nwmo

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Safe Transportation and Packaging of Canada's Used Nuclear Fuel

South Bruce Forum – April 5th 2023

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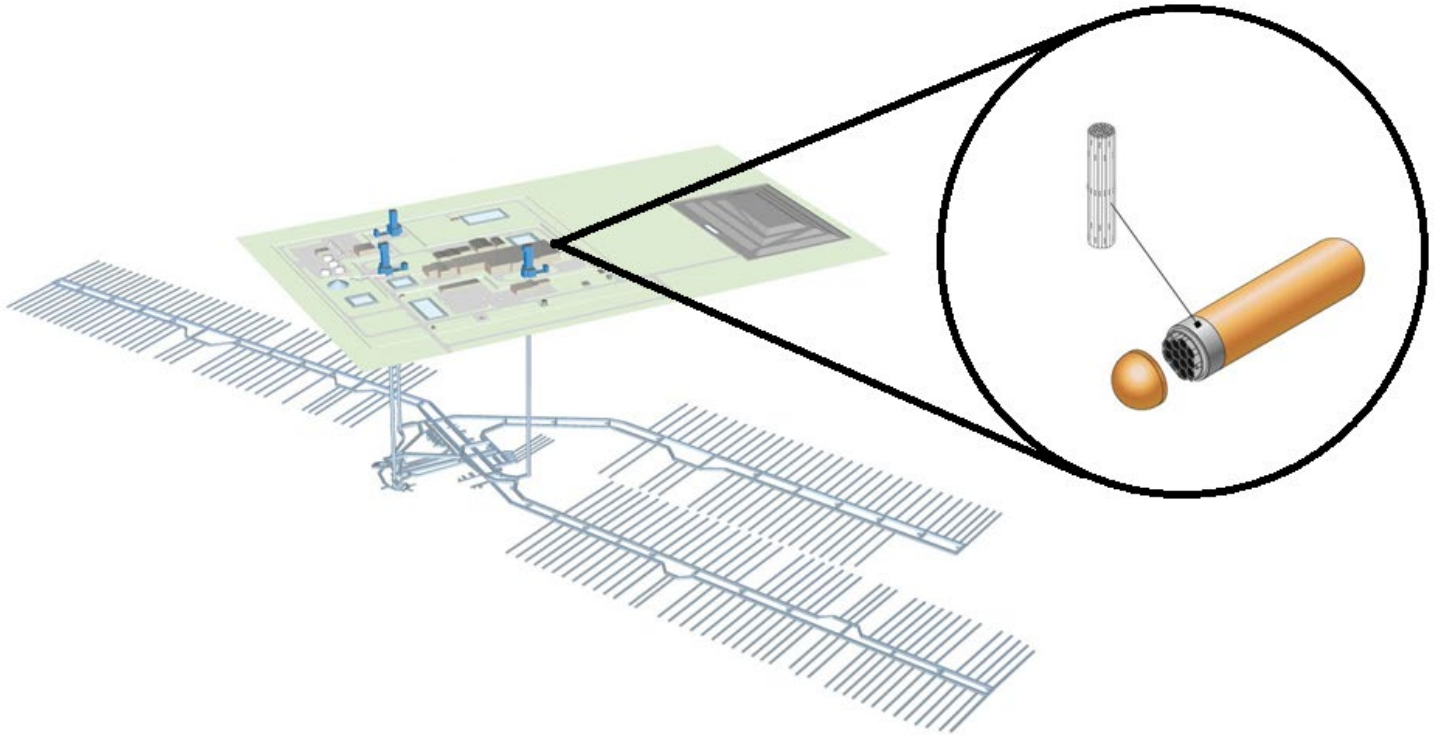
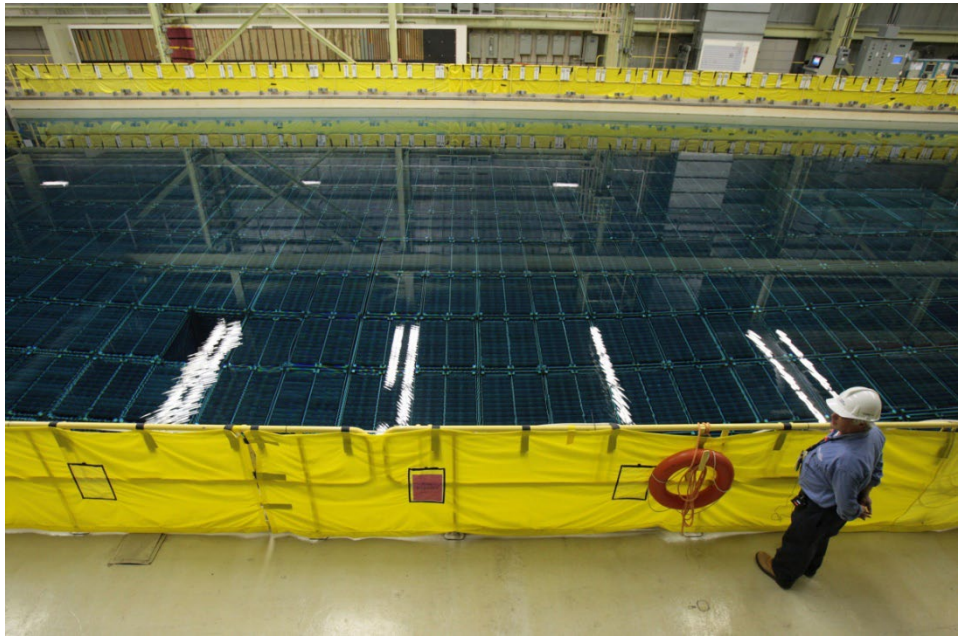
Elements of confidence in safety

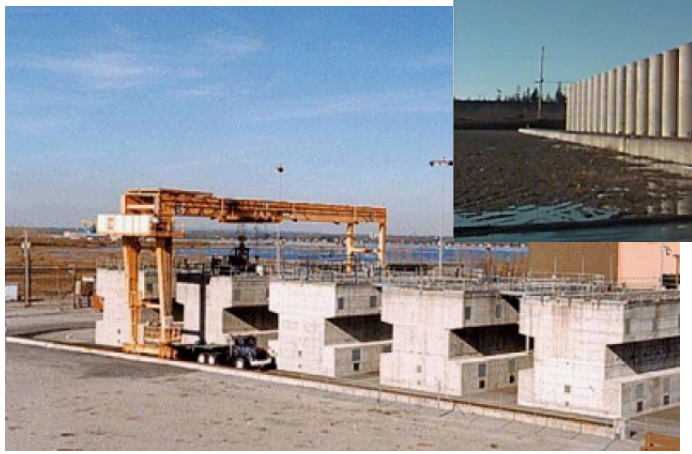
1. Favourable geological setting;
2. Stability of geological setting;
3. Low risk of future human intrusion into the repository;
4. Site is amenable to geological characterization;
5. Robust multiple barrier system;
6. Ability to safely construct and operate the repository;
7. Able to safely transport fuel to the site;
8. Facility performance will meet regulatory criteria

Canada's plan for the long-term management of used nuclear fuel



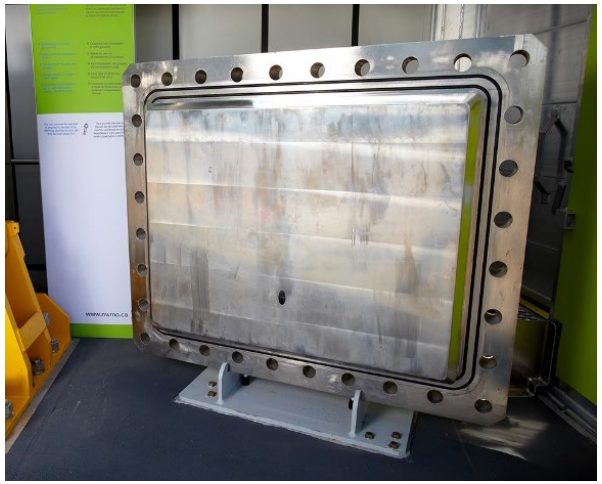
Used Nuclear Fuel and Interim Storage





Introduction to transportation of used nuclear fuel

Transportation is safe and secure



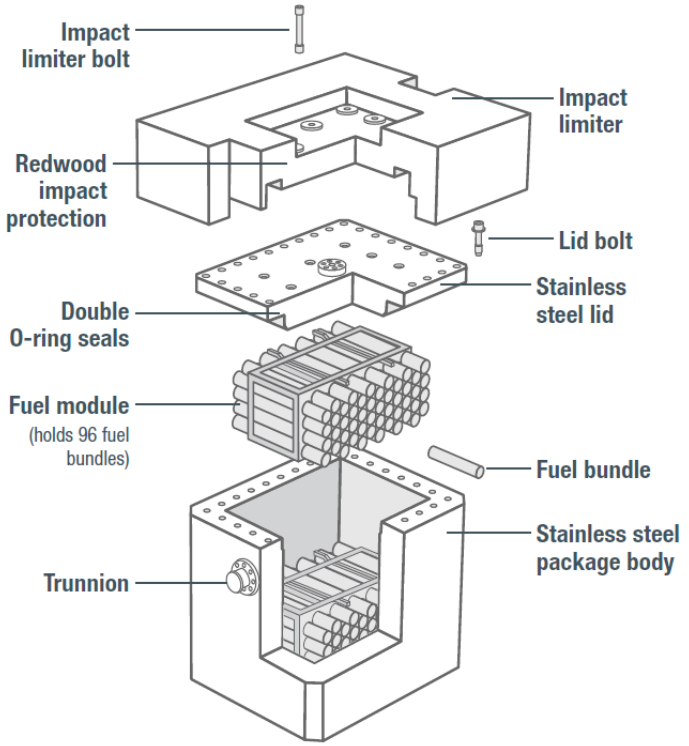
● Interim Storage Facilities

1. Whiteshell Laboratories, Manitoba
2. Bruce Nuclear Generating Station, Ontario
3. Pickering Nuclear Generating Station, Ontario
4. Darlington Nuclear Generating Station, Ontario
5. Chalk River Laboratories, Ontario
6. Gentilly Nuclear Generating Station, Quebec
7. Point Lepreau Nuclear Generating Station, New Brunswick

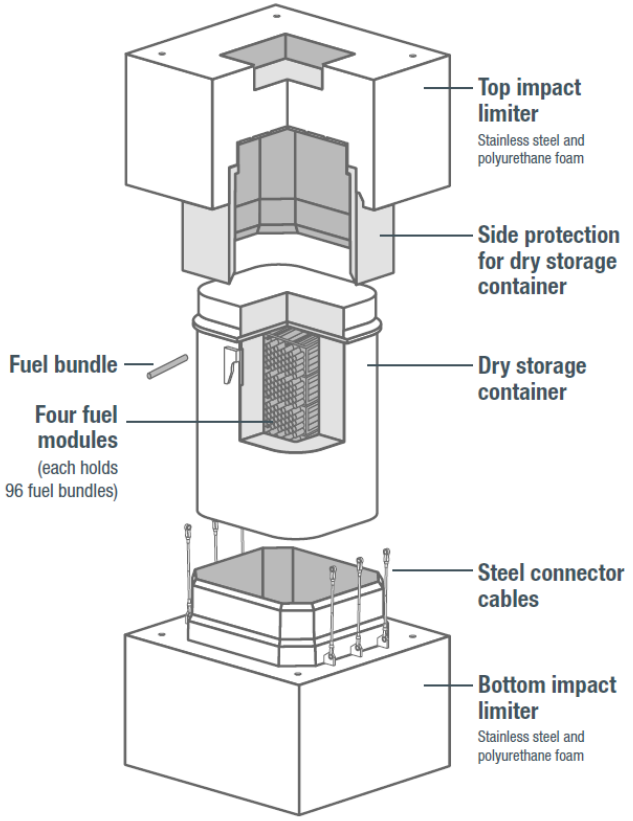
■ Assessments underway in the area

1. Ignace / Wabigoon Lake Ojibway Nation
2. South Bruce / Saugeen Ojibway Nation

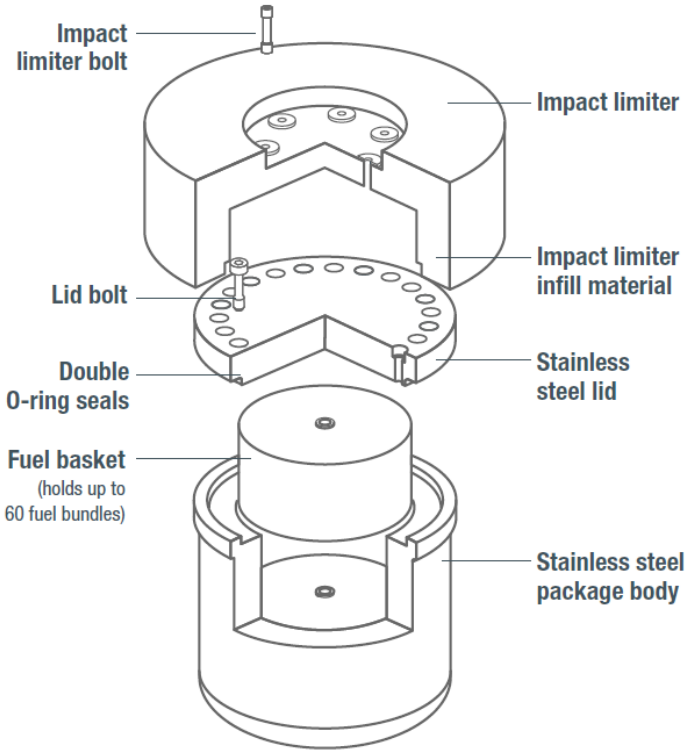
Transportation Packages



Used Fuel Transportation Package (UFTP)



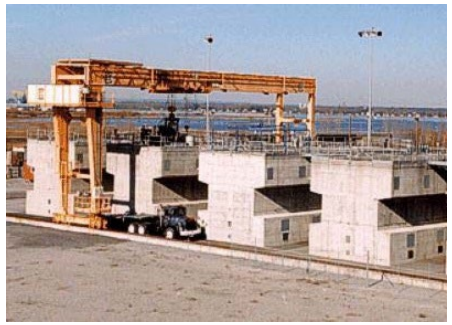
Dry Storage Container Transportation Package (DSC-TP)

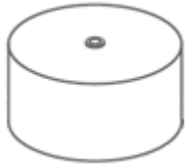


Basket Transportation Package (BTP)

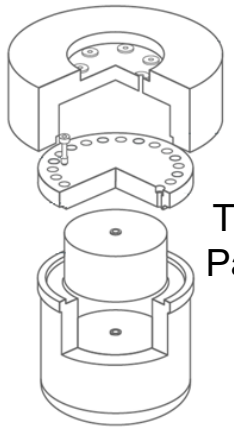
Reference Used Fuel Transportation System

Interim Storage Site Operations





Fuel Baskets



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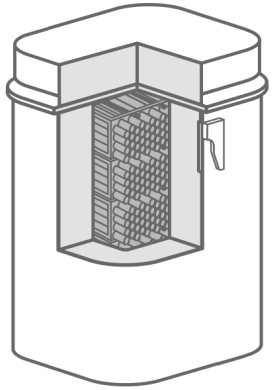
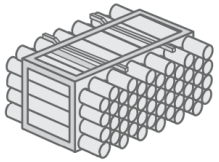
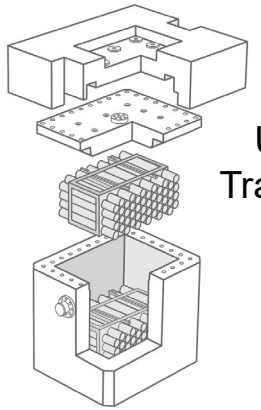


Cut off welded lid



Fuel Modules



Used Fuel Transportation Package (UFTP)

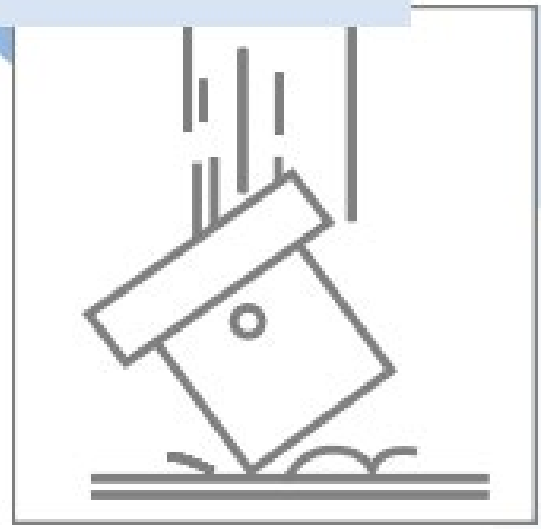
NWMO Operations

Road Transport to NWMO Deep Geological Repository

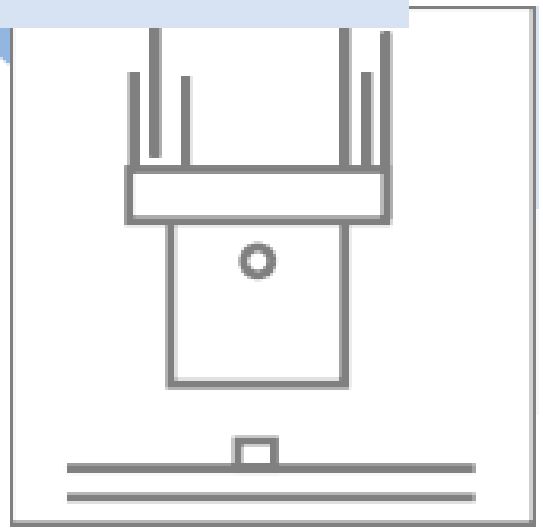
The NWMO's multi-layered safety program

Transportation package testing

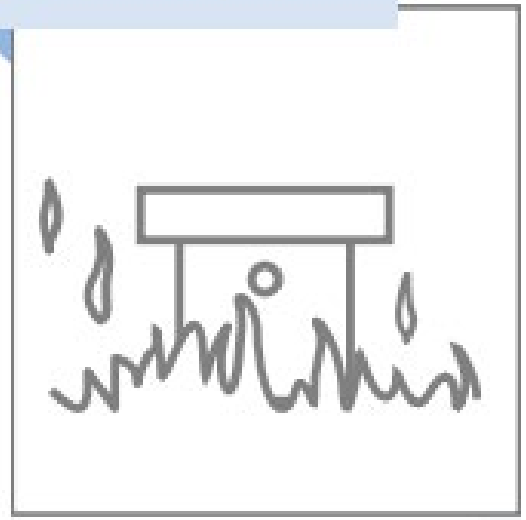
Free-drop test



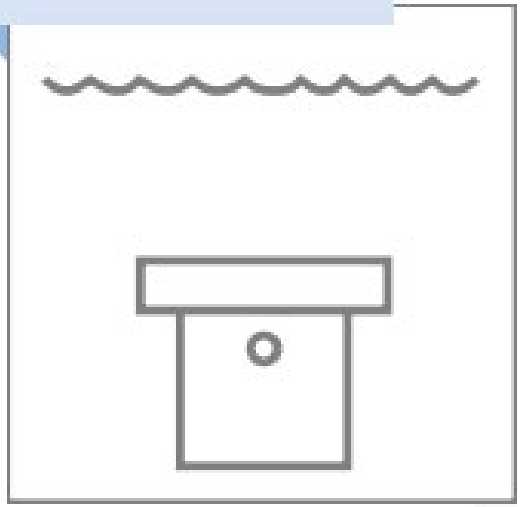
Puncture test



Thermal test

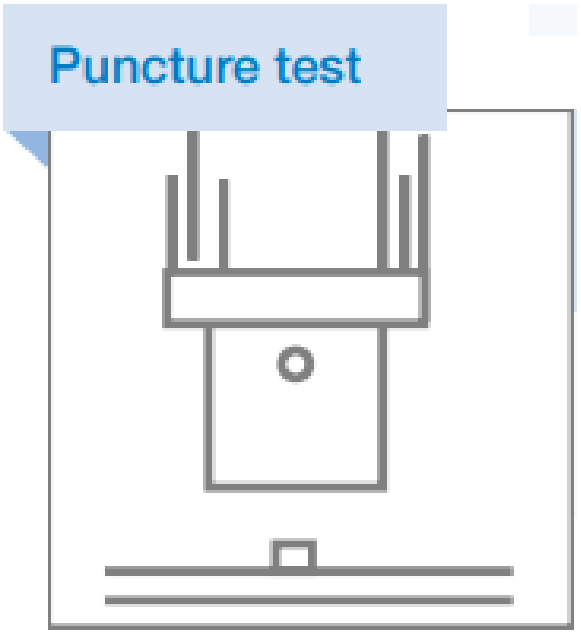


Immersion test



Transportation package testing

Transportation package testing



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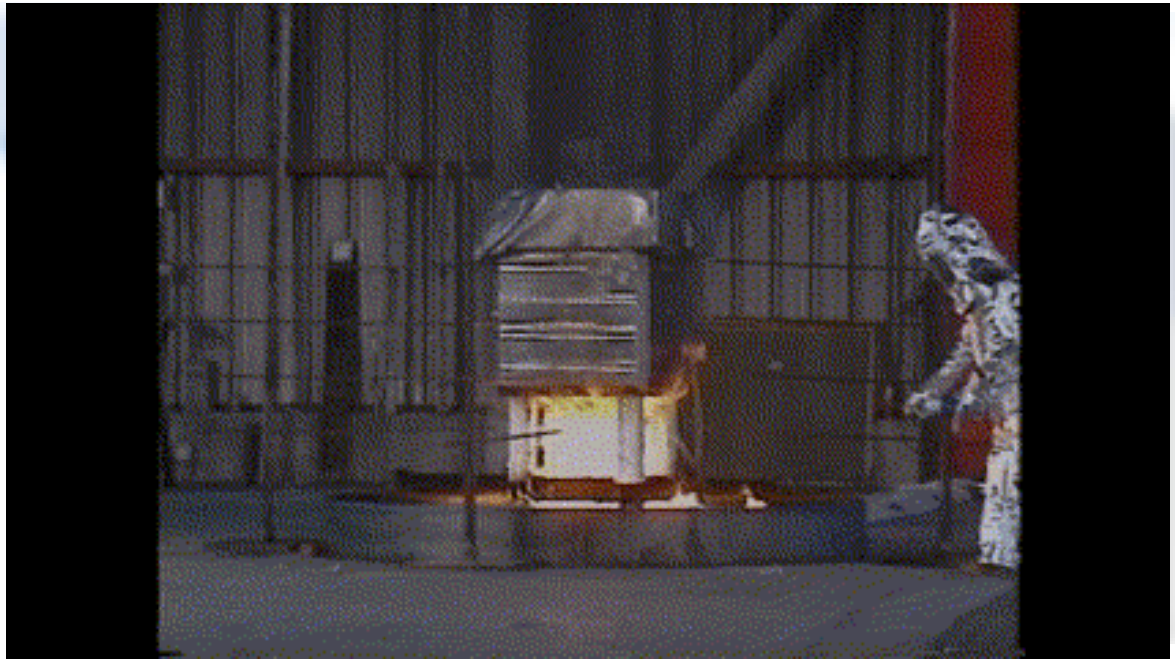

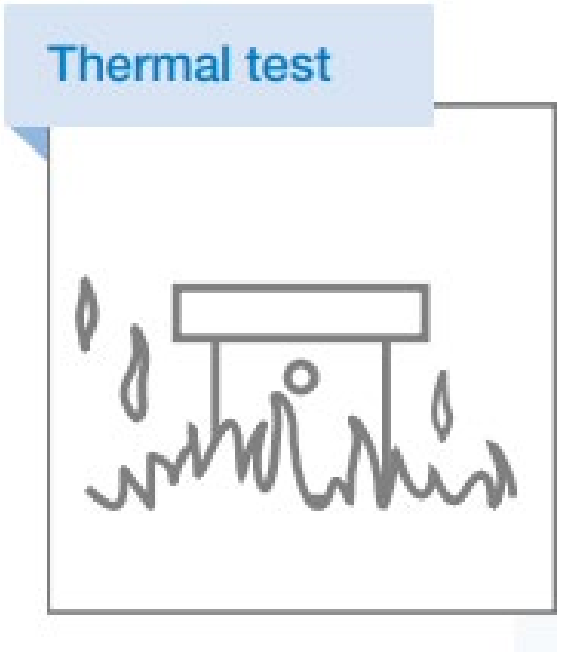

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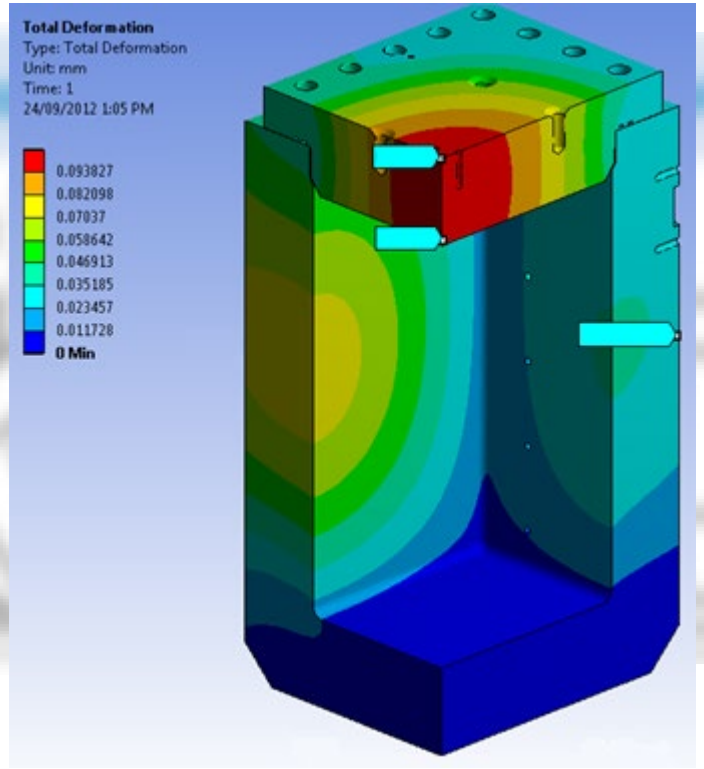
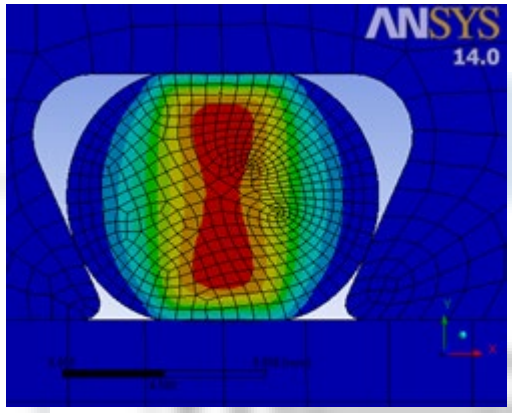
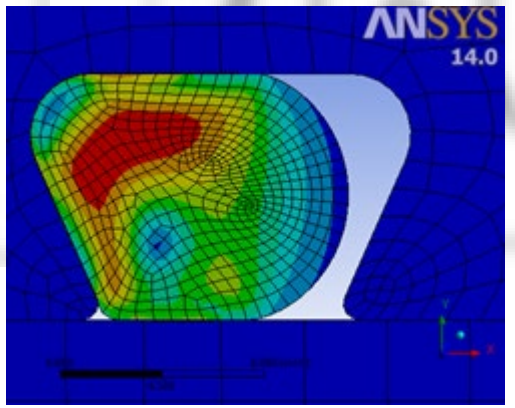
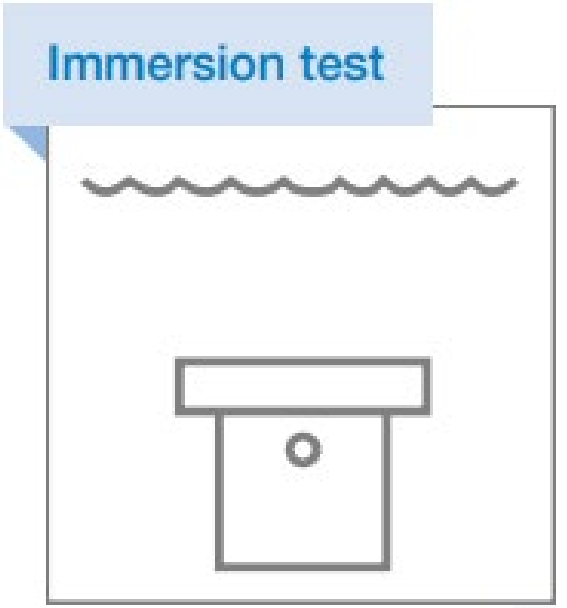








Transportation Management

Security

Communications

Emergency Management

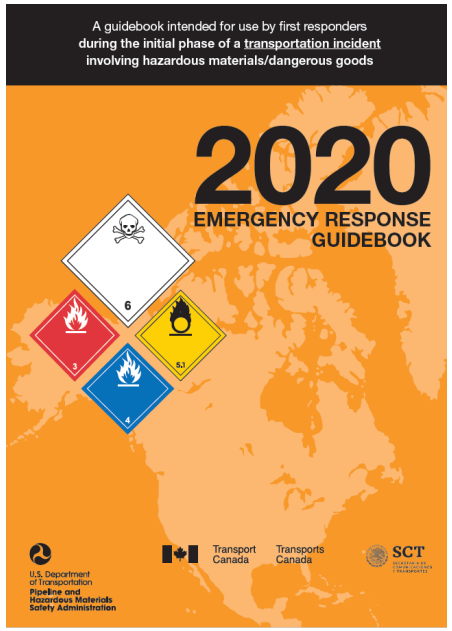
Transportation Security

- Transportation Command Center
  - Continuous monitoring of operations during transportation activities.
- Security Escort Vehicles
  - To accompany transportation conveyance along entirety of the route.
- Crisis Management
  - Procedures and training for the prevention, assessment, and response to security events.
- Physical, People, & Data Security.
  - Fitness-for-duty and experience requirements.
  - Data management standards & methods.

Transportation Communications

- Communications Technologies
  - Cellphones
  - Satellite phones
  - Radio
- Real-time Monitoring from Command Center
  - Real-time GPS tracking
- Emerging Technologies
  - Operations Timeline
  - Infrastructure Changes & Developments

Transportation Emergency Management



- Preparedness
  - Agreements & Partnerships
  - Procedural Controls
  - Training
  - Operational Readiness
- Response
  - Management Plans
  - Roles & Responsibilities
  - Cooperation
- Recovery
  - Package Recovery Operations
  - Equipment & Locations
  - Restoration of Traffic

Small Modular Reactors

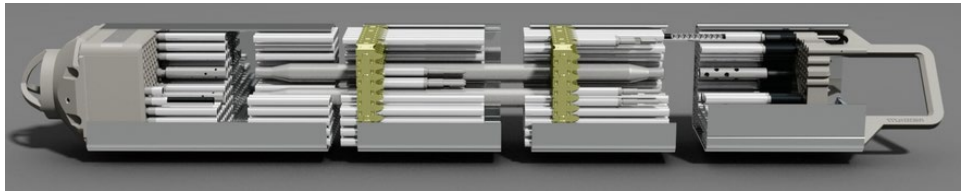
- Legislative requirement for SMR operators to interface with NWMO and for NWMO to manage any used fuel produced.

- Different fuel characteristics (i.e., dimensions, decay heat, decay rate, dose, enrichment, etc.).

- Transportation management;
  - Use of current certified packages.
  - Commercially available solutions.
  - Proprietary solutions.

- NWMO continues to keep a close eye on SMR developments and emerging technologies.

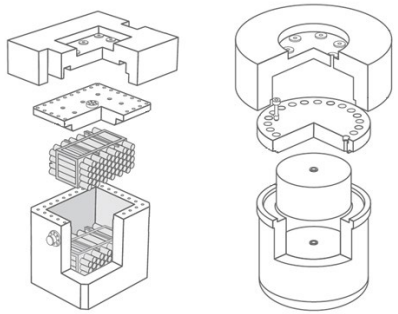
GE-Hitachi BWRX-300 – Darlington Site



GNF2 – Boiling Water Reactor Fuel Assembly

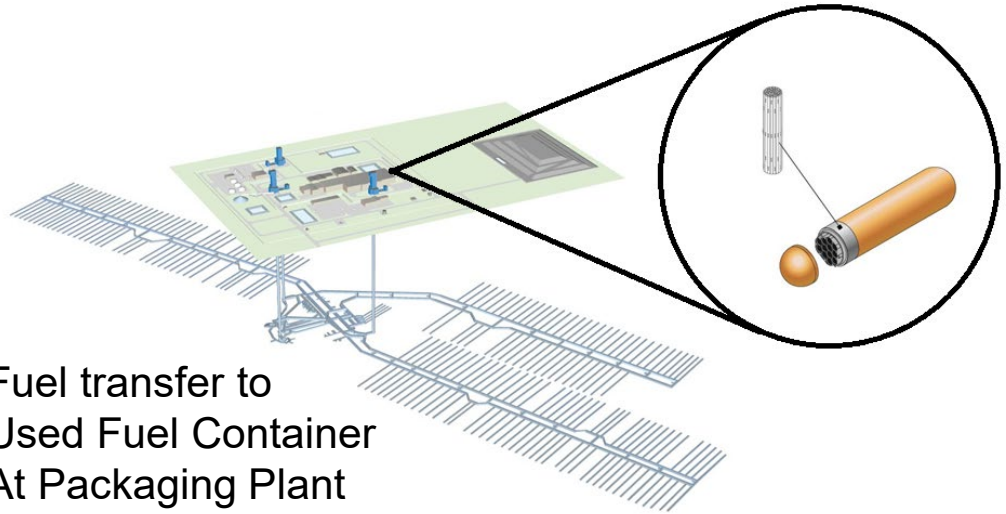
From Transportation to Packaging

Interim Storage



Fuel Transfer to
Transportation Package

Transportation to Used
Fuel Packaging Plant

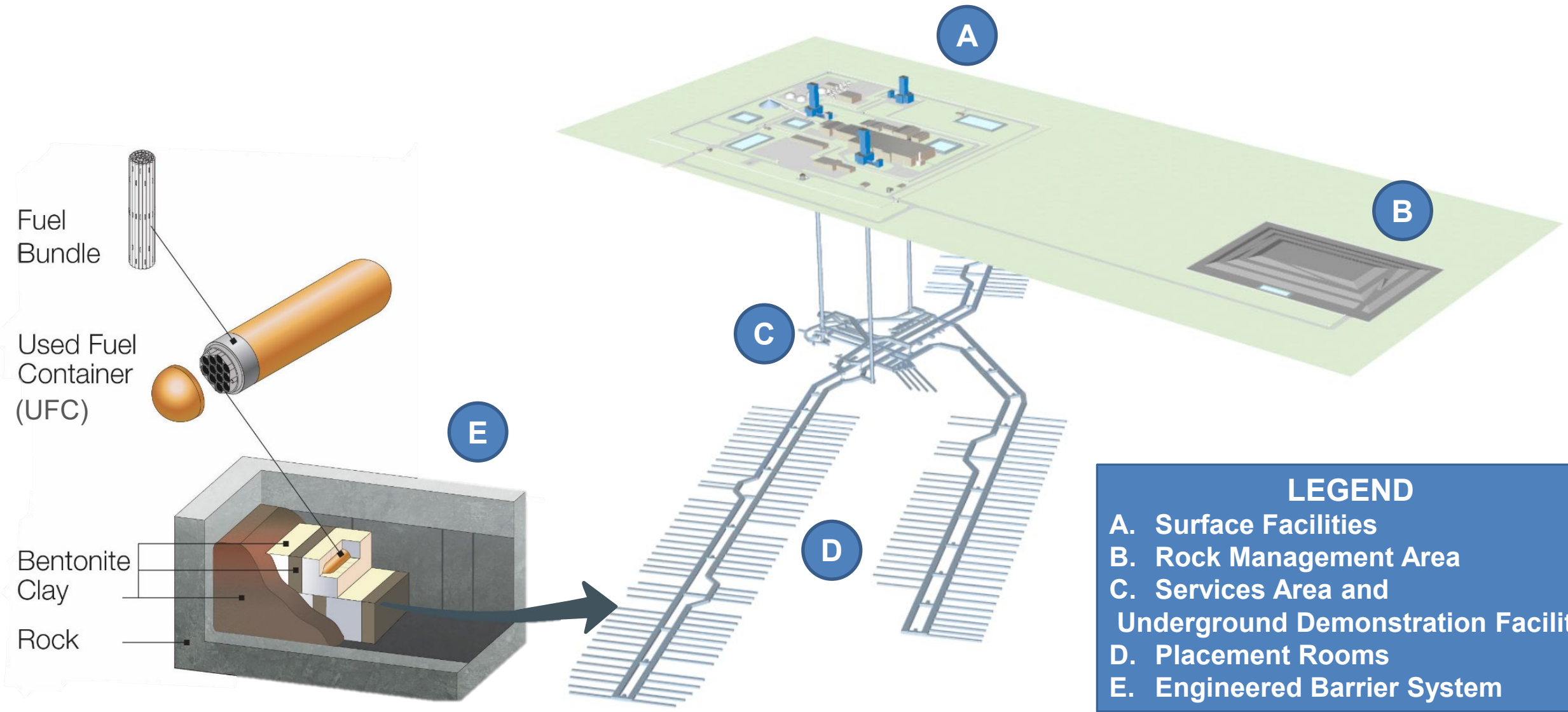


Fuel transfer to
Used Fuel Container
At Packaging Plant

Empty Packages return to pick up more fuel

Confidence in Safety – Used Fuel Packaging Plant

Deep Geological Repository

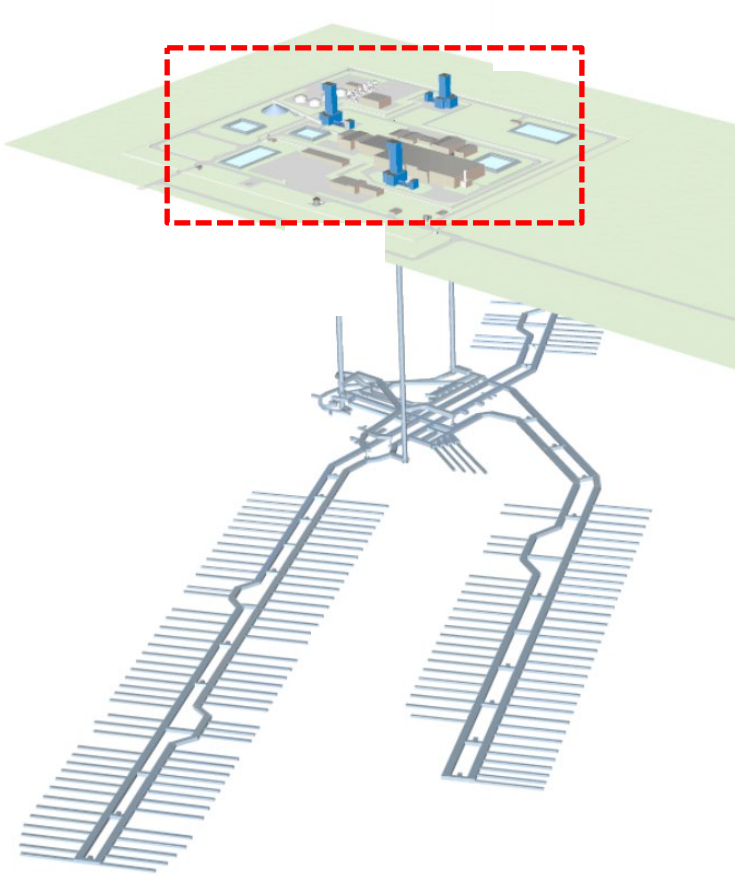


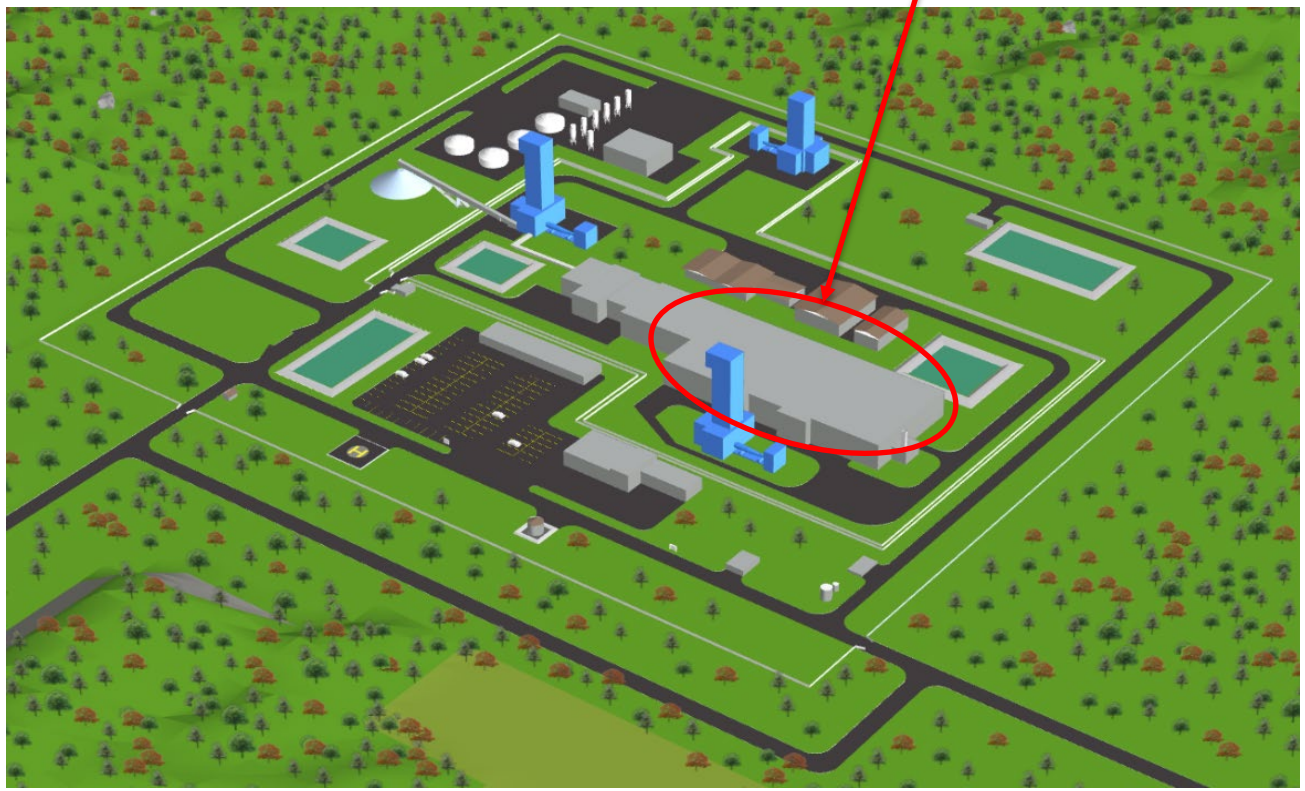
LEGEND

A. Surface Facilities
B. Rock Management Area
C. Services Area and Underground Demonstration Facility
D. Placement Rooms
E. Engineered Barrier System

Surface Facilities

- Conceptual design of surface and underground facilities



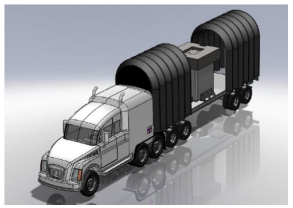


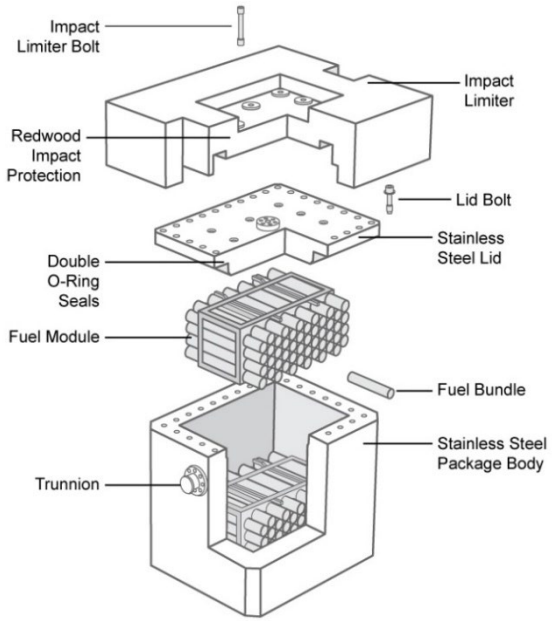
Repository Facility Design and Layout (Generic)

Used Fuel Packaging Plant - Key Processes

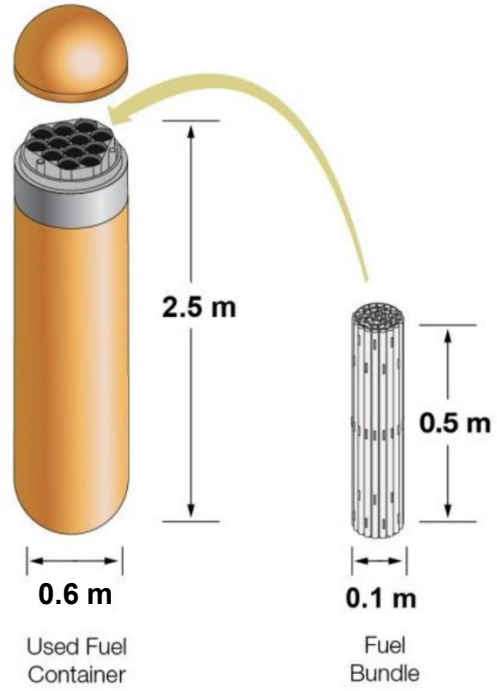
Fuel Receipt and Inspection → UFC Fuel Loading → UFC Closure:
- Welding
- Weld Machining
- Weld NDE
- Copper Application
- Copper Annealing
- Copper Machining
- Copper NDE

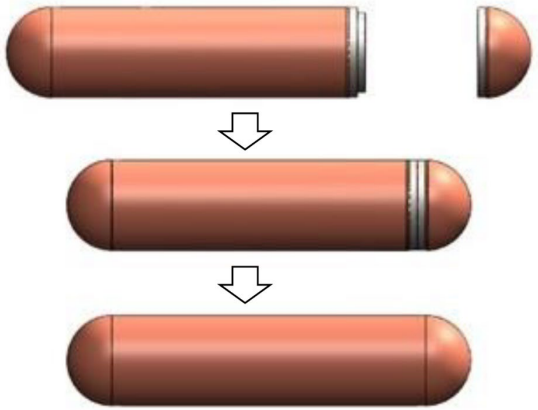
→ Loading and Handling of Buffer Box



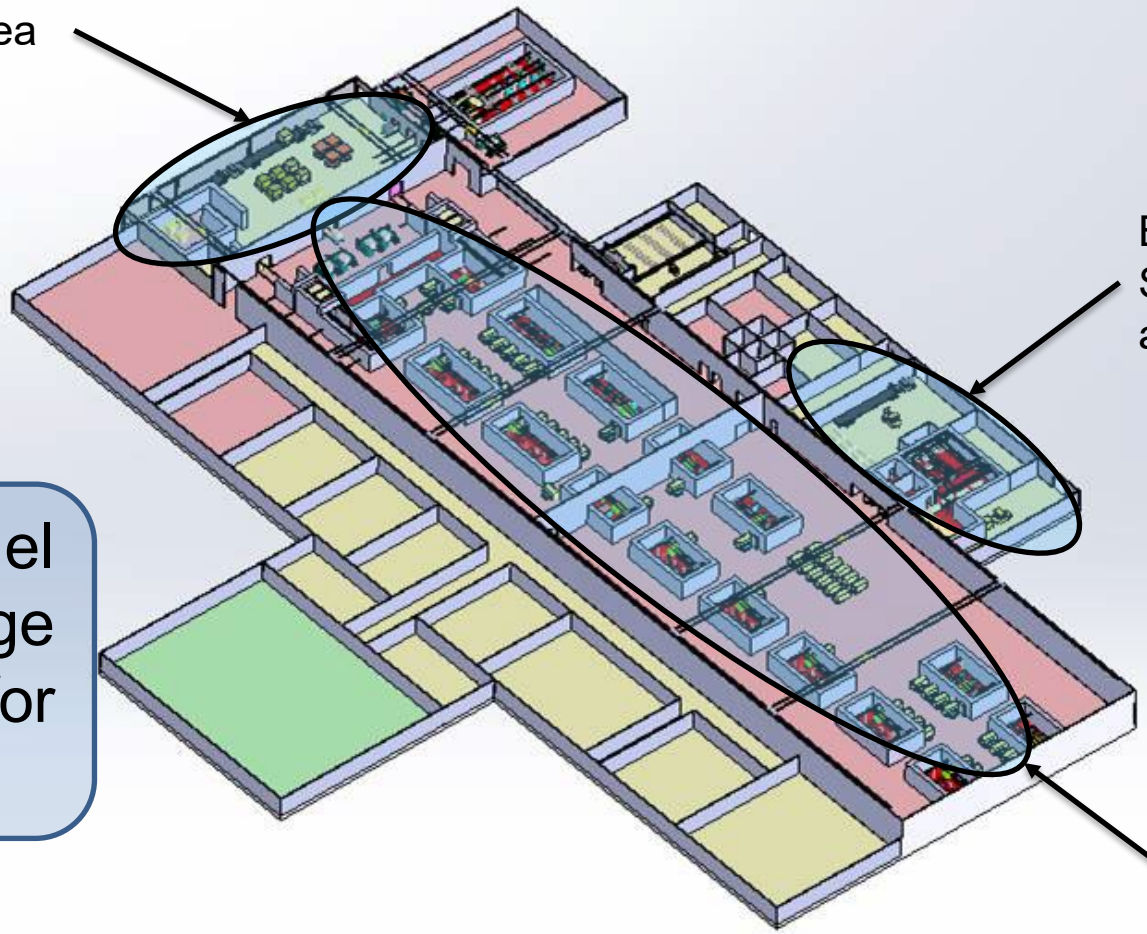


Used Fuel Transportation Package (UFTP)





Used Fuel Packaging Plant (UFPP)

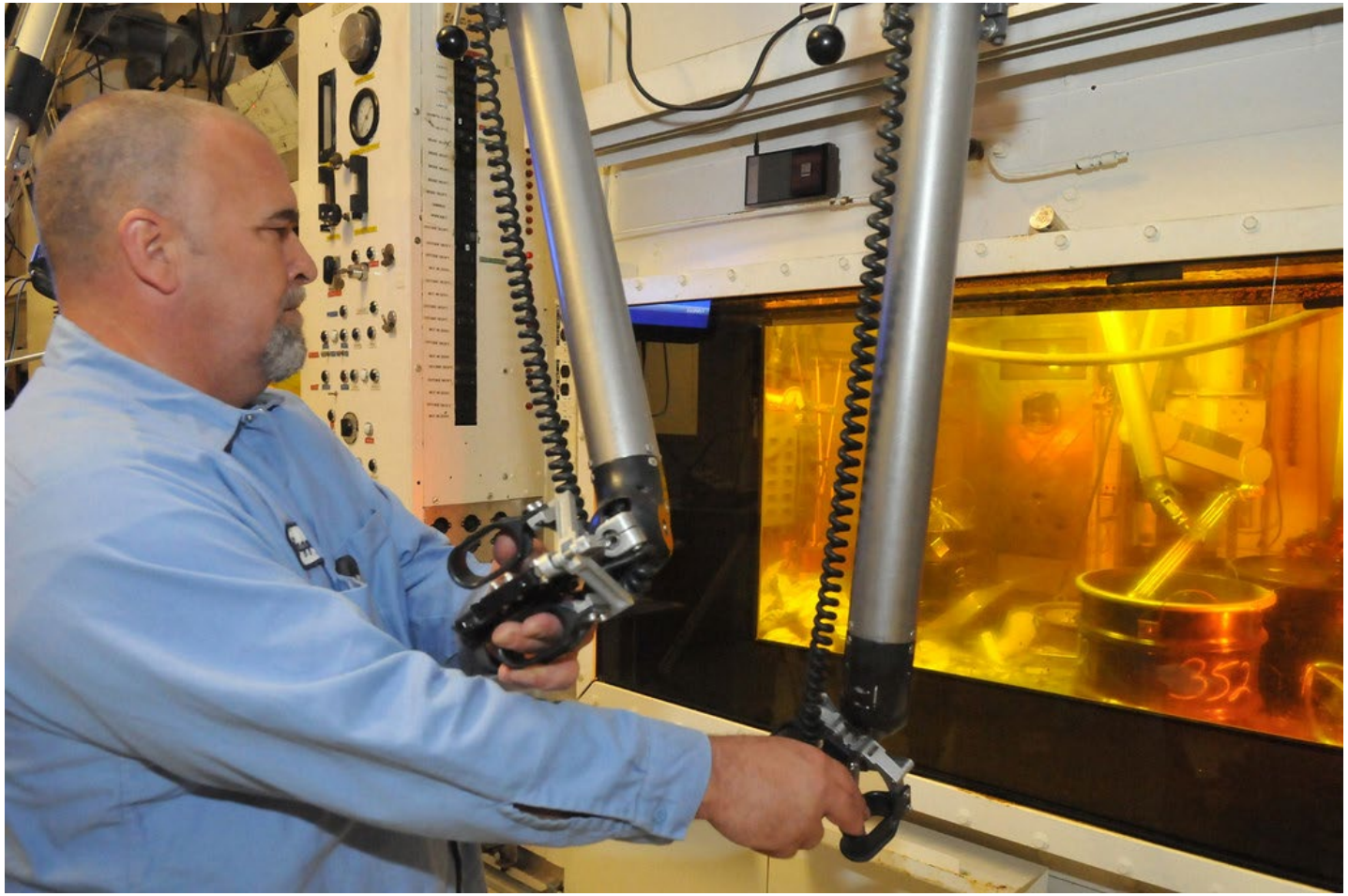


The UFPP will ensure that used fuel received from the interim storage sites will be properly packaged for emplacement in the DGR.

*2021 Conceptual Facility and Zonal Layout of UFPP

What are Hot Cells?

A hot cell is a controlled space where work is performed remotely by manipulators, hoists, or robotics while workers stay outside, safely shielded.



Alpha Gamma hot cell at Argonne Labs, (Chicago, Illinois)

Ref: https://www.flickr.com/photos/argonne/3859726946

Hot Cells – How are they made and how do they work?

Lead and stainless steel construction

TRIUMF ARIEL Hot Cell during Factory Acceptance Test (Vancouver, BC)

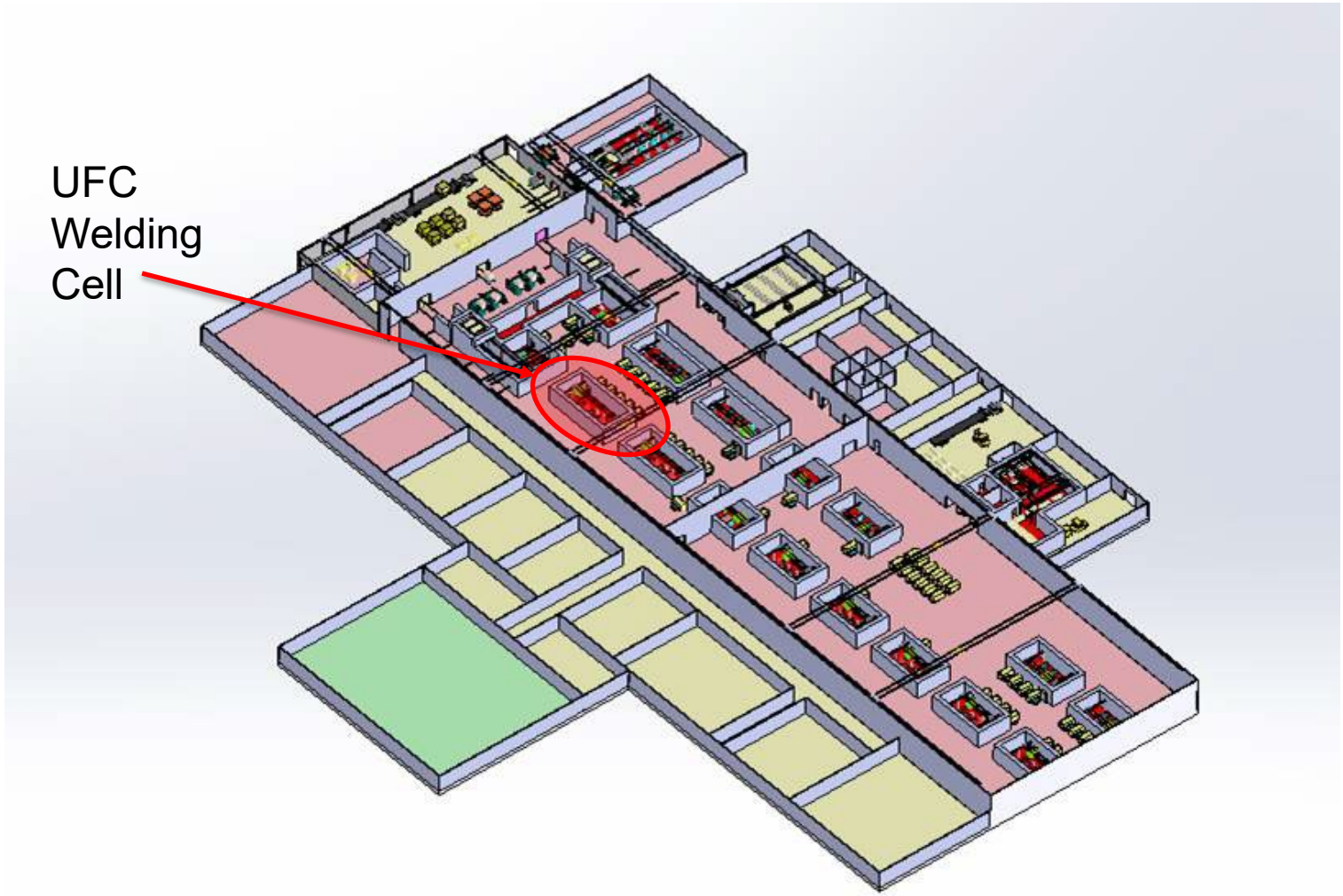
Ref: https://www.triumf.ca/headlines/first-ariel-hot-cell-undergoes-factory-acceptance-testing

Concrete construction

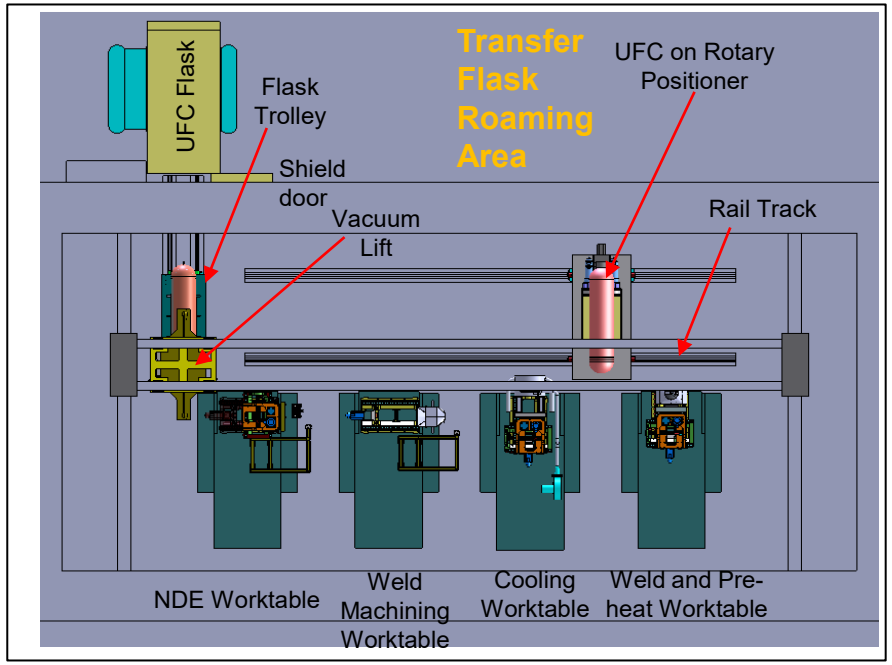
Concrete Cells at REDC (Radiochemical Engineering Development Center), Oak Ridge National Laboratory

Ref: http://knoxblogs.com/atomiccity/2015/06/04/ornls-house-of-hot-cells/

Utilizing Hot Cells in UFPP



*2021 conceptual design



Welding group

- Pre-heating and Welding
- Cooling
- Weld Machining
- Non-destructive Examination (NDE)

Hot Cell Safety Measures

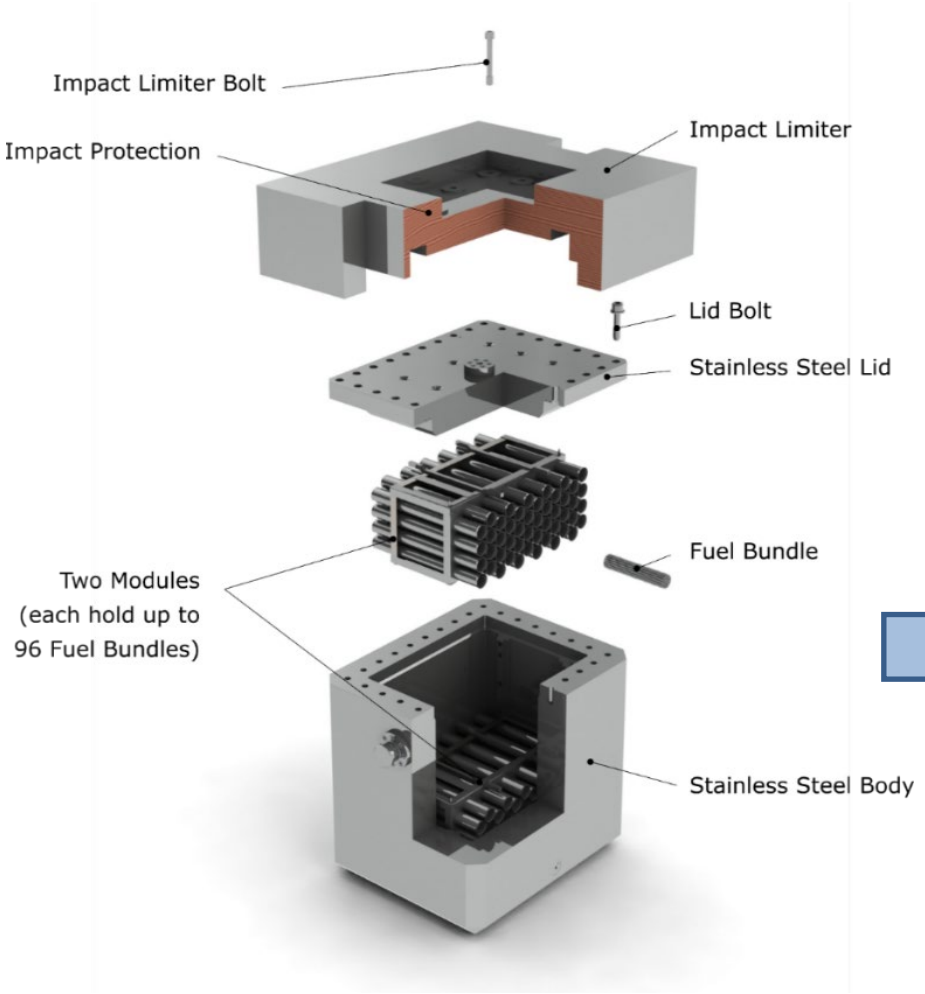
- Hot cells are constructed with shielding material to protect workers on the outside from radiation.
- The ventilation system contains the air inside the hot cells by maintaining constant air depression.
- The stainless steel ductwork is fully sealed with contiguous welding and is equipped to both monitor and filter the air to prevent exposure to people and the environment.
- Access to hot cells is restricted.

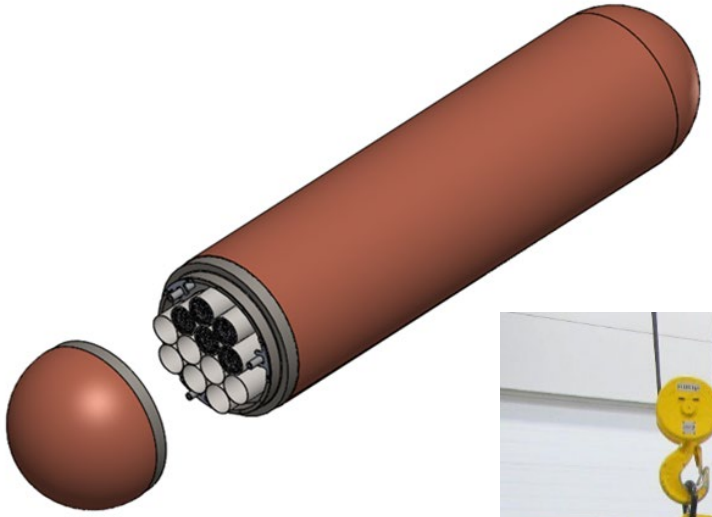
ARIEL Nuclear Ventilation Service Room at TRIUMF
Image used with permission

Thank you & Questions?

Appendix Slides

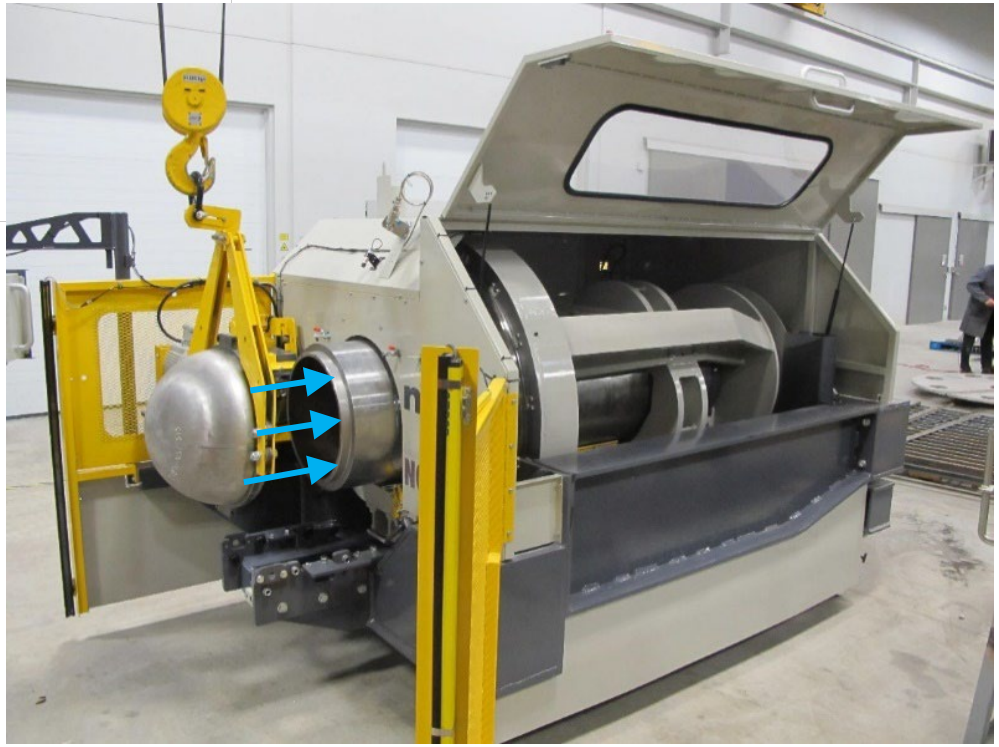
Used Fuel Packaging Plant Key Processes (Part 1)



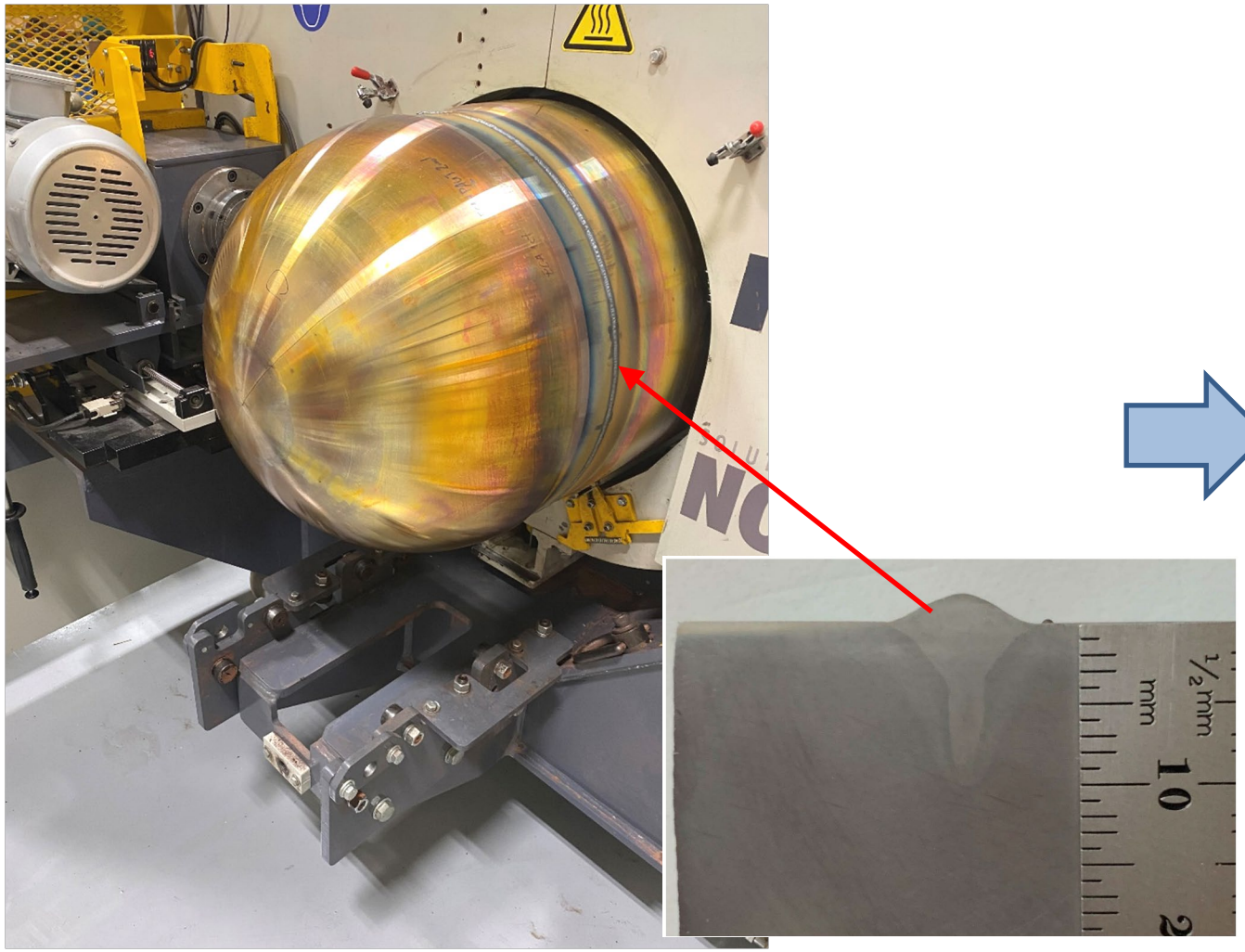


Fuel Receipt, Unloading, and Inspection

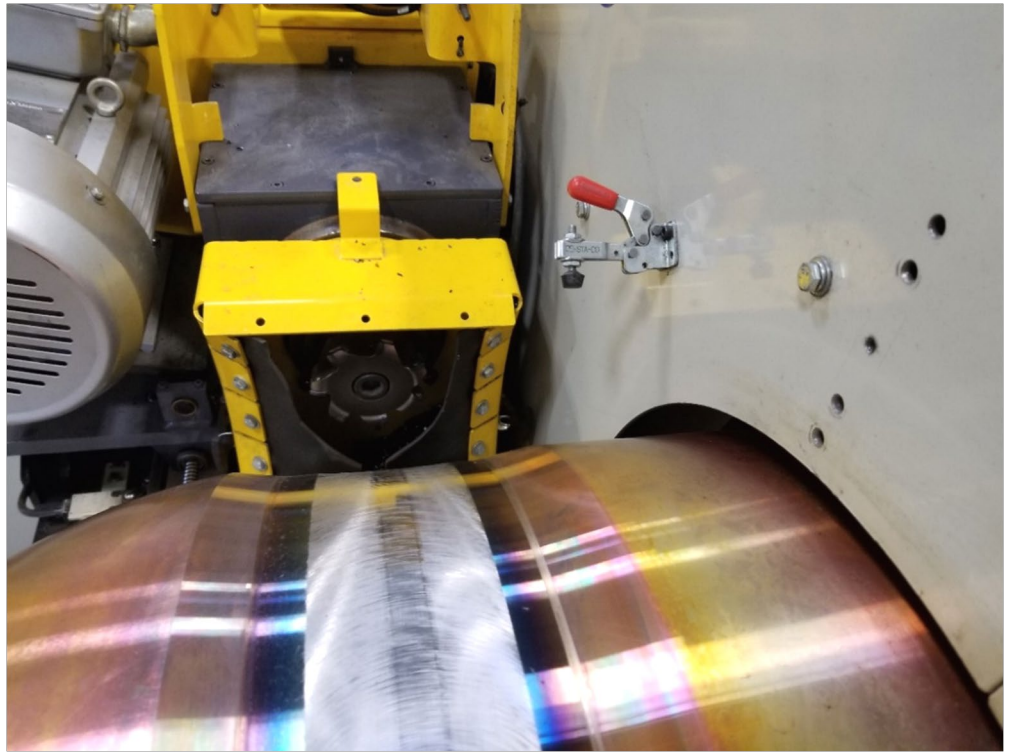
UFC Loading and Hemi-Head Install



Used Fuel Packaging Plant Key Processes (Part 2)

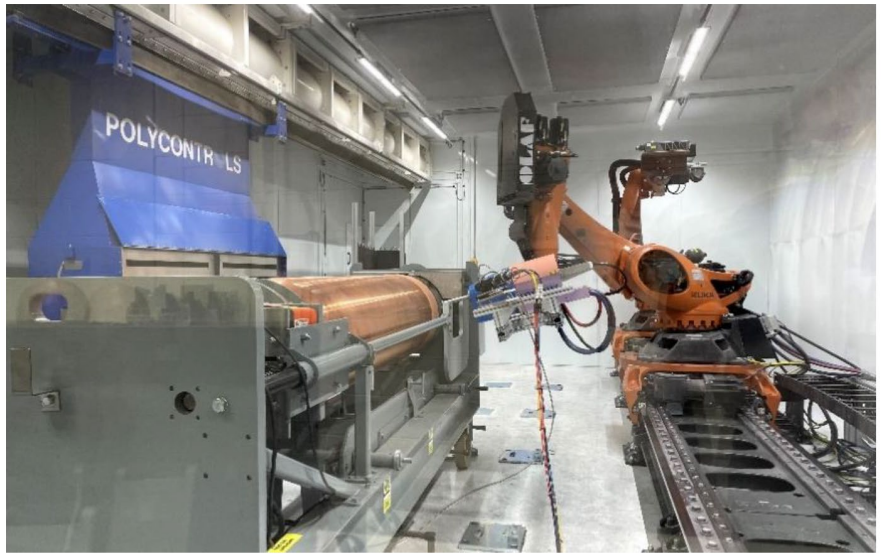


UFC Welding



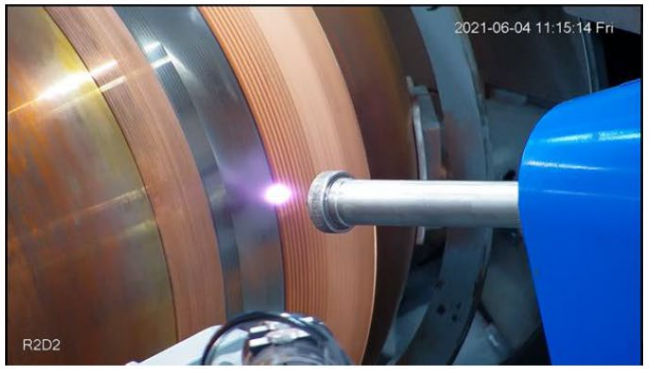
Weld Cap Machining
and Inspection (NDE)

Used Fuel Packaging Plant Key Processes (Part 3)

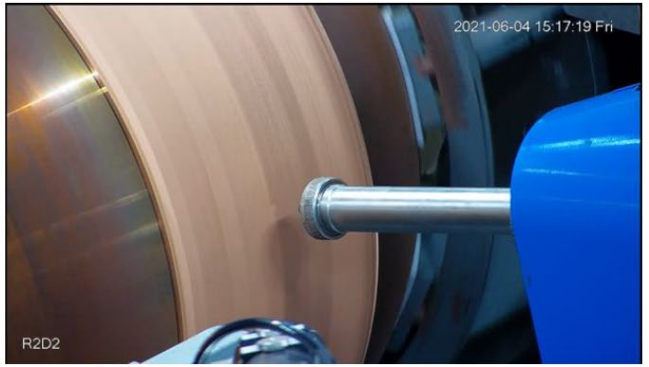


Copper Application

(a)



(b)

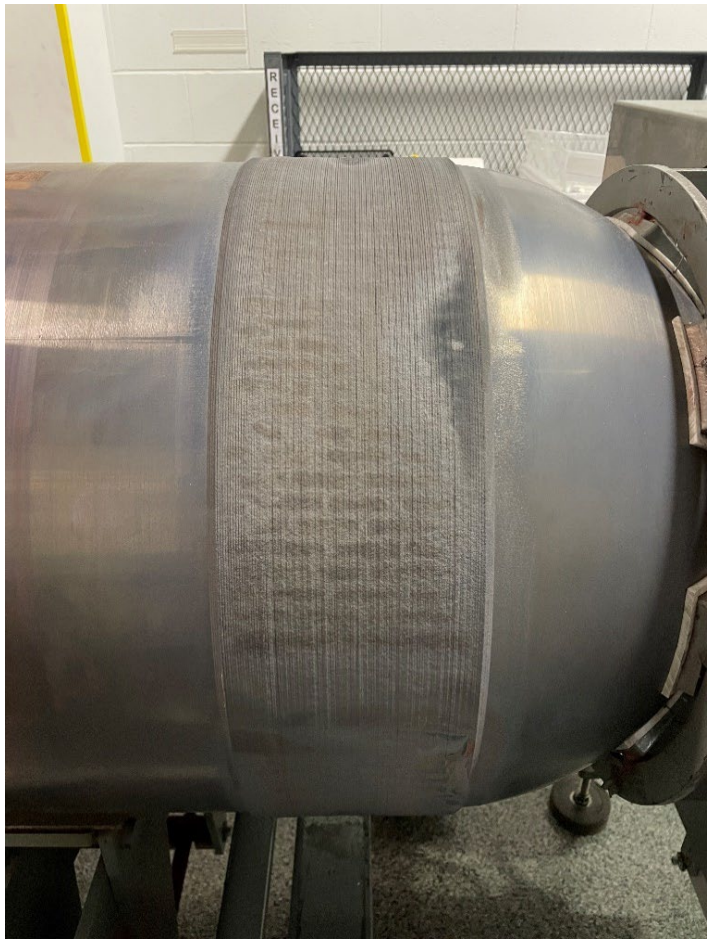


(c)

(d)

(a) laser ablation, (b) bond layer application, (c) thickness build-up, and (d) final coating ready for heat treatment

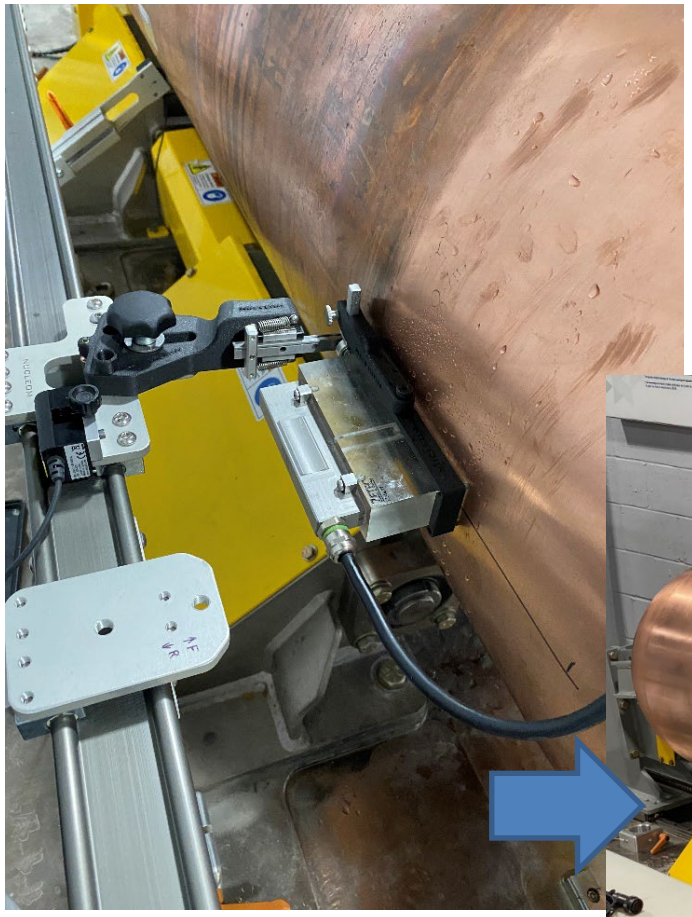
Used Fuel Packaging Plant Key Processes (Part 4)



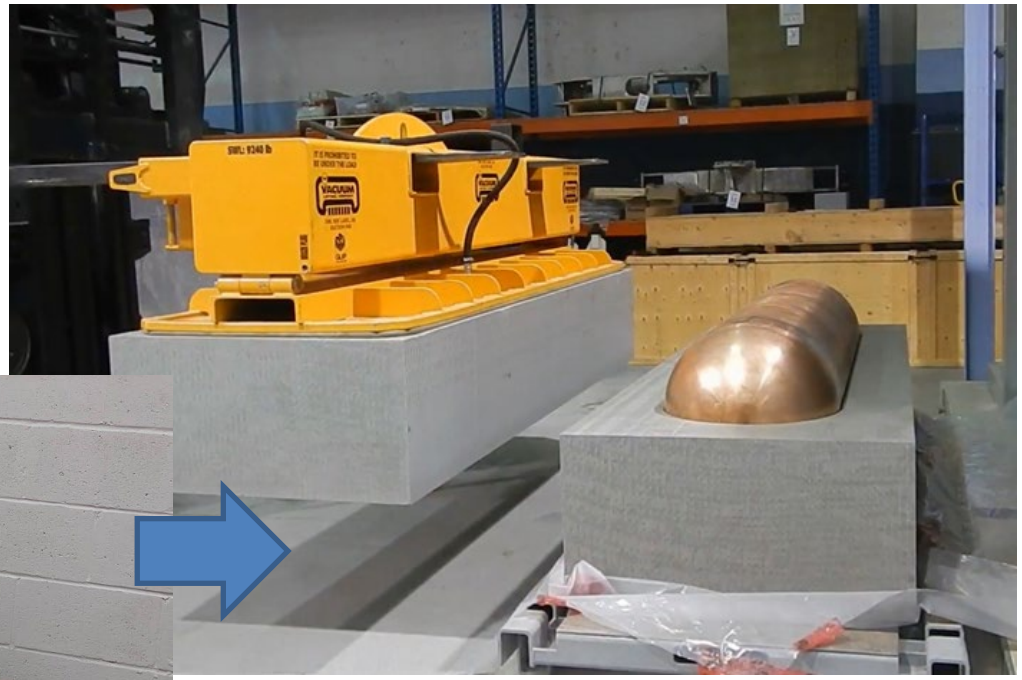
Copper Heat Treatment

Copper Machining

Used Fuel Packaging Plant Key Processes (Part 5)



Copper Inspection (NDE)



Bentonite Buffer Box Loading

Codes, Standards and Regulations

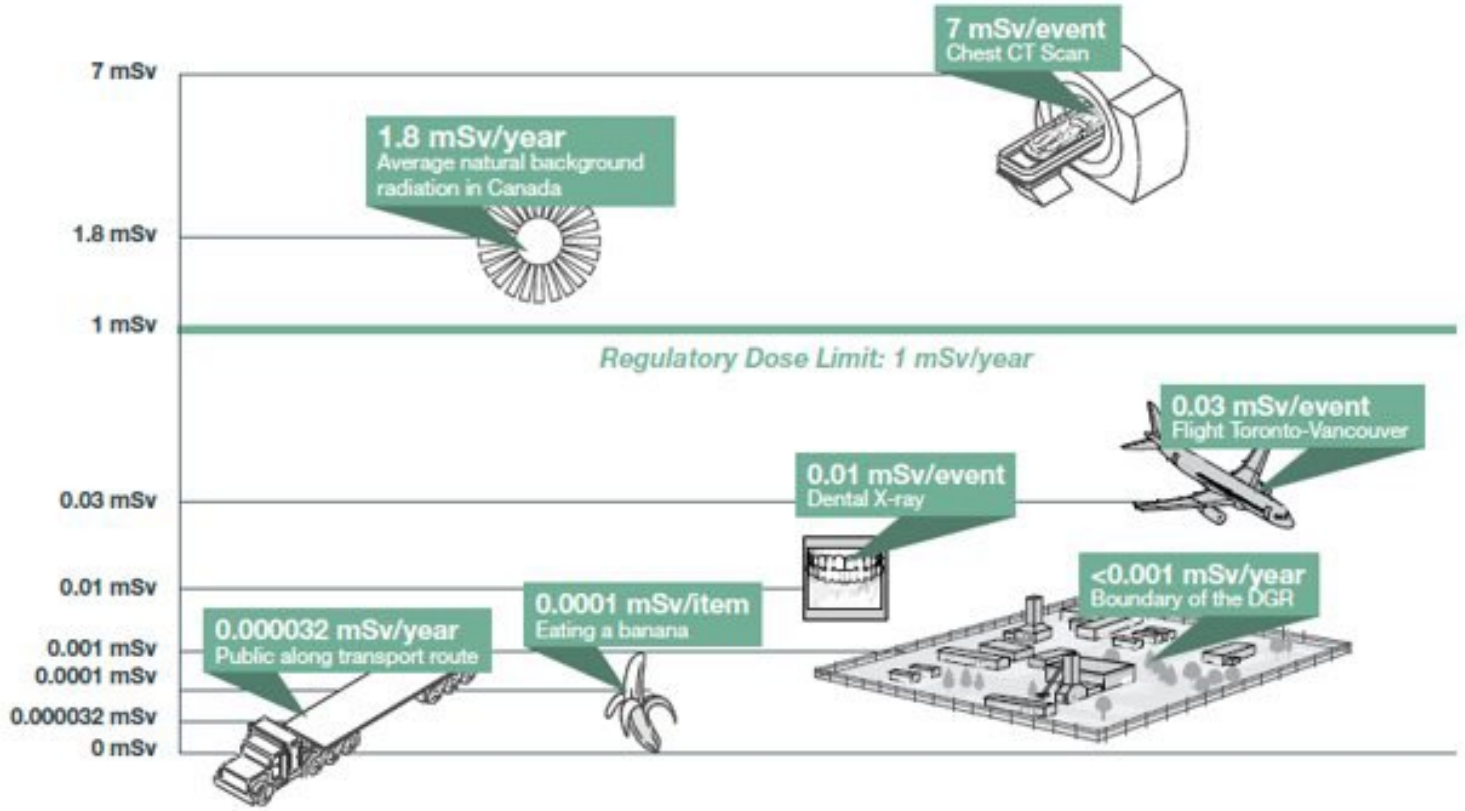
Including but not limited to

CSA N286	Management System Requirements for Nuclear Facilities
CNSC Regulation SOR/2000-202	General Nuclear Safety and Control Regulation
CNSC Regulation SOR/2000-203	Radiation Protection Regulations
CNSC Regulation SOR/2000-204	Class I Nuclear Facilities Regulations
CNSC Regulation SOR/2000-209	Nuclear Security Regulation
IAEA SSG-27	Criticality Safety in the Handling of Fissile Material or CNSC's Regulatory Document RD-327, Nuclear Criticality Safety
CNSC G-129	Keeping Radiation Exposures and Doses As Low as Reasonably Achievable (ALARA)
CNSC Regulation REGDOC-2.5.1	General Considerations: Human Factors
CSA N292.0	General principles for the management of radioactive waste and irradiated fuel
CSA N292.6	Long Term Management of Radioactive Waste and Irradiated Fuel
CNSC Regulation REGDOC-2.5.1	General Considerations: Human Factors
ISO 14001	Environmental Management Systems – Requirements with Guidance for Use
ISO 17873-2004	Nuclear facilities — Criteria for the design and operation of ventilation systems for nuclear installations other than nuclear reactors
CSA N288.3.4-13	Performance testing of nuclear air-cleaning systems at nuclear facilities
DOE-HDBK-1169-2003	Nuclear Air Cleaning Handbook
ISO 11933-4:2001	Components for containment enclosures — Part 4: Ventilation and gas-cleaning systems such as filters, traps, safety and regulation valves, control and protection devices
NVF/DG001	An Aid to the Design of Ventilation of Radioactive Areas
	Canadian Environmental Protection Act
	National Building Code of Canada
	Ontario Occupational Health and Safety Act

Radiation safety

Comparison of Sources of Radiation

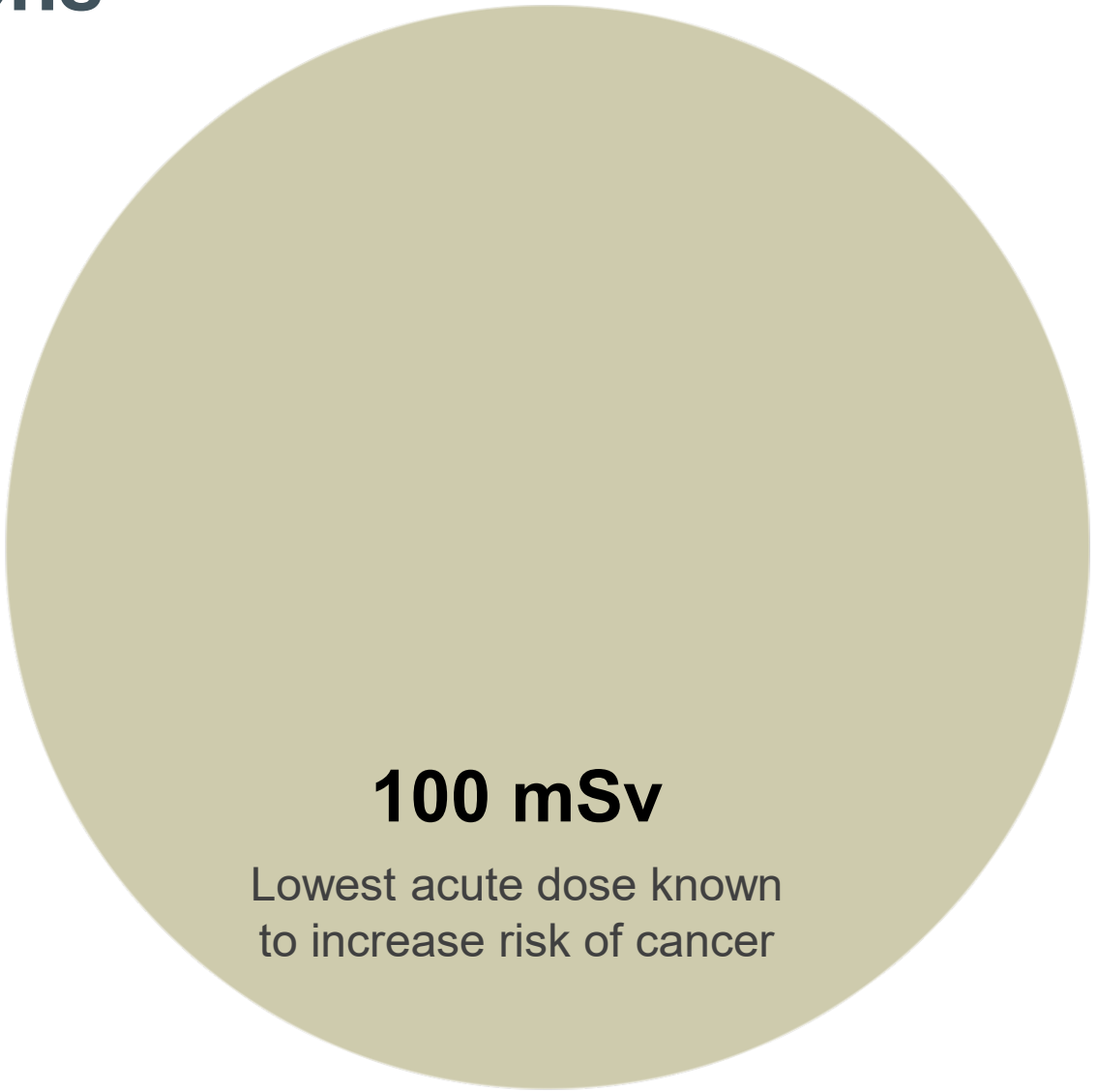
The graphic below compares dose rates from common sources of radiation to what members of the public would encounter if they were located 30 metres from a transportation route for used nuclear fuel and experienced all 620 truck shipments or 62 train shipments. Based on a generic dose study, the annual dose would be 0.000032 mSv, which is significantly lower than the public dose limit of 1 mSv set by the regulator.



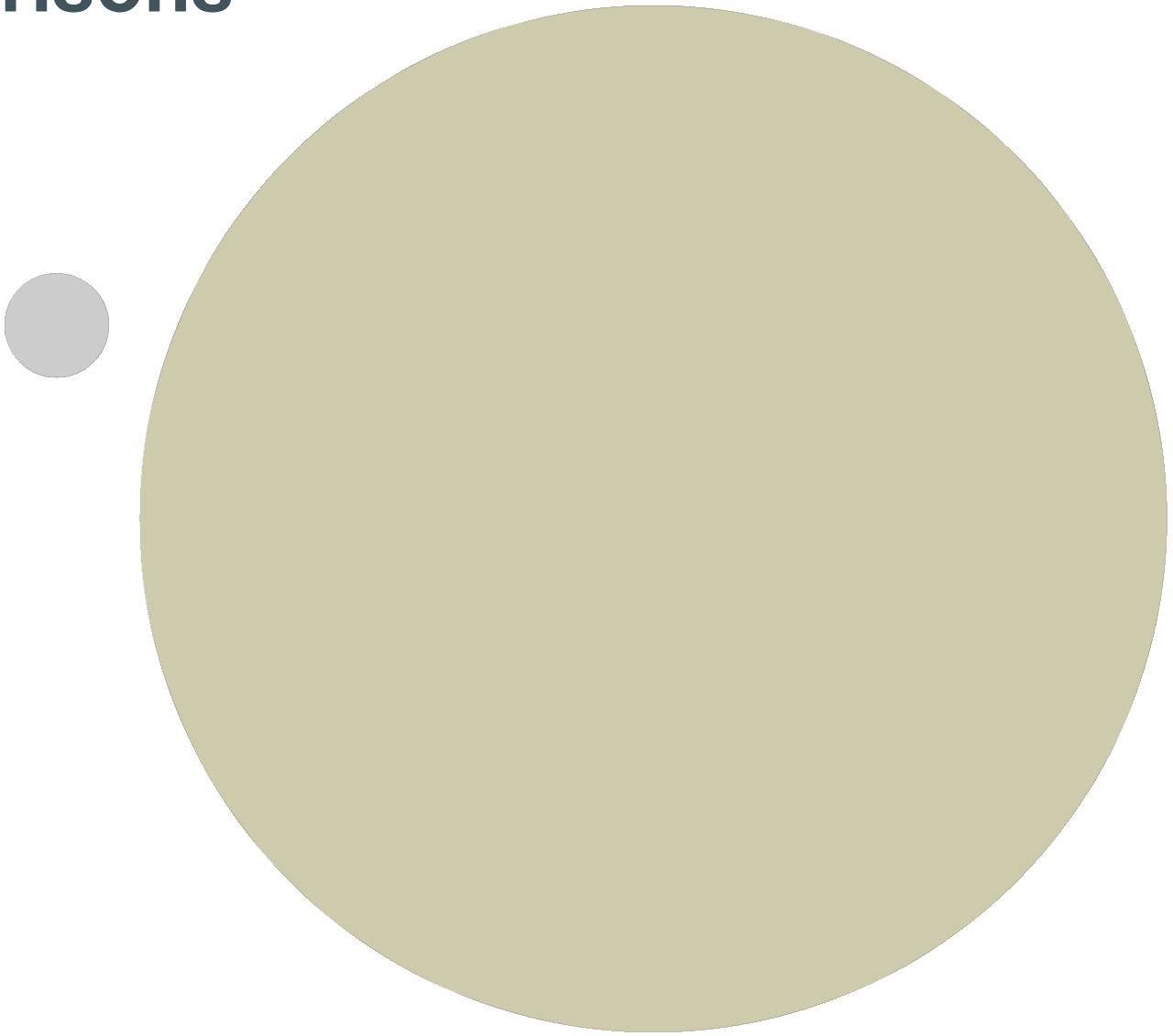
Dose comparisons

1 mSv
Annual public radiation dose limit

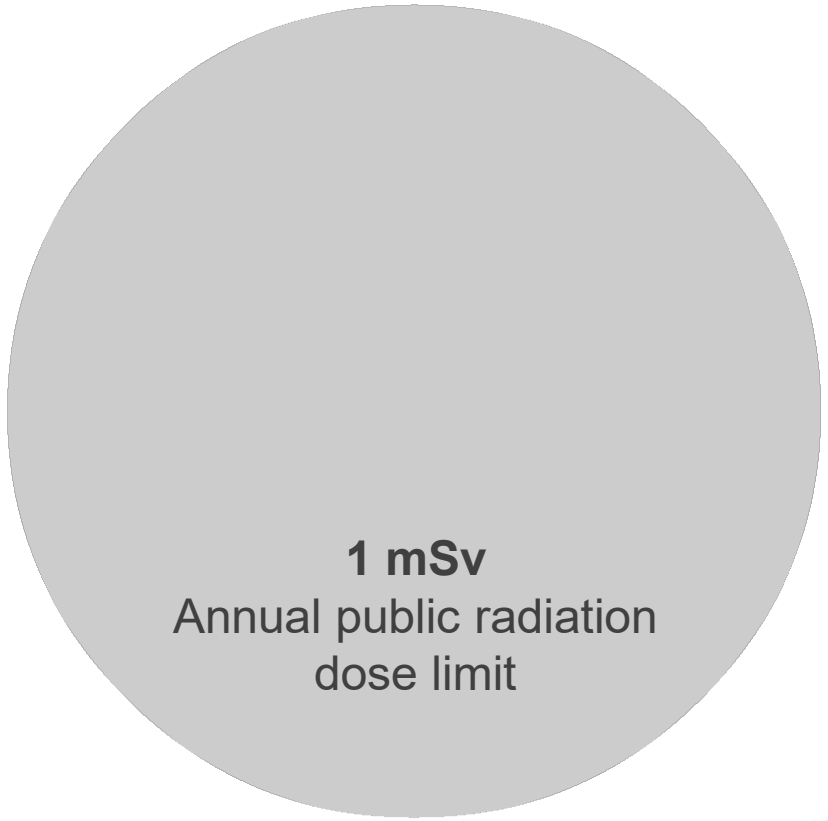
1.8 mSv
Average annual Canadian background dose



Dose comparisons



Dose comparisons



1 mSv
Annual public radiation dose limit

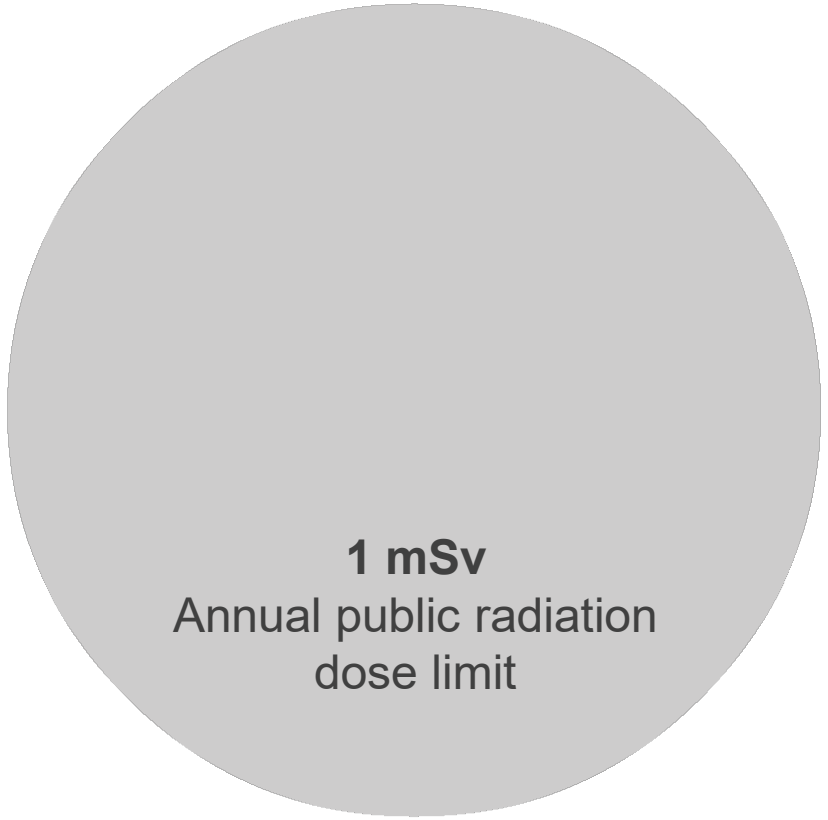
0.01 mSv
Dose from dental x-ray

0.1 mSv
Dose from lung x-ray

100 mSv

Lowest acute dose known to increase risk of cancer

Dose comparisons



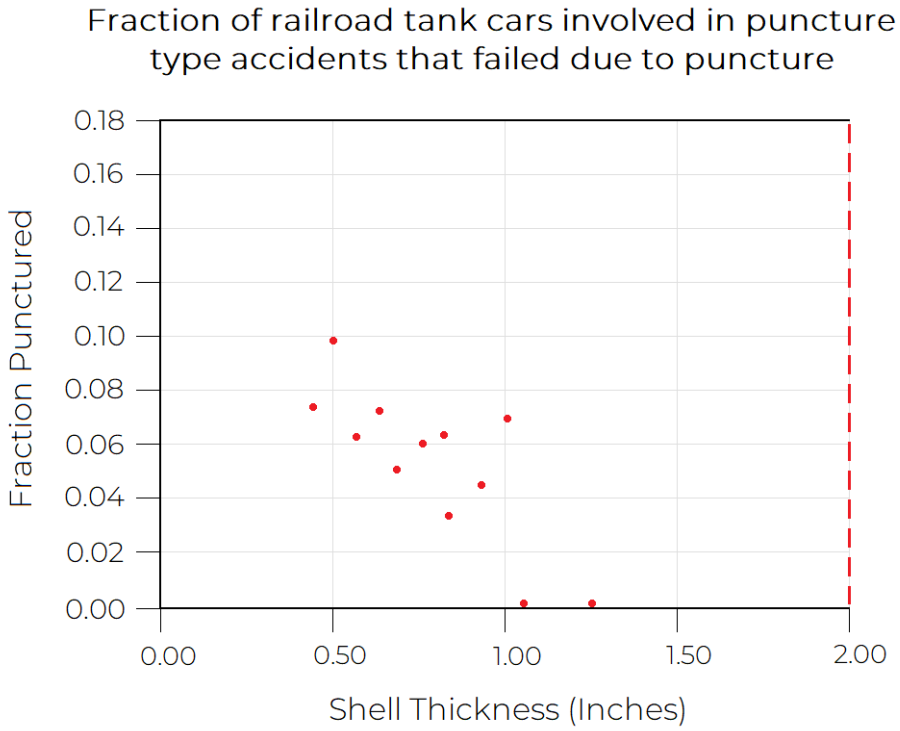
1 mSv
Annual public radiation dose limit

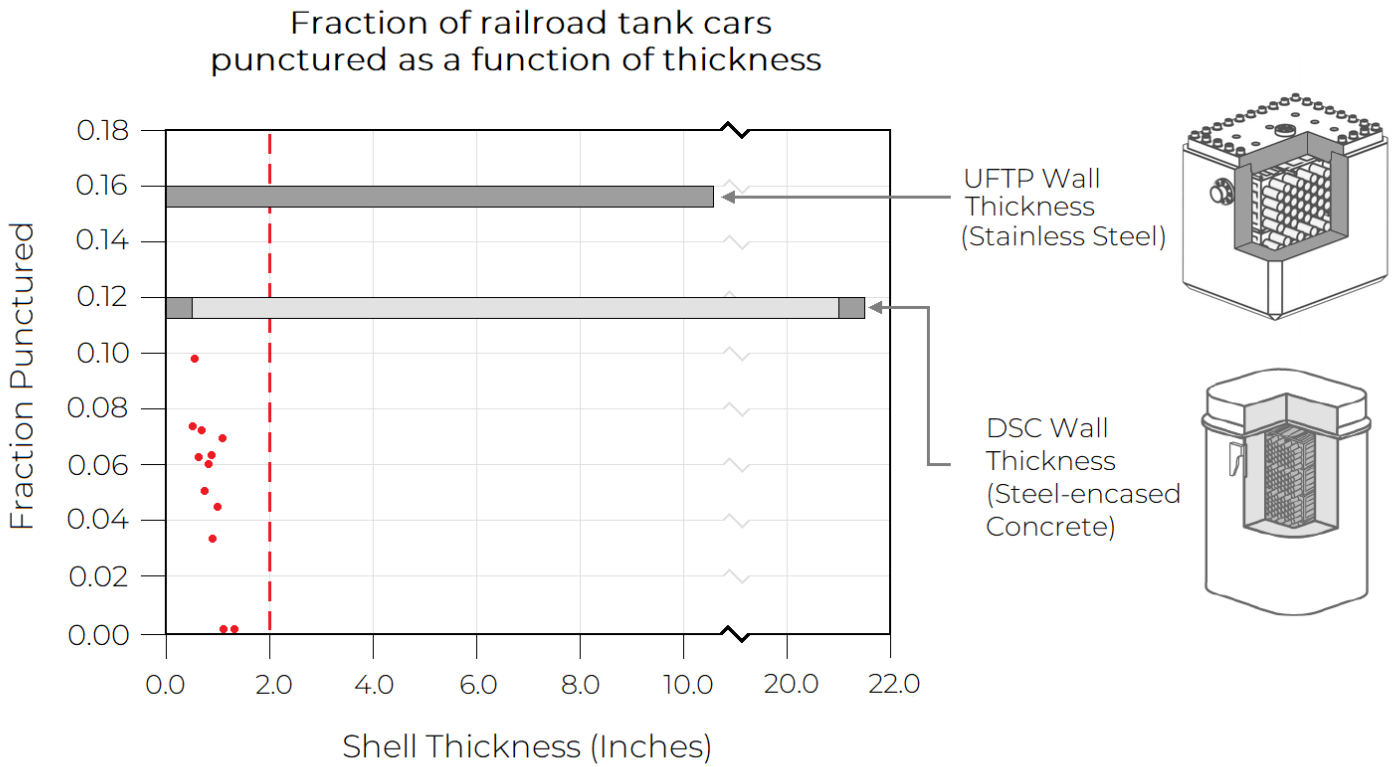
0.000032 mSv
Annual dose to public along transport route

0.001 mSv
Annual Dose at repository boundary

100 mSv
Lowest acute dose known to increase risk of cancer

Puncture - Rail Tank Cars vs Used Fuel Packages

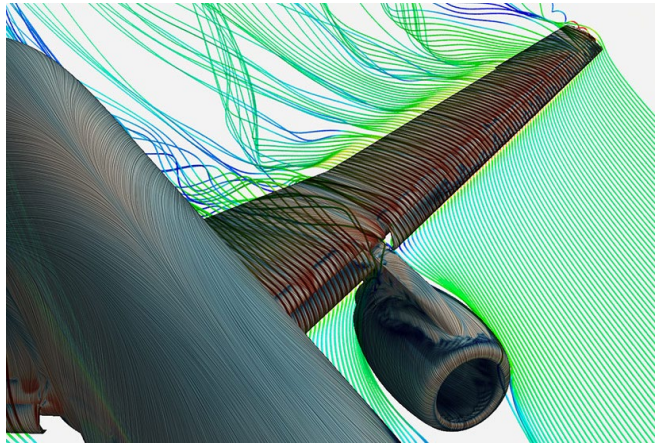




- NUREG/CR-6672. Data from RPI-AAR Railroad Tank Car Safety Research and Test Project, June 1998.

Use of Scale Model and Simulations for certification

- Original UFTP (IFRC) certification carried out via mix of simulation & scale model testing
  - Permitted by IAEA Regulations
  - Industry standard practice (beyond nuclear)
  - Reliable, repeatable testing
  - Work in conjunction to validate results
  - Specialized Facility Requirements



Extra-regulatory Package Testing