CANDU^{TM} 6 Refurbishment and Optimization of Radiation Protection

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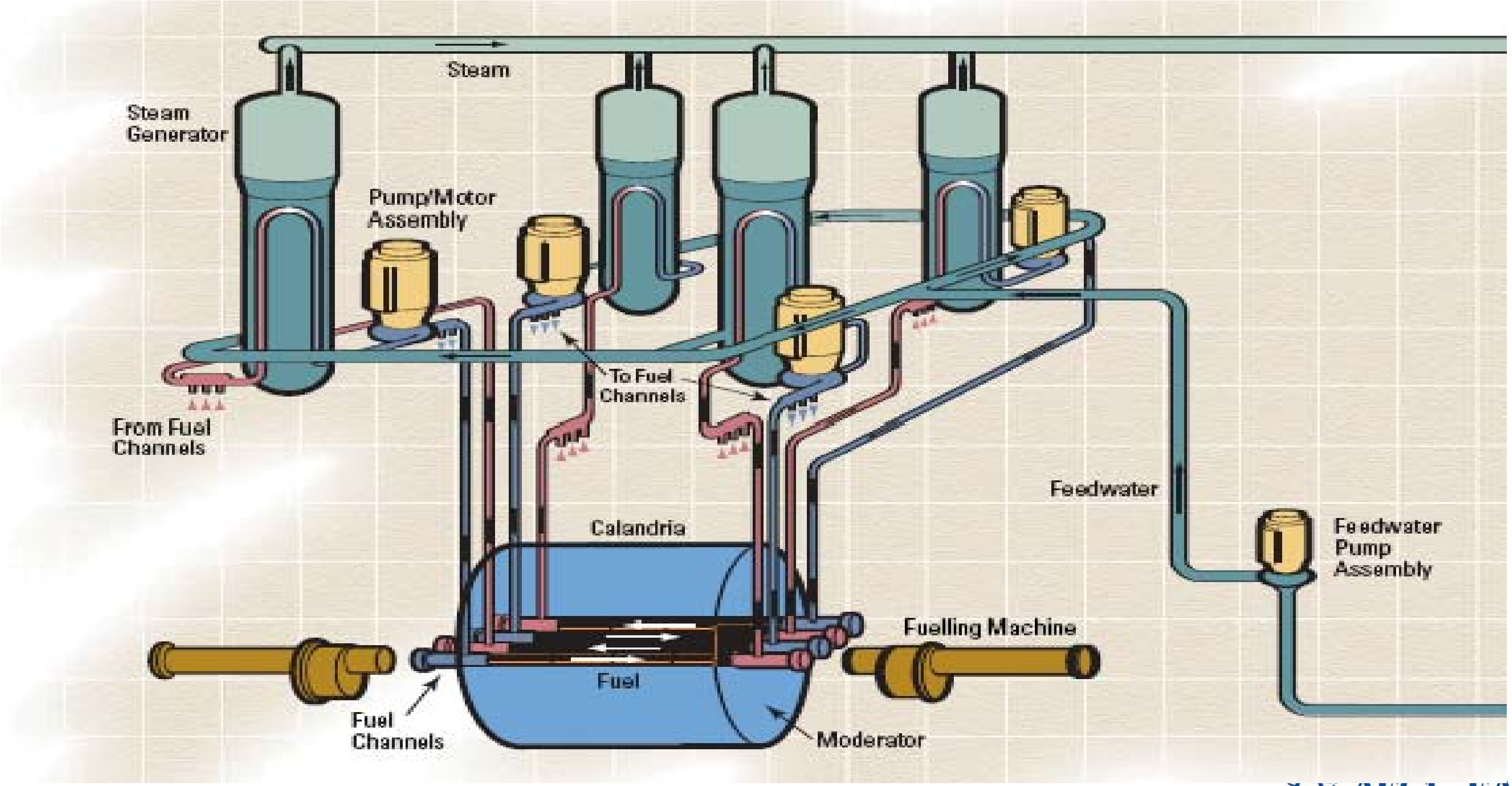
Overview

- Introduction to CANDU reactor
- Point Lepreau Refurbishment (PLR) Project
- Radiological Concerns for PLR Project
- AECL’s ALARA Strategies for PLR Project:
    1. Design Stage
    2. Operational Stage
- AECL’s Method and Means of Controlling Exposures
- Operation Experience (OPEX)
- Summary

Introduction to CANDU^{TM} Reactor Design

CANDU^{TM} (Canada Deuterium Uranium) designed by Atomic Energy of Canada Limited (AECL)



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Important Features of a CANDU^{TM} Reactor

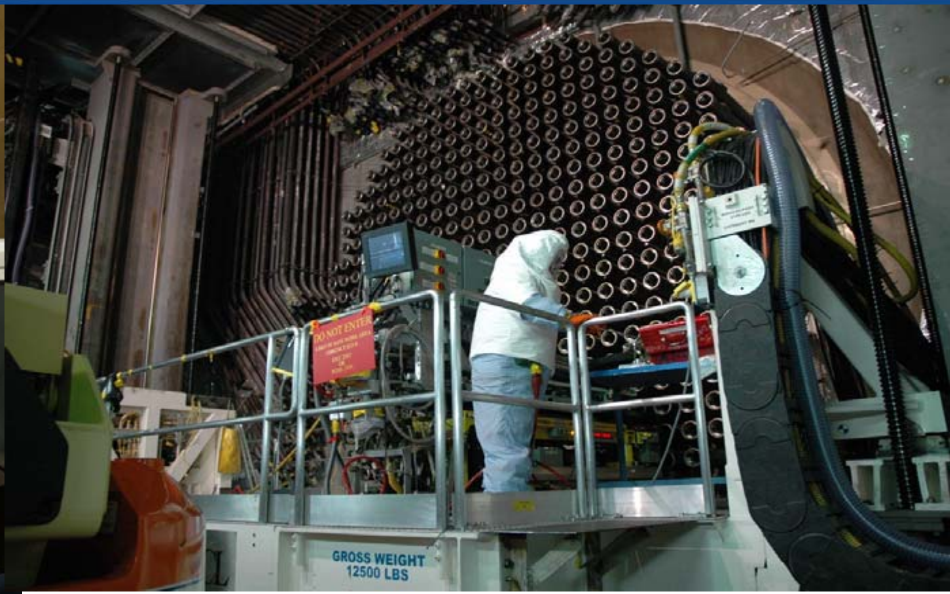
- **Natural uranium fuel, heavy water moderator and coolant**

- **Highest neutron economy of all commercial reactor systems**

- **Online-full power refueling**

- **A reactor core of several hundred small diameter fuel channels rather than one huge pressure vessel**

Point Lepreau Life Extension Project



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Point Lepreau Refurbishment (PLR) Project

The first CANDU™ 6 reactor undergoes a complete Refurbishment comprised of:

- Construction of the Solid Radioactive Waste Management Facility (SRWMF), Phase III
- Retube: 380 fuel channels and 760 associated feeder tubes need to be removed and replaced
- Upgrading a number of plant components defined "refurbishment" activities in the scope of the project

PLR Project and Waste Management

Waste Management Facility on site to storage the waste generated from the PLR project

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UNRESTRICTED / ILLIMITÉ

Radiological Concerns for PLR Project

- **Ambient Radiation Fields**

- **Airborne Tritium and Particulate Hazards**

  When neutrons irradiate heavy water (D_2O), some of the deuterium atoms (D) in the D_2O, absorb neutrons by an (n, γ) reaction, they become tritium atoms ($_1H^3$, H-3, or T)

- **High Radiation Beams**

- **Hot Particles**

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AECL's ALARA Strategies for PLR Project

Radiation protection optimization at the design Stage:

1. **Planning the work**
   - Primary Heat Transport System drained and dried (mitigation of tritium)
   - Moderator system was drained, double flushed and dried (mitigation of tritium)
   - Removal of adjusters (reactivity control rods) from the reactor core (source term removal)
   - Feeder removal from partial to total (source term removal)

2. Identification of Hazards and Dose Assessment

- Design concepts were established, activities for the refurbishment project were proposed
- Process Hazard Analysis, for the defined activities
- Dose assessments for the retube operations

AECL's ALARA Strategies for PLR Project

3. Design and Procurement of the Tools

- ALARA Tool Design Guide

  Guidelines conforming to ALARA concepts of time, distance and shielding

- Simulation of reactor configurations for retube evolutions and radiation fields calculations

- Automated tools to reduce local operator interface and specialized tooling for manual operations

Radiation protection optimization at the operational stage:

1. **Procedural Control**
   - Construction Work Package (CWP) including , Hazard Assessment and Safety Work Provisions
   - Detailed Work Instruction (DWI), defines the process required to efficiently perform a task

Detailed Work Instruction (DWI)

Op.	Task	Comments	Control Point
310.11	**HWT OPERATOR- INDEX HWT TO RAIL #2 POSITION, CT GUIDE TOOL** Move HWT to 'Rail #2' position to bring the Calandria Tube CT GUIDE TOOL (RT-7921) into alignment with the correct Lattice Site. ☐ Unpark HWT ☐ Select "X-Axis" ☐ Select "X-Move to Rail #2 Position", Press GO ☐ Select "Y-Axis" ☐ Select "Y-Move to Rail #2 Position", Press GO ☐ Park HWT	**ALARA!** **Beam will be exposed during HWT movement. All personnel to remain in walk-off until instructed by PA to proceed onto the FCP.**	
310.12	☐ ROC to verify HWT is at the target lattice site.		
310.13	☐ **PA to perform radiation survey of tooling and give approvals that it is safe to approach the tooling.**	**ALARA!**	
310.14	☐ **TRADE:** Using the 'mid front' hand wheel (red) Advance the CT GUIDE TOOL SHIELD SLEEVE to engage against thumbtack.		
310.15	**Receiving Side- CT SHIELD SLEEVE Locked** **TRADE:** ☐ Lock the 'mid front' hand wheel (red) [CT GUIDE TOOL SHIELD SLEEVE] using a ratchet wrench on the locking bolt and clamp the THK rail. Turn the wrench clockwise to secure the shaft. Torque to approx. 25 ft-lbs. **TECH:** ☐ **Complete CT INSERTION AND RECEIVE SIDE ROLLED JOINT CHECK-SHEET in Appendix C**	☑ Check ☑ Check	

AECL's ALARA Strategies for PLR Project

2. **Training**
   - Basic conventional and radiological safety training
   - Mock-up training for retube activities

The feedback from a mock-up training is used:

- To modify steps in a DWI for efficiency
- To plan resource requirement; and
- To identify the ALARA measures required for a safe performance of the task

Mock-up Training

AECL's ALARA Strategies for PLR Project

3. **Radiation Exposure Permit (REP)**

   REP created and dose/ dose rate alarm points are set on PADs (Personal Alarming Dosimeter)

4. **ALARA Plan**

   - When collective dose for a task is expected to exceed 20 person-mSv
   - When a task includes a reactor intrusion

AECL's ALARA Strategies for PLR Project

5. Pre-Job Brief

- Task procedure, expectations and associated conventional and radiological risks
- Personal Protective Equipment

Method and Means of Controlling Exposures

❑Integrated Dose Control Centre (IDCC)

- Audio Visual Telemetry System (AVTS)
- Direct Protection Assistant (PA)
- PA Desk
- Shift Logs
- Personal Protective Equipment (PPE) Storage/Issue

Audio Visual Telemetry System (AVTS)

AECL's Method and Means of Controlling Exposures

- **Retube Operating Centre (ROC)**
  - Critical work direction (DWIs)
  - Quality assurance verification
  - Three way communication
  - ALARA warnings to the Protection Assistant in the field

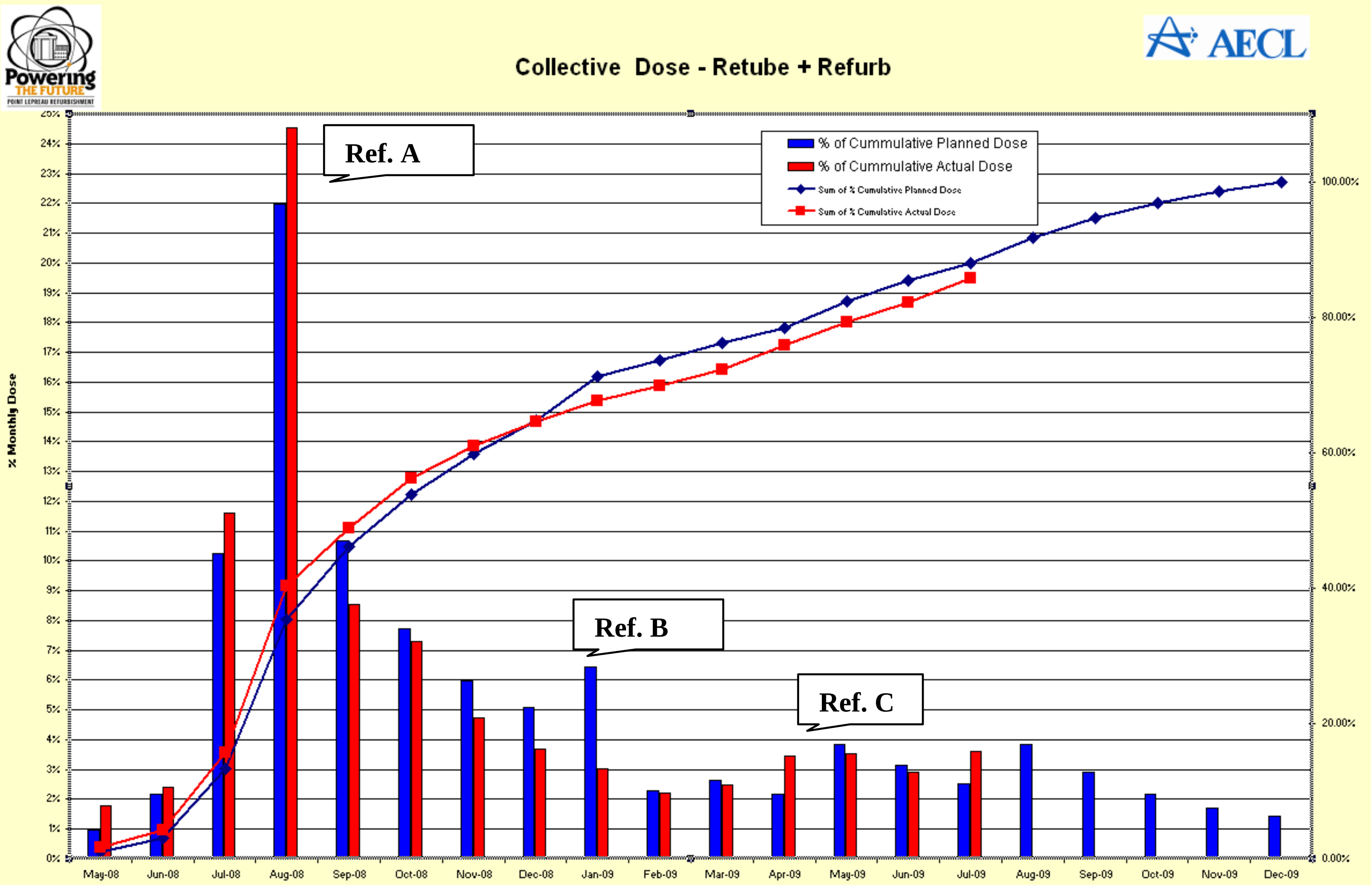
Retube Operating Centre (ROC)

OPerational Experince
OPEX

Major Milestones

- 2008 May 30: Reactor vaults turned over to AECL
- 2008 September: PHT system (Feeder Pipes) was removed
- 2009 February: E/Fs were removed.
- 2009 April: PTs were removed
- 2009 July: CTs were removed

Point Lepreau Refurbishment Dose Planned vs. Actual



OPEX (OPeration EXperience)

- **Contingency Plans**
- **Tooling Modification**
- **ALARA Plan Updates**
- **Post Series Review**
- **Construction History Package (CHP) Document**

  CHP document comprises CWP, DWIs and ALARA Plans

Summary

RP Summary

- Radiation Protection faced significant challenges. Not unusual to deal with Radiation Fields in SIEVERTS and high levels of contamination
- No exposure control level exceeded
- Over 3,500,000 person-hours worked without a lost time accident
- Overall contamination control has been a success
- Program has adapted to the many challenges and maintained healthy balance between Safety and Production

Thank you for your time

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