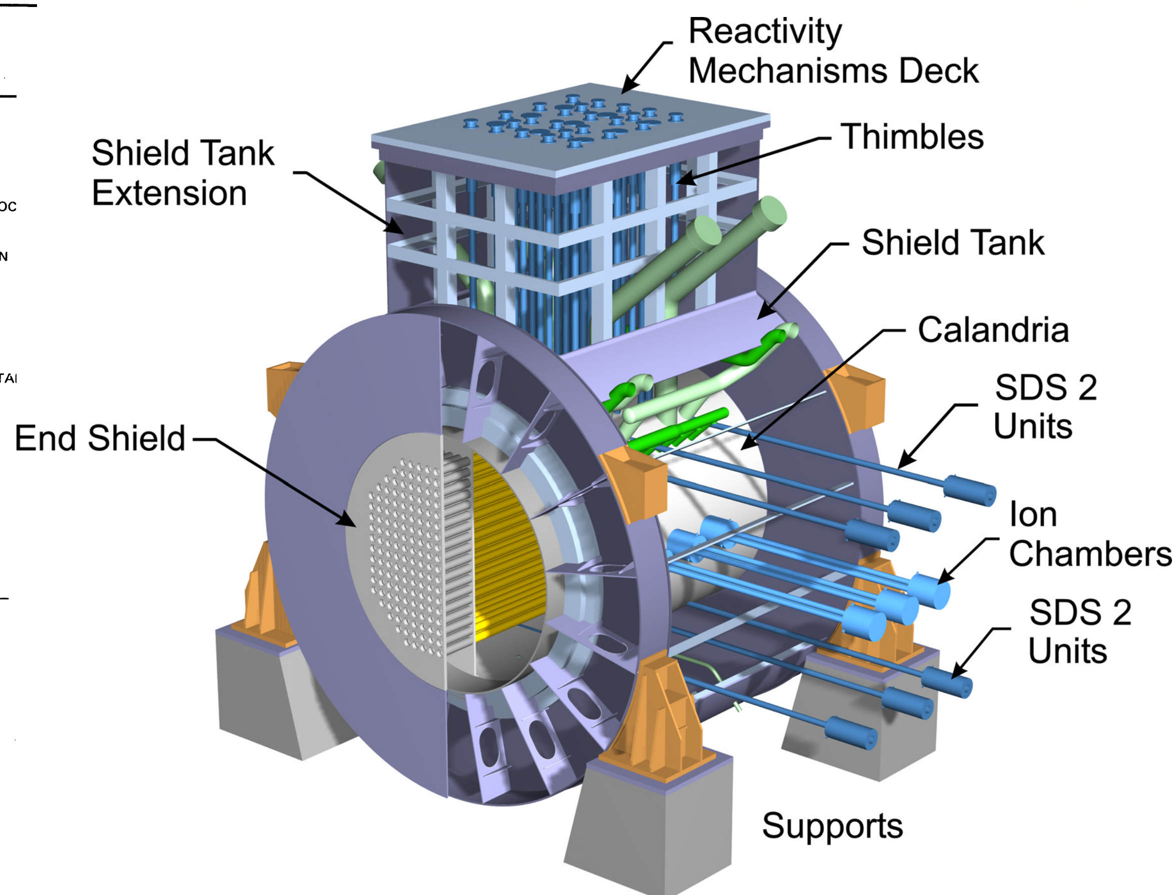
ACR Reactor Design utilizes proven features of CANDU

- **The shield tank has an integral rectangular extension extending up and supporting the reactivity mechanisms deck**
- **Thimbles guide reactivity mechanisms from the reactivity mechanisms deck to the top of the calandria**
- **The assembly of the calandria and integrated shield tank and reactivity mechanisms deck is called the Calandria Shield Tank Assembly (CSTA)**

Darlington/Bruce Calandria and Shield Tank



ACR Calandria Shield Tank Assembly



Reactivity Control Units

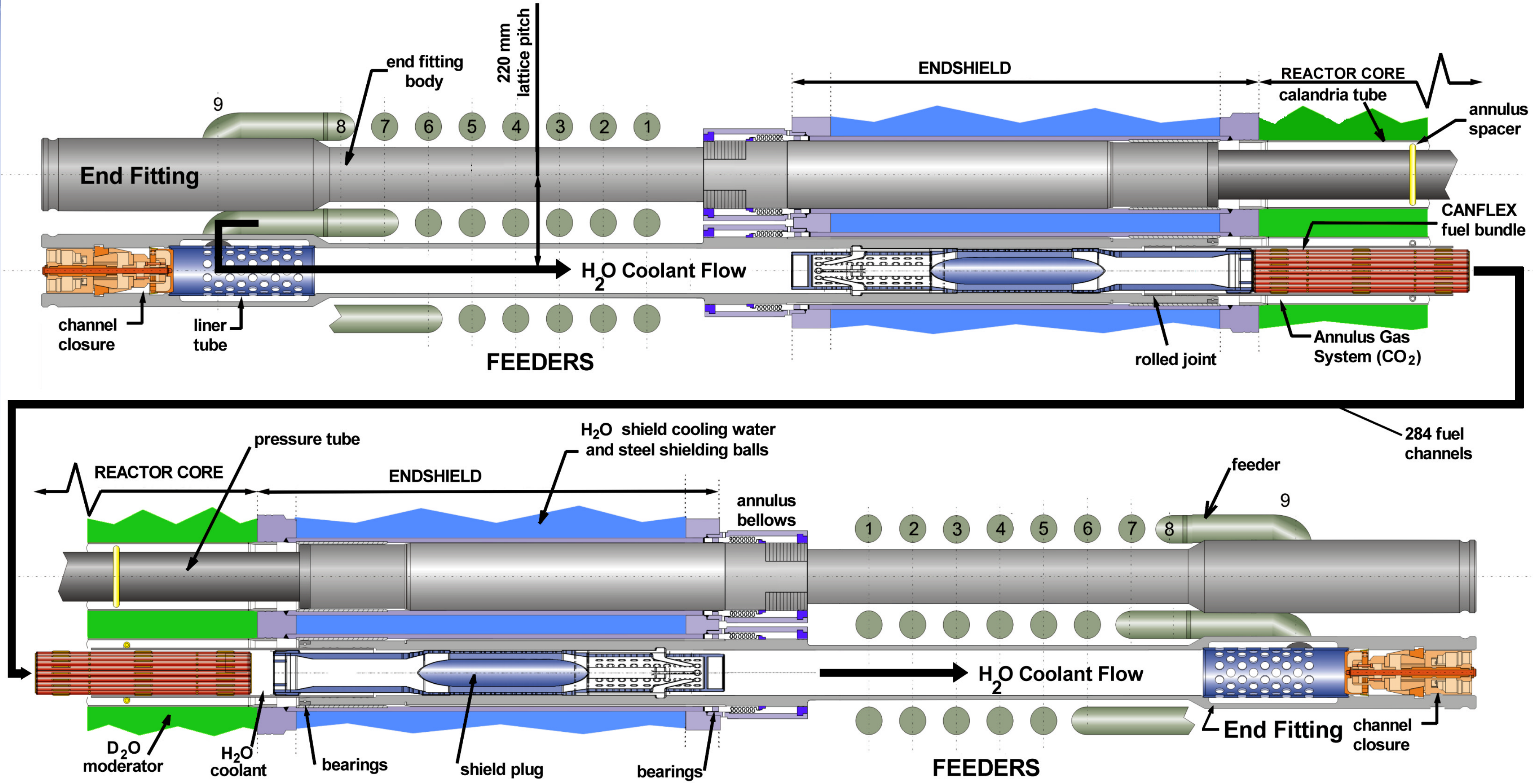
- Reactivity mechanisms include:
  - Reactivity control devices (control absorber units and mechanical zone control units)
  - Safety shutdown systems (shutoff units for shutdown system 1, and liquid injection nozzles for shutdown system 2)
  - Neutron flux measuring devices (self-powered flux detector, fission chamber and ion chamber units)
  - All reactivity mechanisms operate in the low temperature, low pressure moderator environment
  - Designs are simple, rugged, require little maintenance, are highly reliable and are based on CANDU 6 designs
  - Reactivity control units are testable on line.

Reactivity Mechanisms Layout

Fuel Channel

- Supports twelve fuel bundles
- Facilitates flow of coolant past fuel to steam generators
- Accommodates dimensional and performance changes during operating life
- Permits inspection and replacement, if necessary (Single-Channel and Large-Scale Retubing)
- Prevents damage to other channels and calandria in accident scenarios if pressure tube failure occurs
- Pressure boundary consists of closure plugs (2), end fittings (2), and pressure tube.

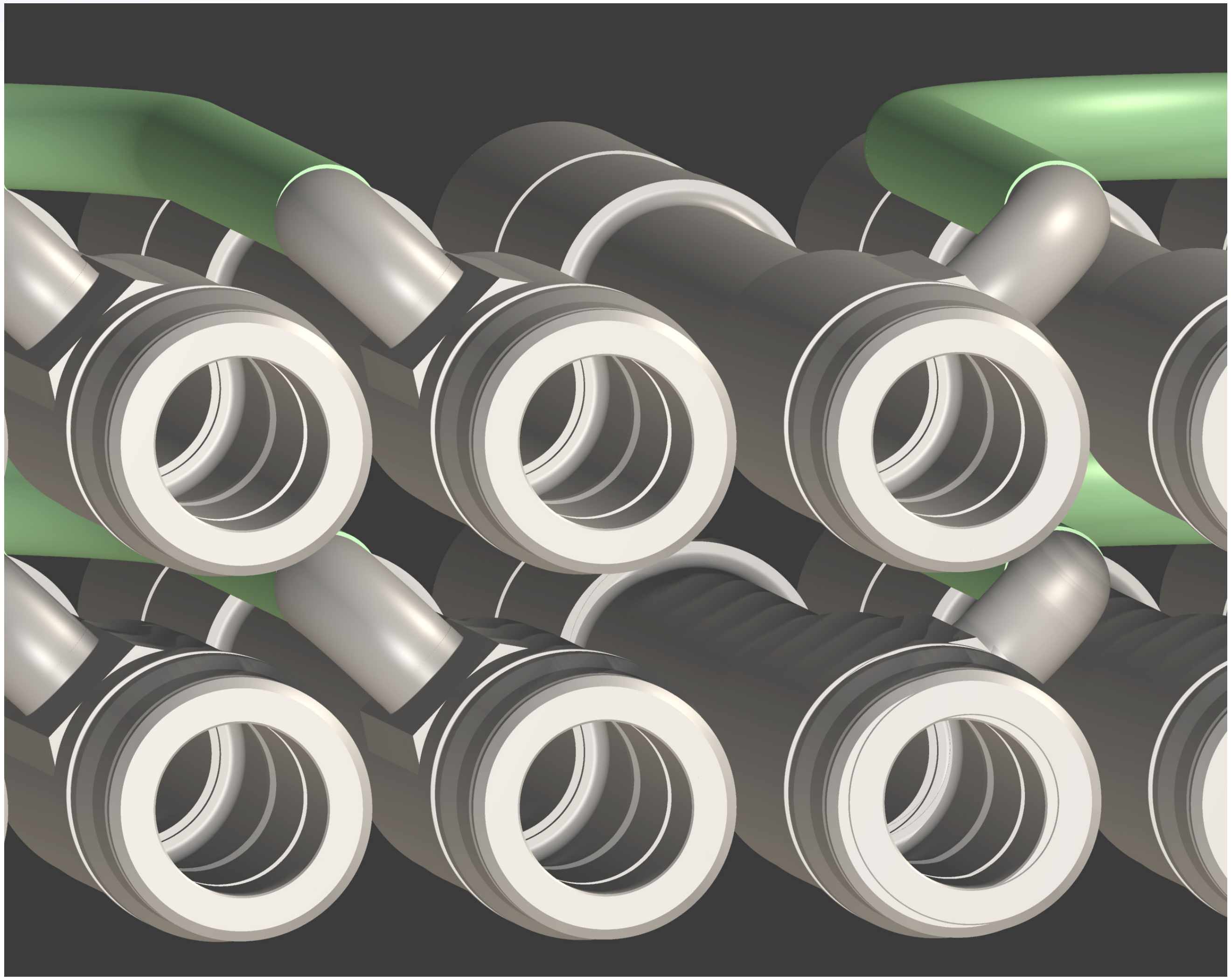
ACR Fuel Channel



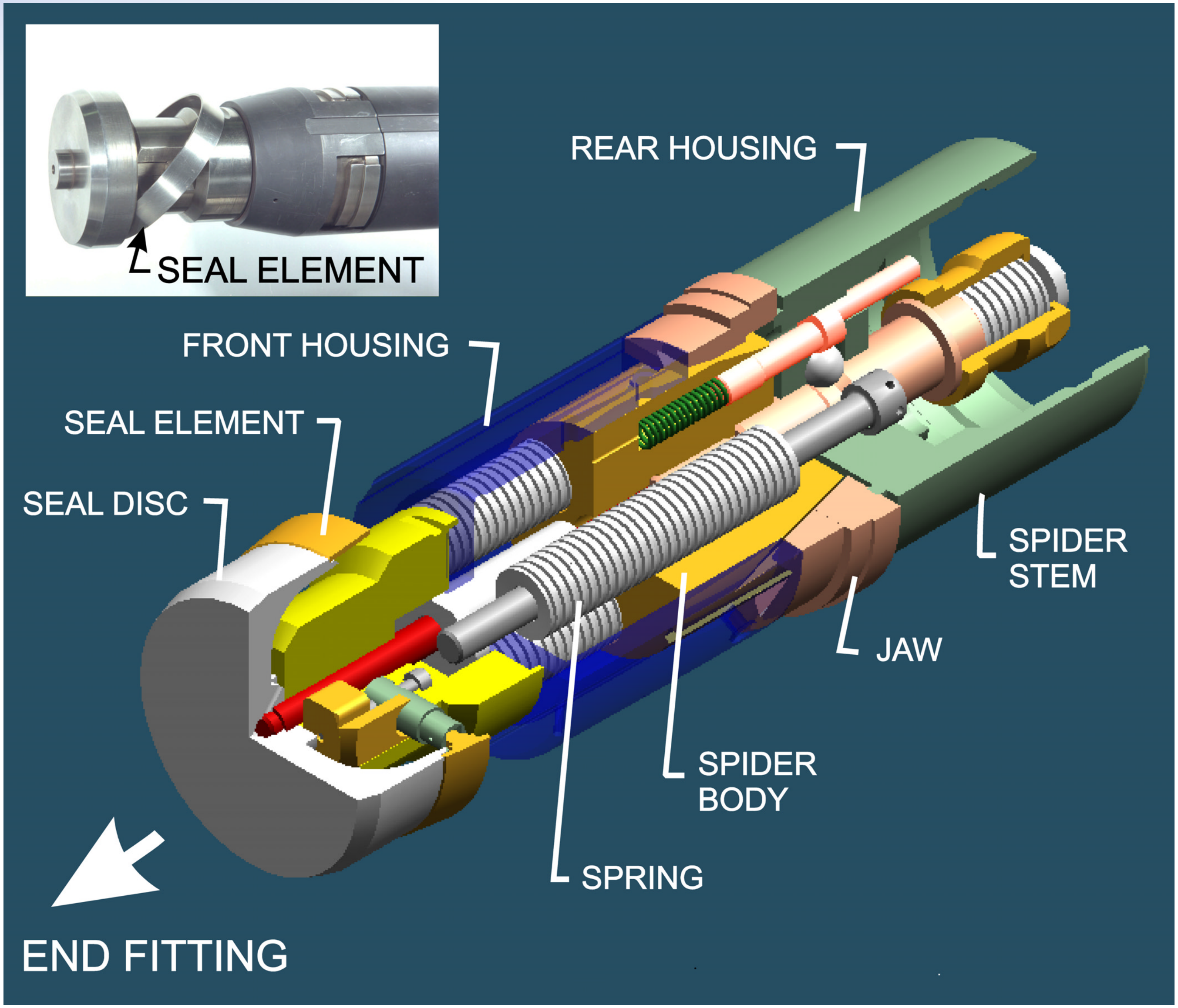
Fuel Channel Design

	CANDU 6	ACR
Lattice pitch	286 mm (11.26”)	220 mm (8.66”)
PT material	Zirconium 2.5wt% Niobium alloy	Zirconium 2.5wt% Niobium alloy
PT wall thickness	4.2 mm (0.165”)	6.5 mm (0.256”)
PT max. operating temperature	313.2 ^{o}C (596 F)	327.7 ^{o}C (622 F)
PT max. operating pressure	11.1 MPa (1610 psi)	13 MPa (1886 psi)
PT max. operating flux ($n/m^2/s$)	$3.7x10^{17}$	$4.1x10^{17}$
Calandria tube material	Zircaloy-2	Zircaloy-4
Calandria tube wall thickness	1.4 mm (0.055”)	2.5 mm (0.098”)
Fuel channel operating life	25 years at 80% capacity	30 years at 90% capacity

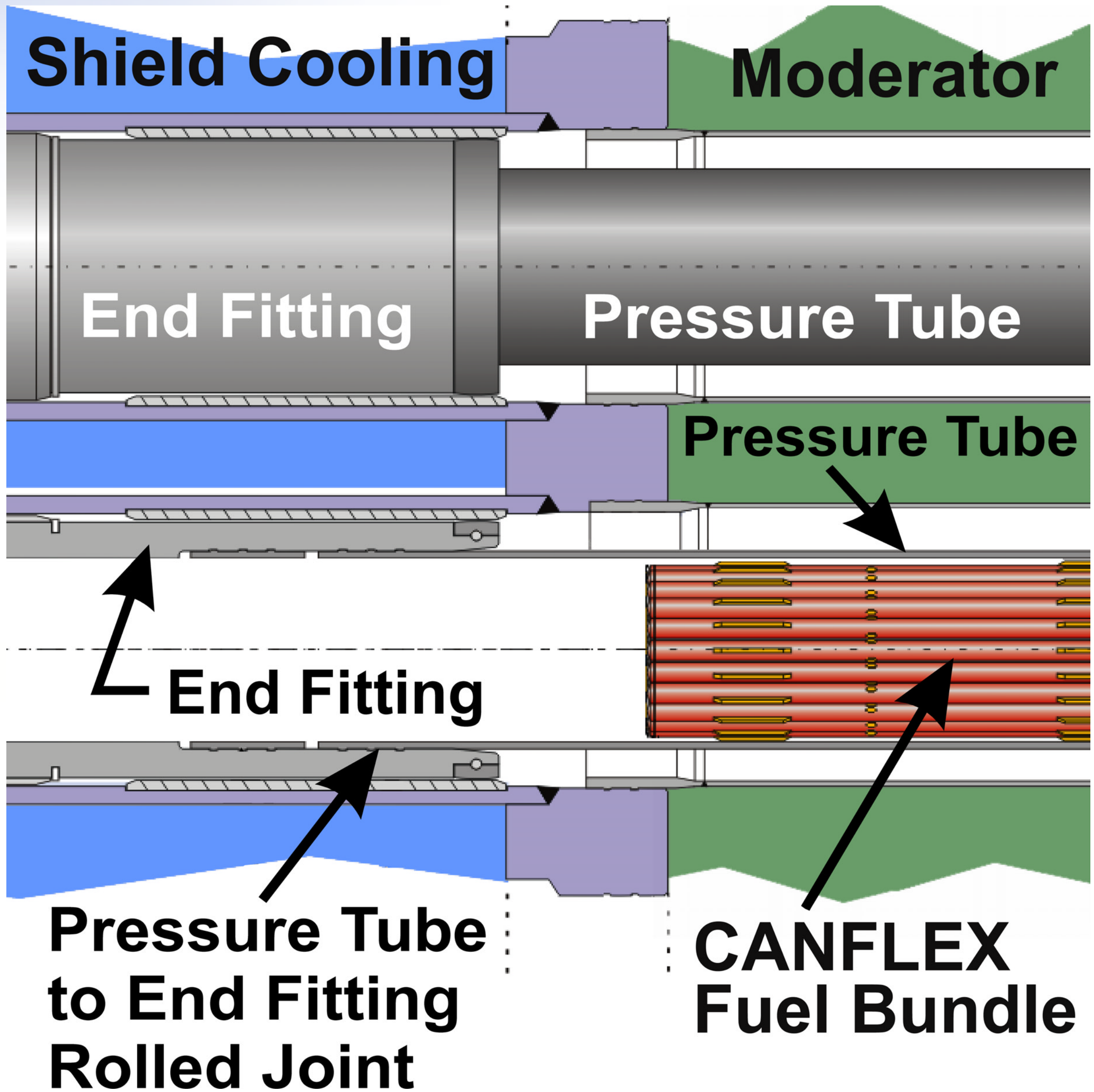
ACR Fuel Channels with Feeders



ACR Channel Closure



ACR Pressure Tube Rolled Joint



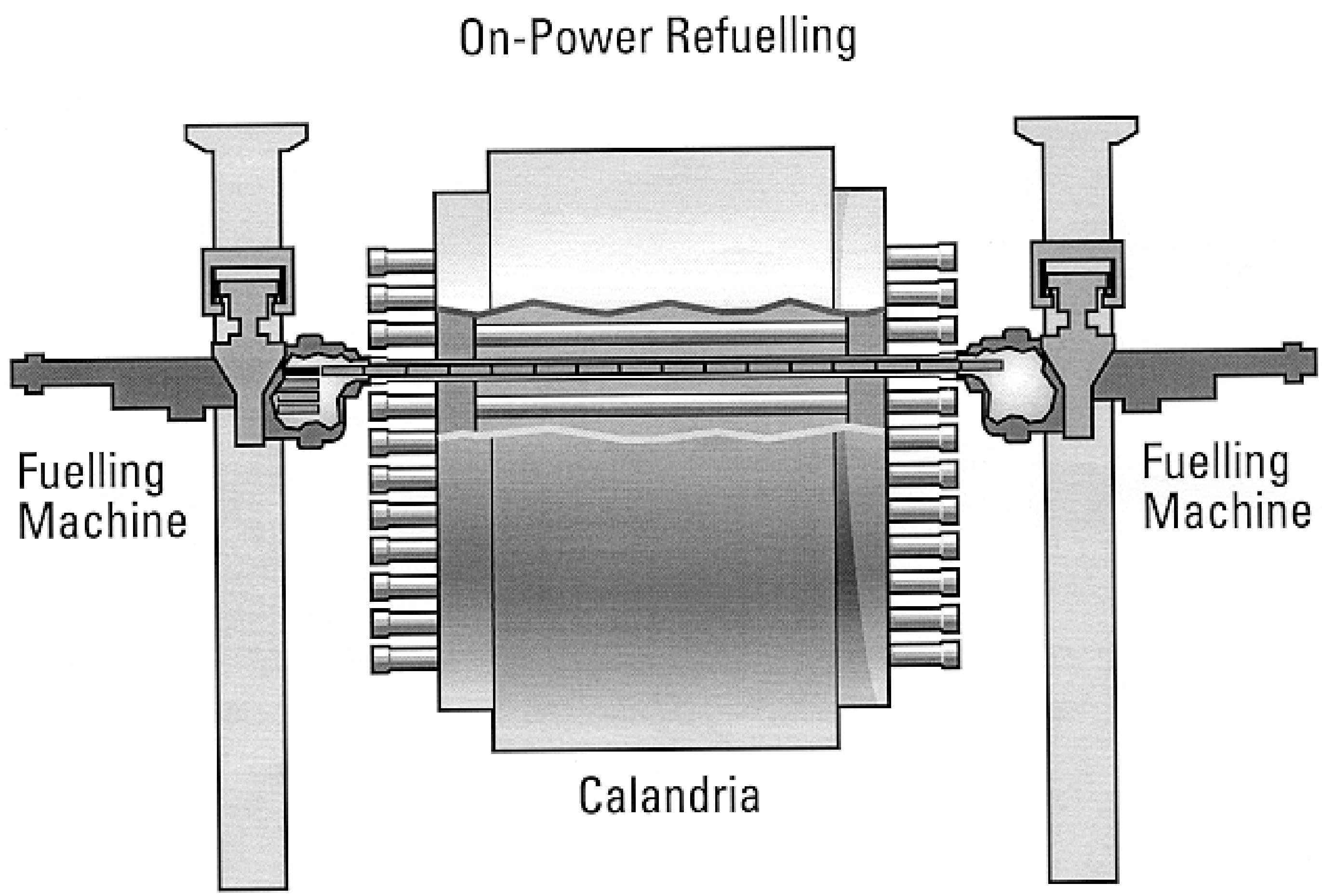
Assessments of ACR Pressure Tube Aging

- Assessments of PT deformation, H ingress, fracture and DHC are based on existing models and data
  - Extrapolated to 30 years and considers ACR conditions
  - Assume highest power channel, worst case material variability
  - Conservative estimates of benefits of improvements to PT (as compared with historical data on which models are based)
- Effects of deformation and H ingress will be acceptable over 30 years at 90% capacity
- Fracture behavior will also be acceptable
- Testing will be performed to confirm assessments results

Fuel Handling System

- The ACR Fuel Handling System is an evolution of the CANDU 6 system
- It consists of :
  - New fuel transfer and storage
  - On-power fuel changing
  - Spent fuel transfer and storage

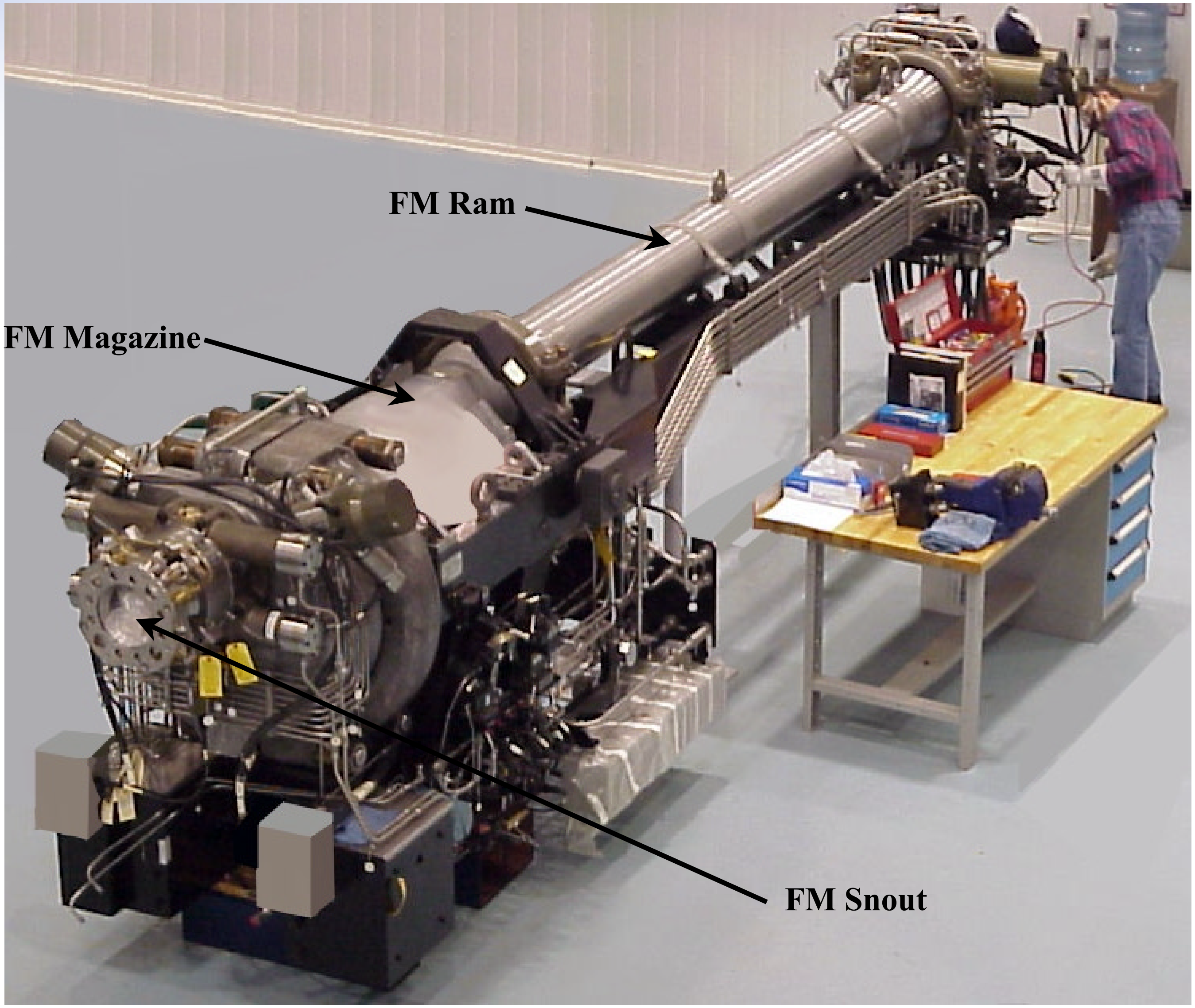
On-Power Refueling



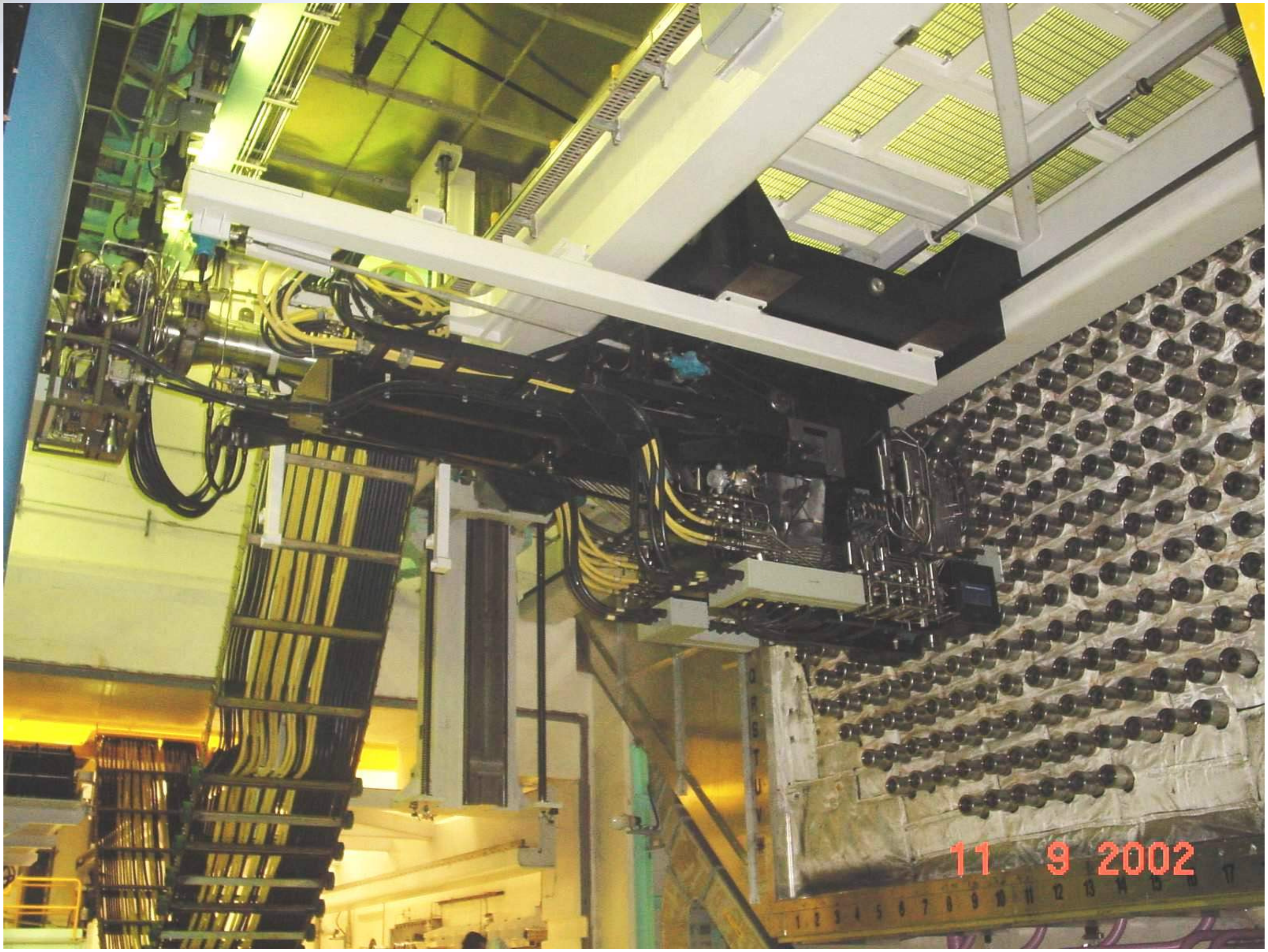
Fuel Handling System

- Provides a safe and reliable method to refuel reactor on power
- ACR system is designed to:
  - simplify manufacture, installation and commissioning
  - reduce O & M costs
- Major improvements in the design include:
  - Fueling machine head and carriage simplified
  - Elimination of D_2O from fueling machine system
  - Electric drives replace oil hydraulic drives
  - Fueling machine support enhanced
  - Spent fuel transferred in water (H_2O)

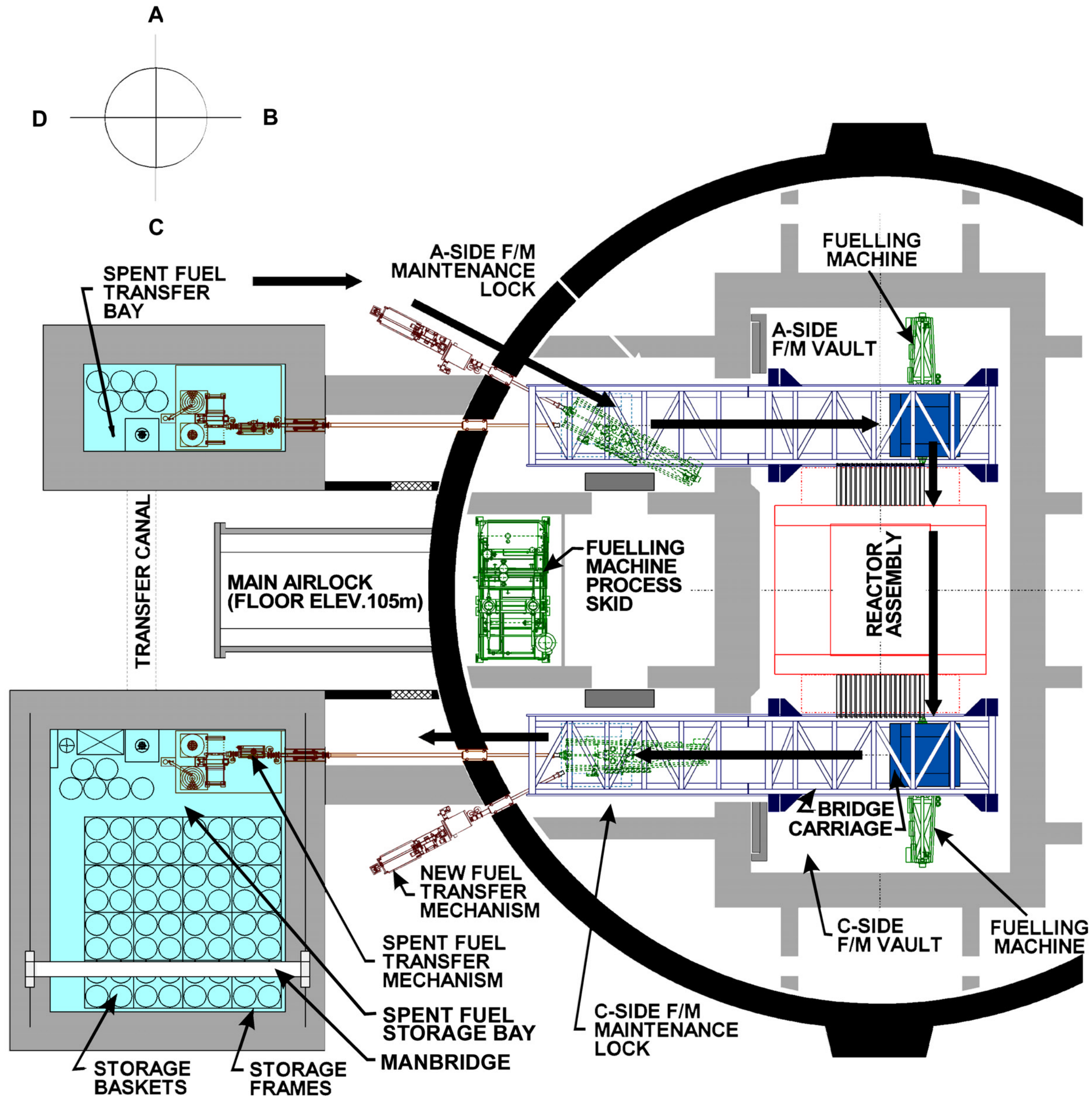
CANDU 6 Fueling Machine



Fueling Machine on Reactor



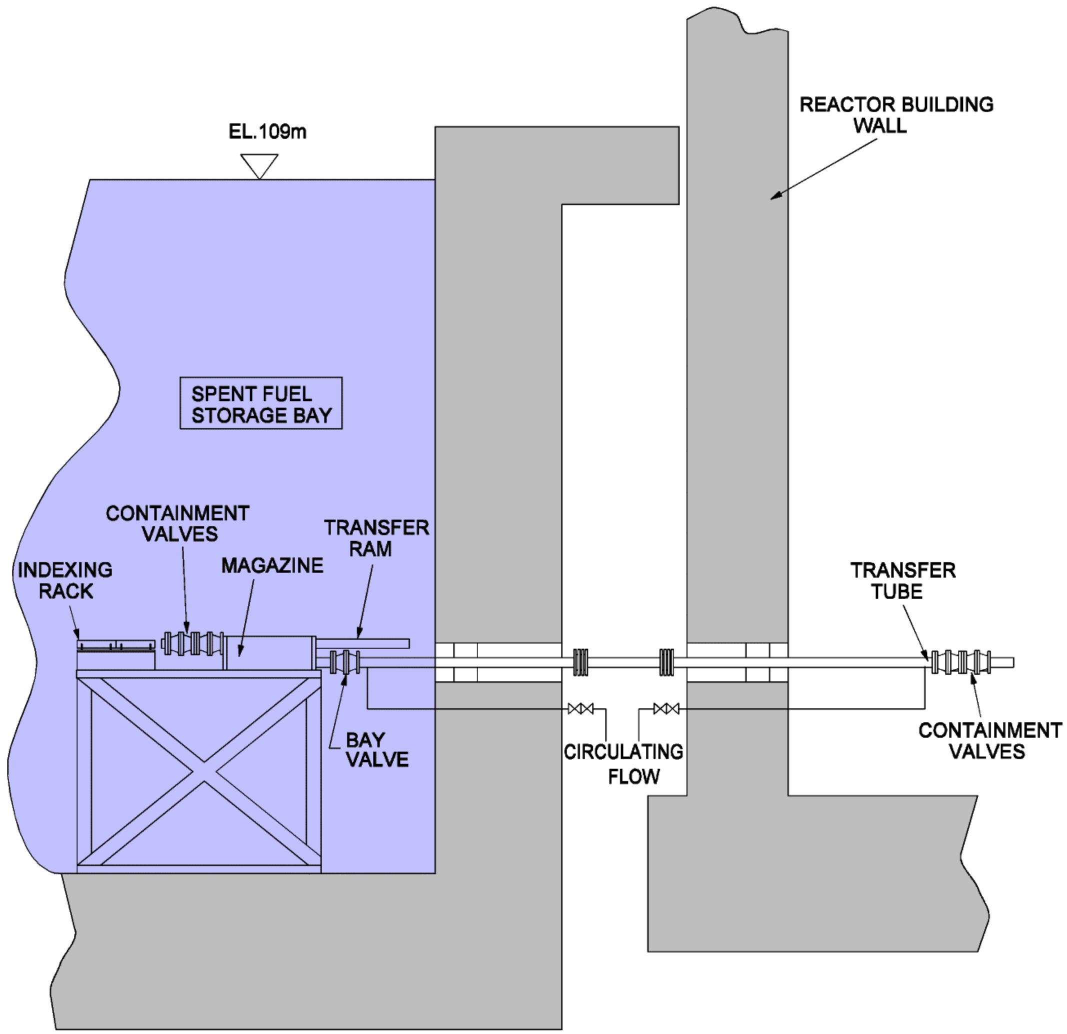
ACR Fuel Handling Layout



On-Power Fueling

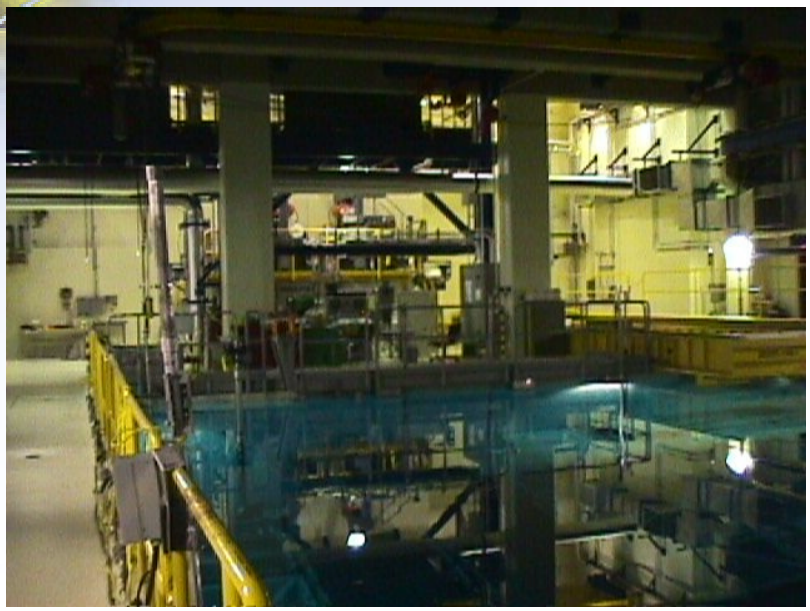
- Controls the global power distribution in the ACR core
- Fueling scheme consists of changing:
  - 2 of 12 bundles per channel visit
  - 21 channels per week
- Requires 4 hours/ day fueling everyday or 6 hours/day fueling 4 days per week
- Channels to be fueled are scheduled to:
  - Control the global flux distribution
  - Maximize fuel discharge burn-up
- Improves fuel economy
- Allows on-power removal of defective fuel

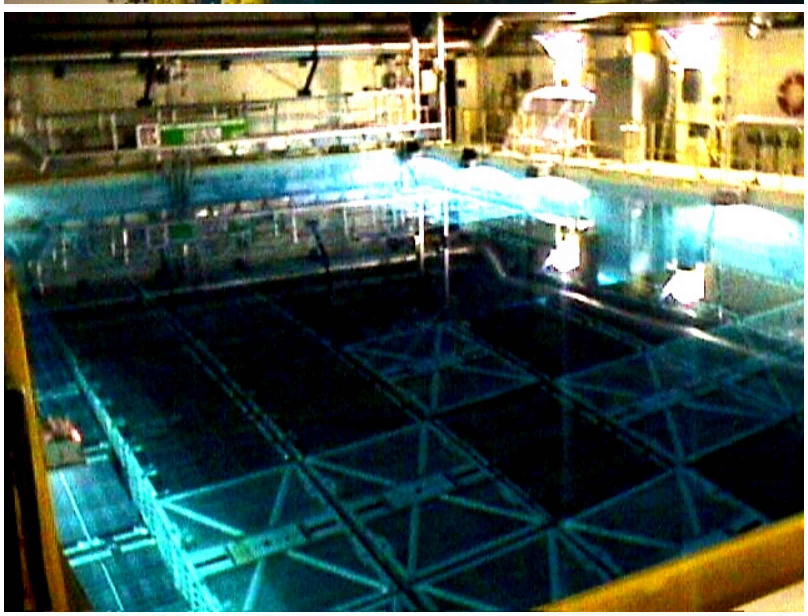
Spent Fuel Transfer



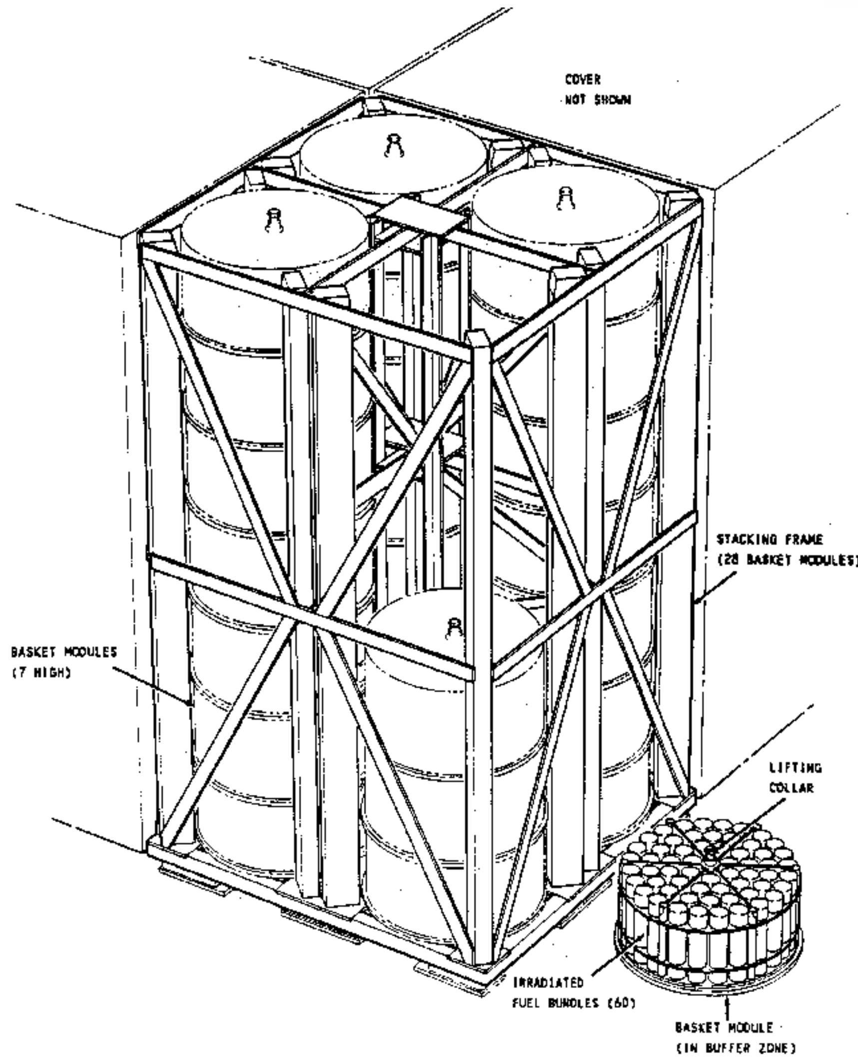
- Spent fuel is transferred in water
- Double containment isolation at both ends of transfer tube

CANDU Spent Fuel Bay

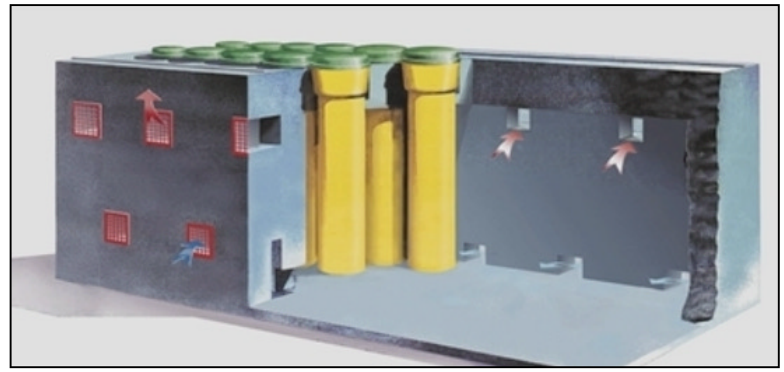


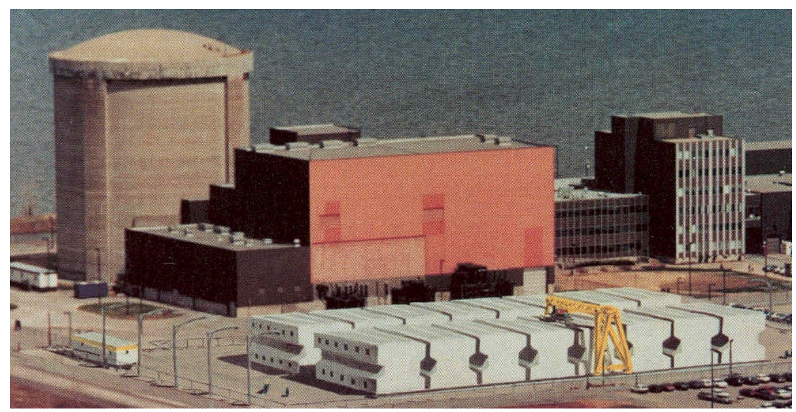


ACR Spent Fuel Storage



Dry Fuel Storage





Module Stores 12,000 Bundles (26 Modules required for 60 years storage)

Summary

- Compact ACR core results in smaller lattice pitch and reduced volume of D_2O moderator
- ACR Reactor design is an evolution of existing CANDU reactor designs
- Fuel Channel design has increased margins with extended operating life
- Fuel Handling system design has been optimized and simplified to improve overall performance and availability

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