ACR R&D CRL

Presented to CNSC/US NRC

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Canada

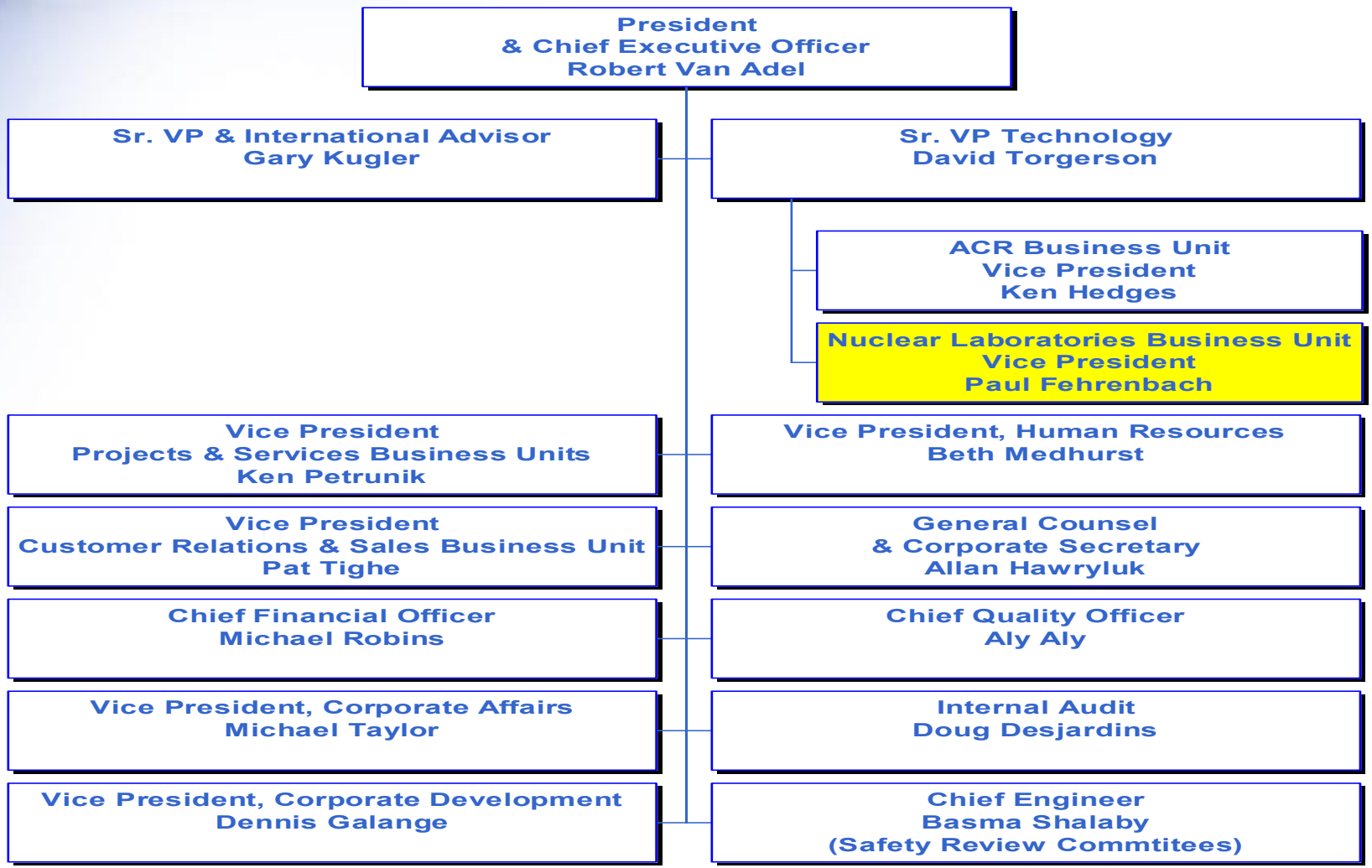
AECL Atomic Energy of Canada Limited
EACL Énergie atomique du Canada limitée

R&D Laboratories

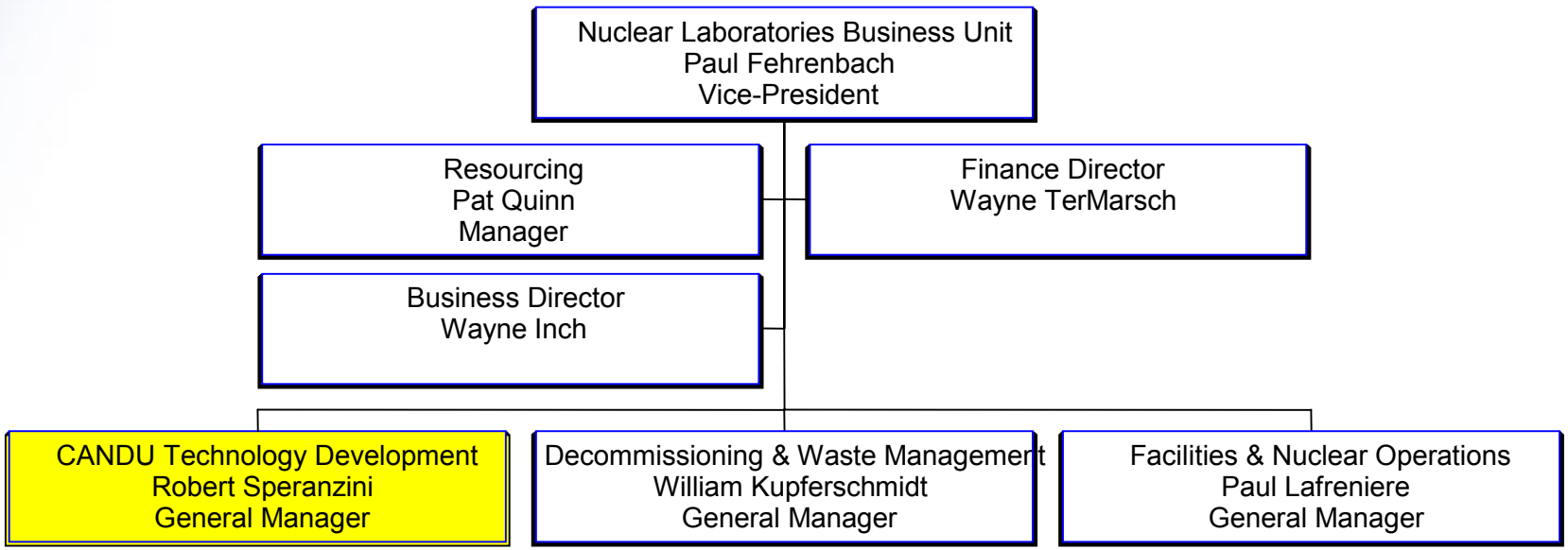
- ACR R&D primarily conducted within AECL laboratories
  - CPFS – primarily component development and verification
  - WL – safety thermalhydraulic code validation
  - CRL – code validation and safety phenomena research

Chalk River Laboratories

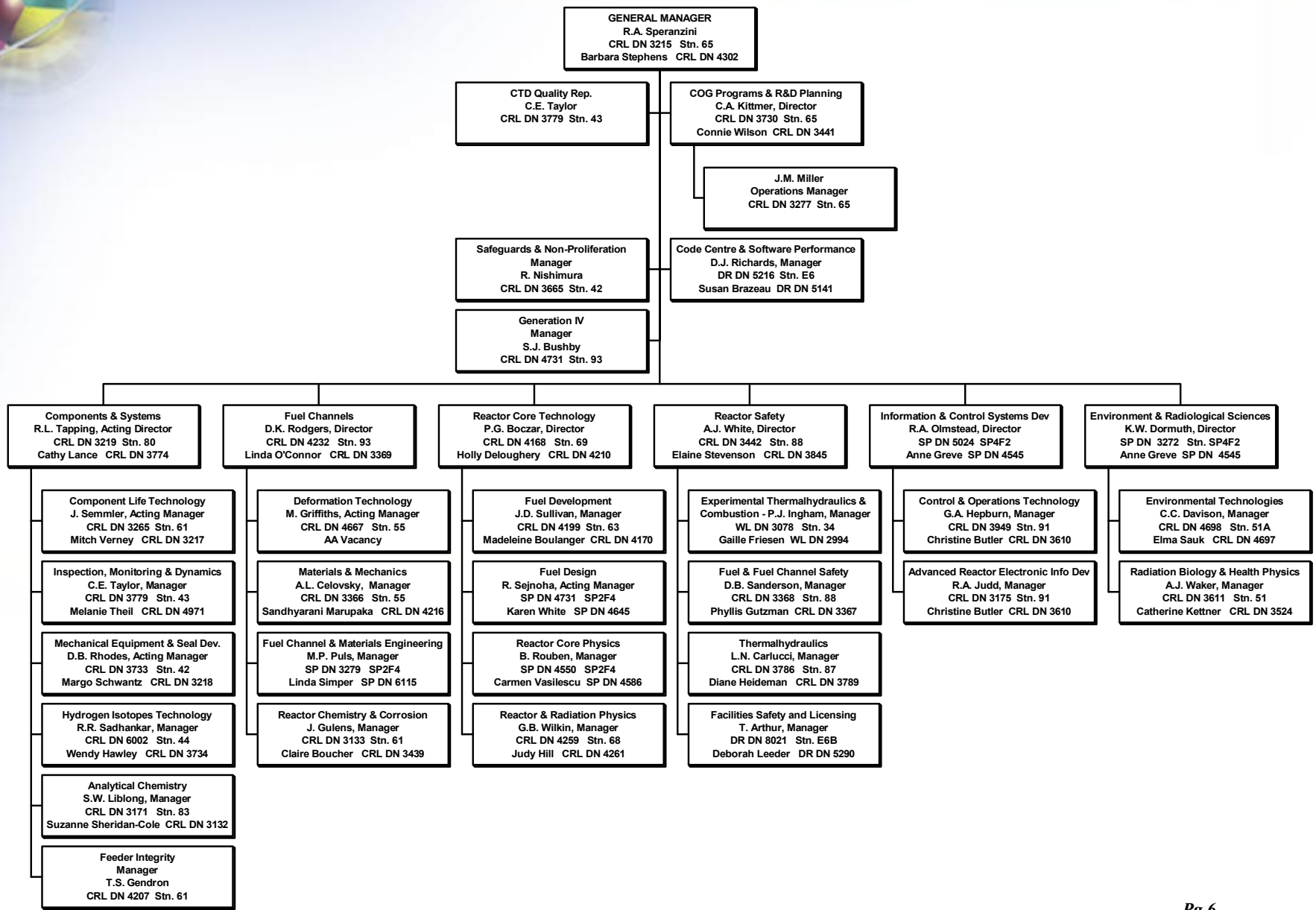
AECL Organization



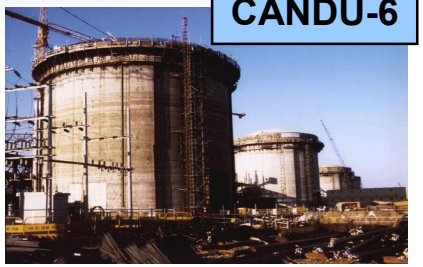
Nuclear Laboratories Business Unit

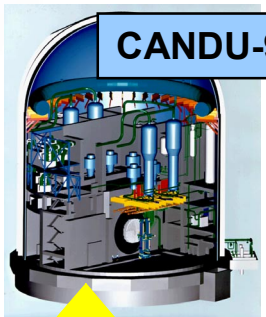


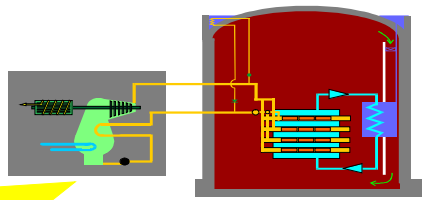
CANDU TECHNOLOGY DEVELOPMENT



CANDU Technology







Research
Development
Engineering

Safety Technology

Reactor Chem. & Systems

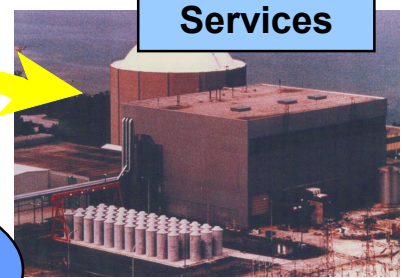
Heavy Water & Tritium Technology

Health & Environmental Technologies

Control & Information Technology

Fuel Channels

Reactor Core Technology



Safety Technology Base

- The ACR design is based on the proven CANDU 6 design is terms of the overall safety system and safety-related system function.

  ➔ Most key phenomena associated with safety analyses are common with the current CANDUs.

  ➔ The analysis tools and methodologies used for safety analysis of current plants are generally applicable to the ACR.

ACR Safety Verification

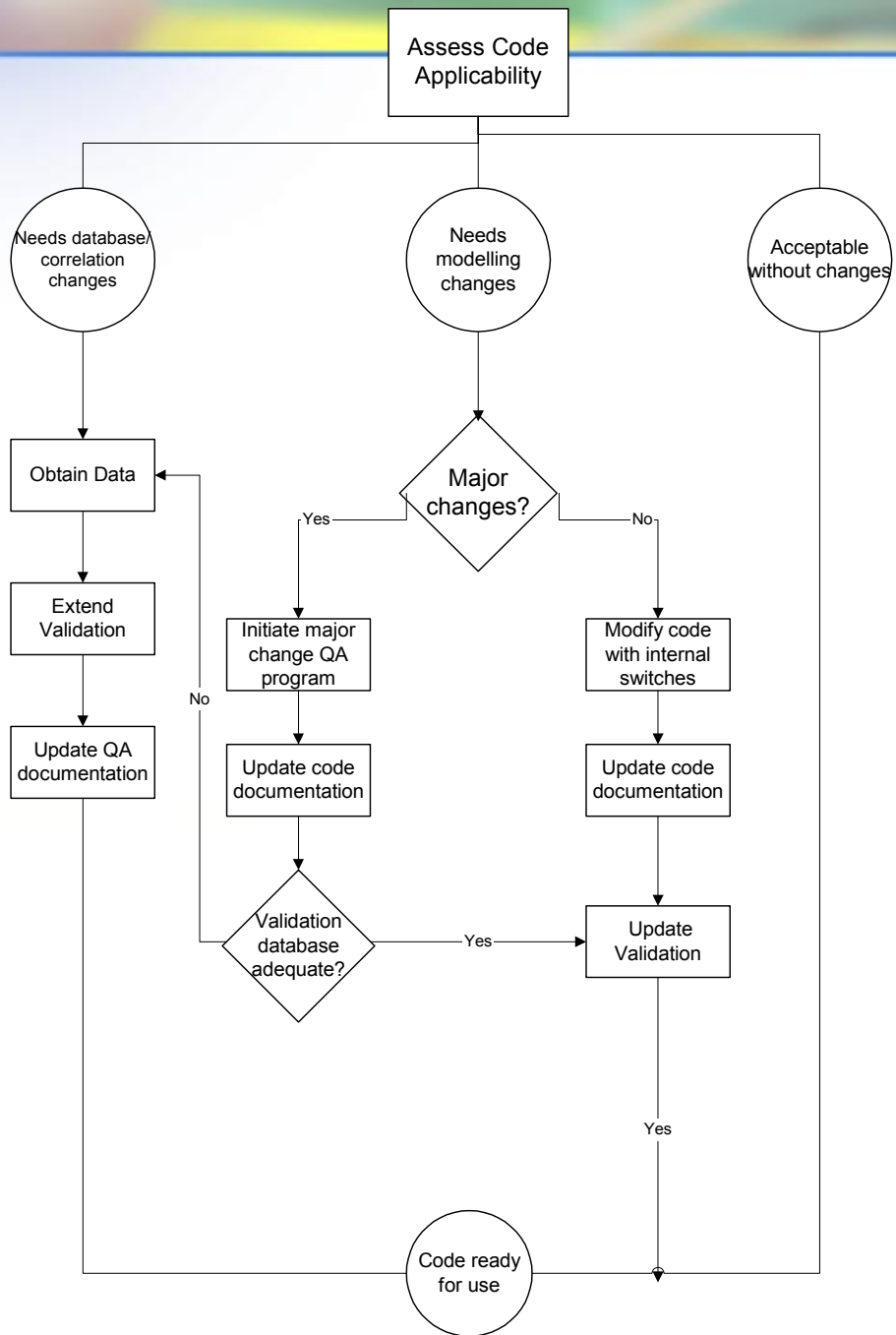
- ACR will use the validated CANDU Industry Standard Toolset (IST) for safety analyses.
- In selected areas the validation base of the codes will be extended to cover a new range of application for the ACR.
- In even fewer areas, limited modifications to the IST codes will be supported to address new ACR analysis requirements.

IST Code Validation

- AECL and the Canadian CANDU utilities have carried out a comprehensive program to fully document and validate the IST codes.
- An extensive package of documentation has been submitted to the CNSC for review.
- The validation process is ongoing for a limited number of codes.

Code Validation for ACR Application

- The computer codes to be used in the safety analysis of the ACR will be qualified following the requirements AECL's Software Quality Assurance Manual and processes.
- The qualification process starts with an assessment of code applicability and additional validation requirements (if any).


Assess Code Applicability
Needs database/ correlation changes
Needs modelling changes
Acceptable without changes
Obtain Data
Major changes?
Yes
No
Extend Validation
Initiate major change QA program
Modify code with internal switches
No
Update QA documentation
Update code documentation
Update code documentation
Validation database adequate?
Yes
Update Validation
Yes
Code ready for use

ACR Code Validation

- Technical Basis Document (TBD) for code application
  - ACR-specific version of TBD.
  - ACR analyses will involve the same broad accident categories and technical disciplines as current CANDUs.
- Validation Matrices for key phenomena updated for ACR.
- Additional validation exercises (as required) for ACR code application.

Key ACR Code Validation

- CATHENA – safety thermalhydraulics
- NUCIRC – steady-state thermalhydraulics
- WIMS/RFSP/DRAGON – reactor physics
- ELESTRES – fuel, normal operation
- ELOCA – fuel, accident conditions
- MODTURC – moderator thermalhydraulics
- Fuel Design Codes

Site Visit

- NRU ACR Fuel Tests
- Moderator Test Facility
- Thermalhydraulics Loops
- ZED-2 – Physics Tests
- High-Temperature Heat Transfer Laboratory

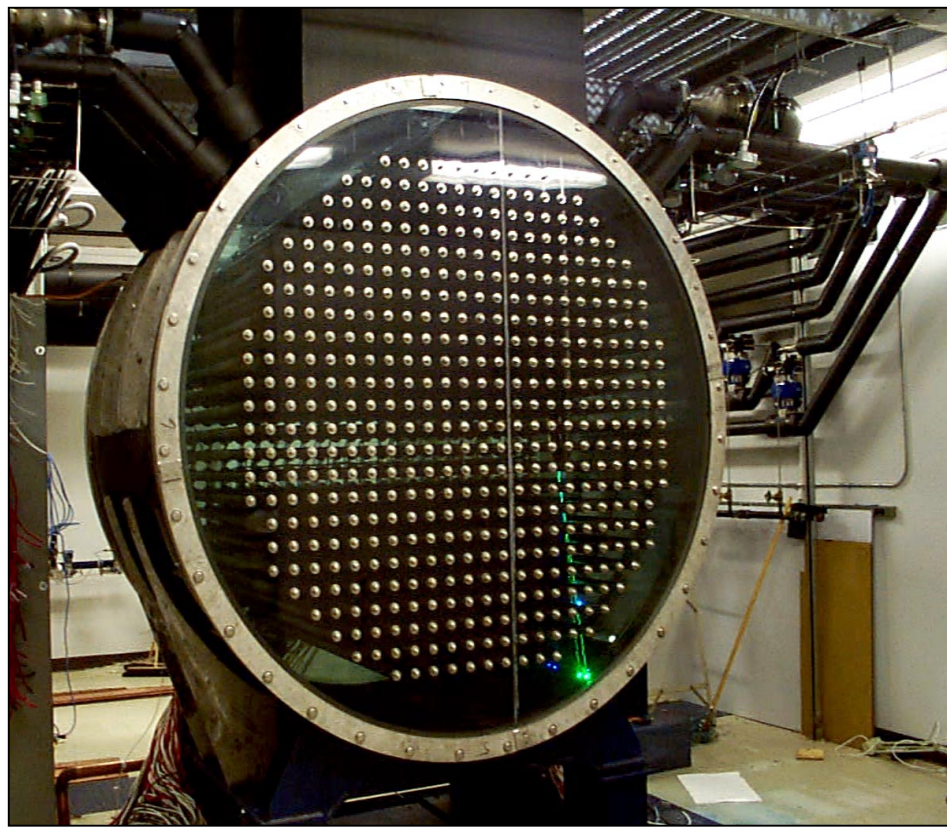
In-Reactor Fuel Tests

- Irradiation of bundles in NRU to full burnup.
  - High power channel envelope
- Irradiation of individual elements in CANFLEX demountable bundle in NRU.
  - high-power envelope,
  - power ramp transients(fuel handling),
  - dysprosium fuel performance
- Halden fuel element irradiation (ACR coolant temperature)
  - Cladding performance data.

Moderator Test Facility

- Large-scale facility to measure three-dimensional velocity and temperature distributions in moderator geometry.

- 1/4 scale calandria used to validate CANDU 9 design.
- 1/3 scale calandria will be used to validate ACR design.



Full-Scale Thermalhydraulic Tests

- **Water Tests – Stern Laboratories**
  - Full-scale ACR bundle string fabricated with representative axial flux distribution (AFD) and radial (RFD)
  - CHF and PDO tests using three flow-tube creep profiles (0, ~2%, and ~5%).
  - Conditions up to 12.5 MPa and 29 kg/s.
- **Freon Tests - CRL**
  - Full-scale ACR bundle string with representative AFD and RFD (RFD can be varied over a range) will be constructed.
  - CHF (mainly RFD effect) and PDO tests to confirm earlier results obtained from the uniform AFD bundle tests.

Physics

- Physics analyses performed using IST codes
  - WIMS, RFSP, DRAGON
- Physics code validation using ZED-2 facility
  - Zero-power critical lattice

High Temperature Heat Transfer

- Heat transfer for overheated fuel channels
  - LOCA + LOCEI
- Pressure tube/calandria tube failure
- TUBRUPT validation tests


AECL