Activation and Waste Stream Analysis for RTL of Z-Pinch Power Plant

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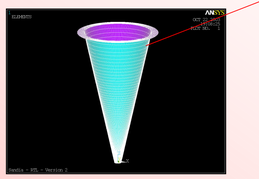
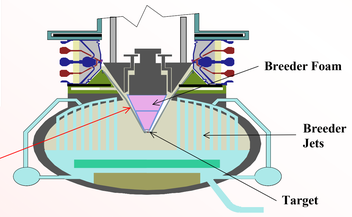
Z-Pinch Power Plant

Recyclable Transmission Lines (RTL)
Top diameter = 1 m
Bottom diameter = 0.1 m
Length = 2 m
Total thickness = 0.142 cm
50 kg / RTL





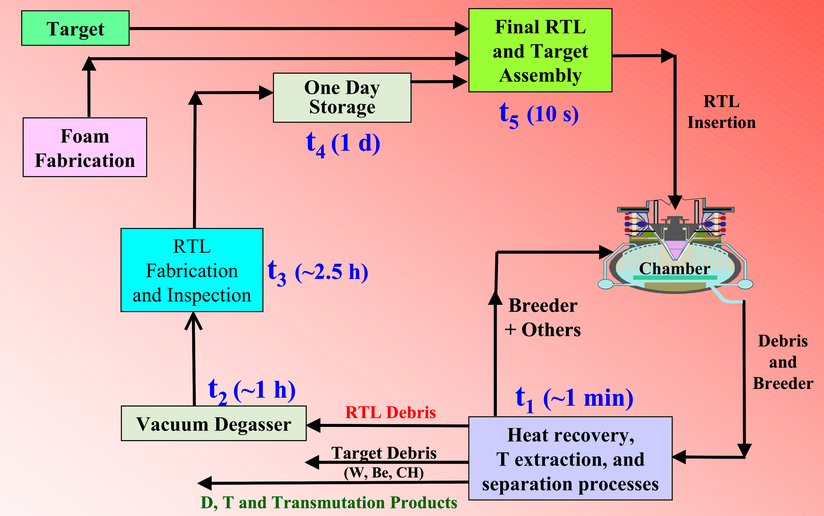
Chamber
(10 units / plant)

Key Parameters

Target Yield	**3 GJ**
Rep Rate	**0.1 Hz**
# of Units per Plant	**10**
RTL material	**Carbon Steel***
RTL Thickness (2 cones)	**0.142 cm**
RTL Mass	**50 kg / RTL**
RTL Volume	**0.006 m^3 / RTL**
Plant Lifetime	**40 FPY (47 y)**
Projected Plant Availability	**85%**

* 99.51% Fe, 0.08% C, 0.32% Mn, 0.04% P, and 0.05% S

Recycling Process



Objectives

- Develop irradiation history and timeline for RTL recycling approach.
- Examine **conservative** recycling approach without slag or transmutation product removal.
- Compare RTL waste volume to other plant waste.
- Determine classification of RLT waste:
  - Waste disposal rating (WDR):
    - High-level waste
    - Low-level waste (Class A or Class C)
  - Clearance
- Monitor radiation dose to recycling equipment during RTL fabrication.

Recycling Scenario

- **Pros:**
  - Low inventory of radwaste.
  - Negligible cost of original materials.
- **Cons:**
  - May generate high-level waste.
  - Require radioactive storage facility.
  - Need purification system to deliver highly pure materials.
  - No hands-on and no personnel access to fabrication facility.
  - Slow, remotely controlled process.
  - Costly re-fabrication process.

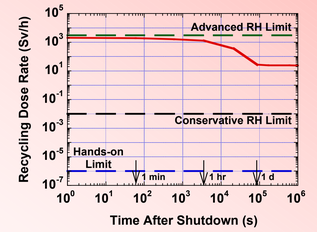
WDR Results

LLW	WDR	Limits
Class C	**10^{-6}** (^{32}Si)	1
Class A	**10^{-4}** (T,^{14}C)	1

RTLs generate very low-level waste (WDR << 1)
and could qualify for clearance
if CI < 1 @ 100 y after decommissioning

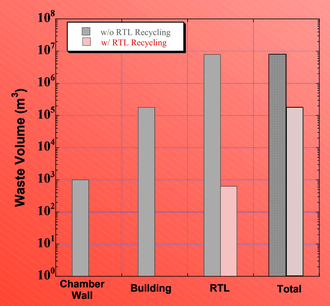
Effect of carbon steel impurities on WDR needs to be examined

Dose Results



- Hands-on recycling not allowed.
- No personnel access to fabrication facility.
- Advanced remote handling equipment must be developed to handle 3000 Sv/h.
- Main contributors at 1 day: ^{54}Mn (90%, $T_{1/2}$=312.2 d) and ^{56}Mn (9.6%, $T_{1/2}$=2.58 h).

RTL Recycling is a "Must" Requirement to Minimize Waste Stream and Enhance Economics



No recycling for 40 FPY
Total RTL mass = 70 M Tons

With recycling
1.1 day RTL inventory
Total RTL mass = 0.005 M Tons

Design Criteria and Codes

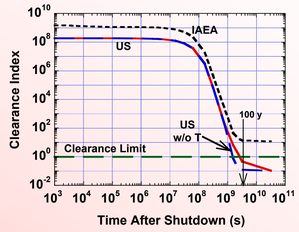
Waste disposal rating (WDR) **1**
(for low-level waste)

Clearance Index **1**
(for waste containing traces of radionuclides)

Recycling dose **3000 Sv/h**
(for **advanced** remote handling equipment)

- **Codes and data:**
  - **3-D MCNP transport code to compute average flux at RTL**
  - **ALARA Pulsed activation code**:
    Exact modeling of all pulses (~13,000 over 40 FPY)
  - **FENDL-2 IAEA Nuclear Data.**

Clearance Results



According to U.S. guidelines, RTL waste could be stored for 50 y after plant decommissioning, then reused within nuclear industry or released to commercial market

Concluding Remarks

- Carbon steel RTLs satisfy design requirements when recycled for entire plant life (40 FPY):
  - Class A low-level waste ⇒ Near-surface shallow land burial
  - Clearance index < 1 ⇒ Store waste for 50 y after decommissioning, then reuse within nuclear industry or release to commercial market
  - Dose ~ 3000 Sv/h ⇒ Only remote handling (no hands-on).
- Online removal of transmutation products helps meet design requirements with wider margin, but may generate limited amount of high-level waste.
- Advanced remote handling equipment ***must*** be developed to handle dose rate of 3000 Sv/h.
- Fabricate RTL out of breeding material. Benefits:
  - No separation process
  - No disposal/clearance issues
  - Lower energy demand (< 200 MW$_e$).