Recommended Change to ARIES Radwaste Top-Level Requirement

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Objectives

- Revisit 1997 top-level requirements developed for ARIES power plants.

- Recommend change to radwaste requirement based on most recent waste management approach.

ARIES Power Plants Demonstrate Adequate Performance in Several Safety Areas

Environmental impact:

- Minimal radioactive releases[#] during normal and abnormal operations.
- No high-level waste.
- Low activation materials with strict impurity control
  - ⇒ minimal long-term environmental impact.

Occupational and public safety:

- Low doses to workers and personnel during operation and maintenance activity (< 2.5 mrem/h[*]).
- No evacuation plan following abnormal events (early dose at site boundary < 1 rem[*]) to avoid disturbing public daily life.
- Public safety during normal operation (bio-dose << 2.5 mrem/h[*]) and following credible accidents:
  - LOCA, LOFA, LOVA, and by-pass events.
  - External events (seismic, hurricanes, tornadoes, etc).

No energy and pressurization threats to confinement barriers (VV, cryostat, and bioshield):

- Decay heat problem solved by design
- Chemical reaction avoided
- No combustible gas generated
- Chemical energy controlled by design
- Overpressure protection system
- Rapid plasma shutdown.

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* 1 rem = 10 m Sv

Such as T, volatile activated structure, corrosion products, and erosion dust. Or, from liquid and gas leaks.

ARIES Top-Level Requirements
(Starlite report, 1997)

P 2-2: Fusion power in its present embodiments will result in a large, central-station power plant. At present, the investor-owned, public electric utilities best represent the customers for this type of power plant. To better understand the needs of this class of customer, the **Starlite Project solicited several large public utilities and support industries to help define the requirements and goals for fusion power**. Several utilities and industries agreed to help establish and participate in a Power Plant Studies Utility Advisory Committee. This committee provided advice to help formulate the mission and goals for fusion in general, and for a fusion demo power plant in particular.

P 1-2: Based on interaction and advice from U.S. electric utilities and industry, a set of criteria for fusion power is derived. A similar set of criteria has been developed by the EPRI fusion working group. These criteria and associated top-level **requirements and goals can be divided into three general categories**:

1. Cost
2. **Safety and environmental features**
3. Reliability, maintainability, and availability.

ARIES Top-Level Requirements (Cont.)
(Starlite report, 1997)

P 1-3:

Safety and environmental features

- Must use technologies to be employed in commercial power plant
- COE must be competitive (65-80 mills/kWh- $1992; 80-100 milsl/kWh- $2004)
- **No evacuation plan required for any credible accident: Total dose at site boundary < 1 rem**
- **Generate no radwaste greater than Class C**
- **Must demonstrate public day-to-day activity is not disturbed**
- **Must not expose workers to a higher risk than other power plants**
- Must demonstrate robotic maintenance of power core
- Must demonstrate routine operation with less than 1/10 unscheduled shutdowns per year including disruptions
- Demonstrate a closed tritium fuel cycle
- Must demonstrate operation at partial load conditions at 50%.

Recent Trend in Waste Management

- **Options**:
  - **Disposal** in repositories – LLW (WDR < 1) or HLW (WDR > 1)
  - **Recycling** - reuse within nuclear facilities (dose < 3000 Sv/h)
  - **Clearance** – recycle slightly-irradiated components and release to commercial market, if CI < 1.

- Limited capacity of existing repositories **and** slim chance of building new repositories call for new requirement that promotes recycling/clearance, avoiding geological disposal No radwaste burden on future generation

- Recycling of liquids and solids may generate limited amount of radioactive waste that needs special treatment.

Modify ARIES top-level requirement to reflect recent trend in radwaste management

Adopt **MRCB** Philosophy

M – minimize volume of active materials by design

L. El-Guebaly, "Development of Waste Volume Minimization Schemes for ARIES Power Plants," to be published.

R – recycle

L. El-Guebaly, P. Wilson, D. Henderson, A. Varuttamaseni, and the ARIES Team, "Recycling of IFE Target Materials versus One-Shot Use Scenario: Key Issues and Preferred Option," University of Wisconsin Fusion Technology Institute Report, UWFDM-1183 (November 2002).

L. El-Guebaly, P. Wilson, M. Sawan, D. Henderson, and A. Varuttamaseni, "Radiological Impact of IFE Target and RTL Recycling Option: A comparative Study," University of Wisconsin Fusion Technology Institute Report, UWFDM-1227 (July 2004).

L. El-Guebaly, P. Wilson, D. Henderson, and A. Varuttamaseni, "Feasibility of Target Materials Recycling as Waste Management Alternative," Fusion Science & Technology, **46**, No. 3, 506-518 (2004).

L. El-Guebaly, P. Wilson, M. Sawan, D. Henderson, and A. Varuttamaseni, "Recycling Issues Facing Target and RTL Materials of Inertial Fusion Designs," Nuclear Instruments & Methods in Physics Research, Section A, **544,** 104-110 (2005).

L. El-Guebaly, P. Wilson, M.E. Sawan, "Recycling and Clearance of the Slightly Activated RTLs of the 2005 Z-Pinch Design," University of Wisconsin Fusion Technology Institute Report, UWFDM-1284 (October 2005). Available at: http://fti.neep.wisc.edu/pdf/fdm1284.pdf

M. Zucchetti, L. El-Guebaly, R. Forrest, T. Marshall, N. Taylor, K. Tobita, "The Feasibility of Recycling and Clearance of Active Materials from Fusion Power Plants," Submitted to ICFRM-12 conference at Santa Barbara (Dec 4-9, 2005).

L. El-Guebaly, "Evaluation of Disposal, Recycling, and Clearance Scenarios for Managing ARIES Radwaste after Plant Decommissioning," 8th IAEA TM on Fusion Power Plant Safety (July 10-13, 2006, Vienna, Austria).

C – clear slightly-irradiated materials

L. El-Guebaly, D. Henderson, A. Abdou, and P. Wilson, "Clearance Issues for Advanced Fusion Power Plants", Fusion Technology, 39, No. 2, 986-990 (2001).

L. El-Guebaly, P. Wilson, and D. Paige, "Status of US, EU, and IAEA Clearance Standards and Estimates of Fusion Radwaste Classifications," University of Wisconsin Fusion Technology Institute Report, UWFDM-1231 (December 2004).

L. El-Guebaly, P. Wilson, and D. Paige, "Evolution of Clearance Standards and Implications for Radwaste Management of Fusion Power Plants," Journal of Fusion Science & Technology, **49**, 62-73 (2006).

L. El-Guebaly, R. Forrest, T. Marshall, N. Taylor, K. Tobita, M. Zucchetti, "Current Challenges Facing Recycling and Clearance of Fusion Radioactive Materials," University of Wisconsin Fusion Technology Institute Report, UWFDM-1285 (Nov 2005). Available at: http://fti.neep.wisc.edu/pdf/fdm1285.pdf

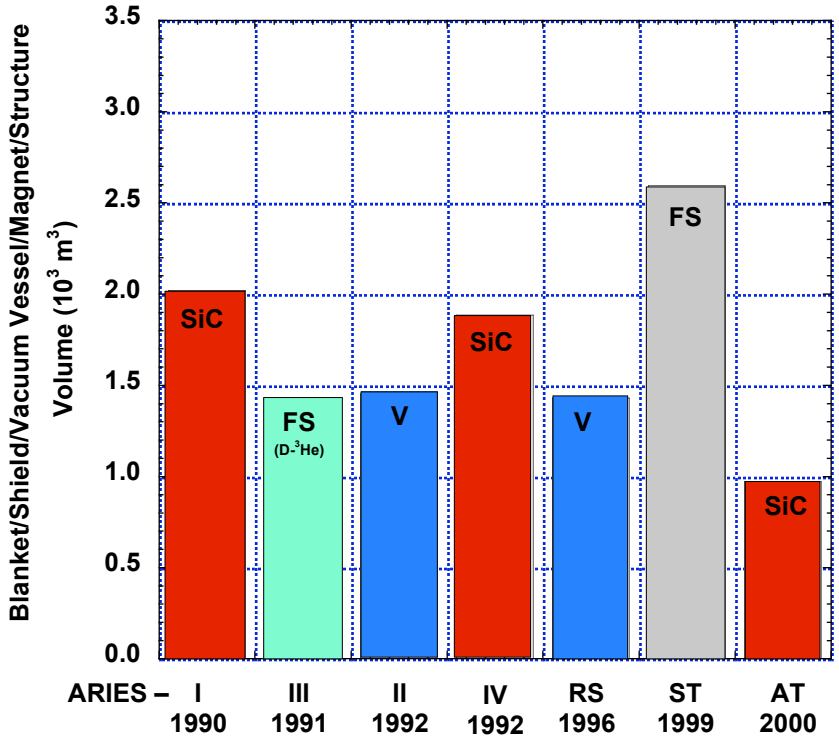
L. El-Guebaly, R. Pampin (UK), and M. Zucchetti (Italy), "Clearance Considerations for Slightly-Irradiated Components of Fusion Power Plants," 8th IAEA TM on Fusion Power Plant Safety (July 10-13, 2006, Vienna, Austria).

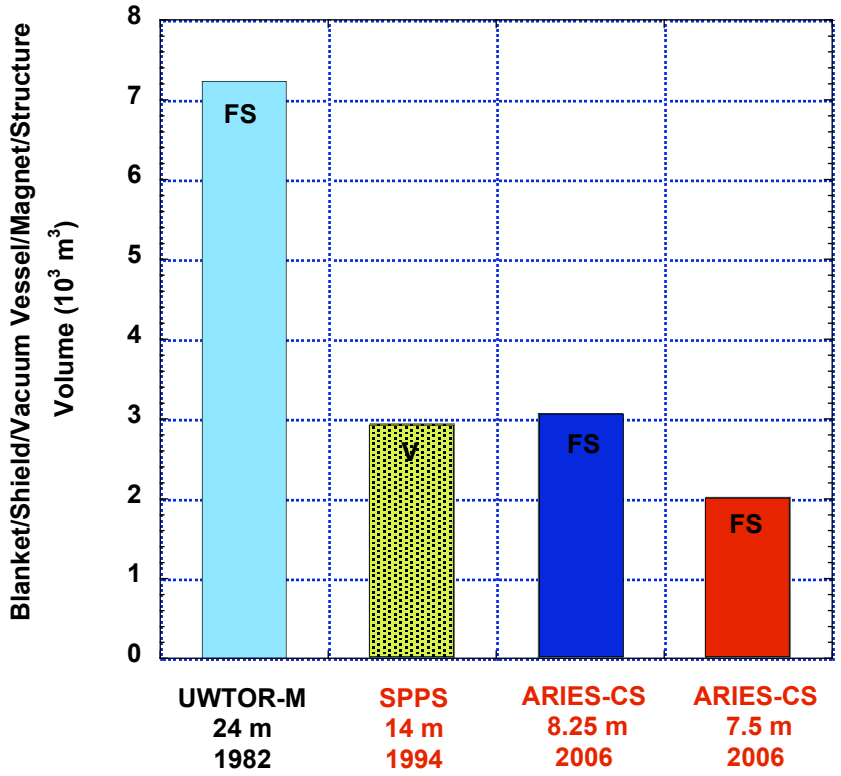
B – burn long-lived radionuclides in fusion devices

L.A. El-Guebaly, "Need for Special Burning Module in Fusion Devices to Transmute Fusion High-Level Waste," University of Wisconsin Fusion Technology Institute Report, UWFDM-1155 (June 2002).

L. El-Guebaly, "Managing Fusion High Level Waste – a Strategy for Burning the Long-Lived Products in Fusion Devices," Fusion Engineering and Design, 81 (2006) 1321-1326.

ARIES Project Committed to Waste Minimization

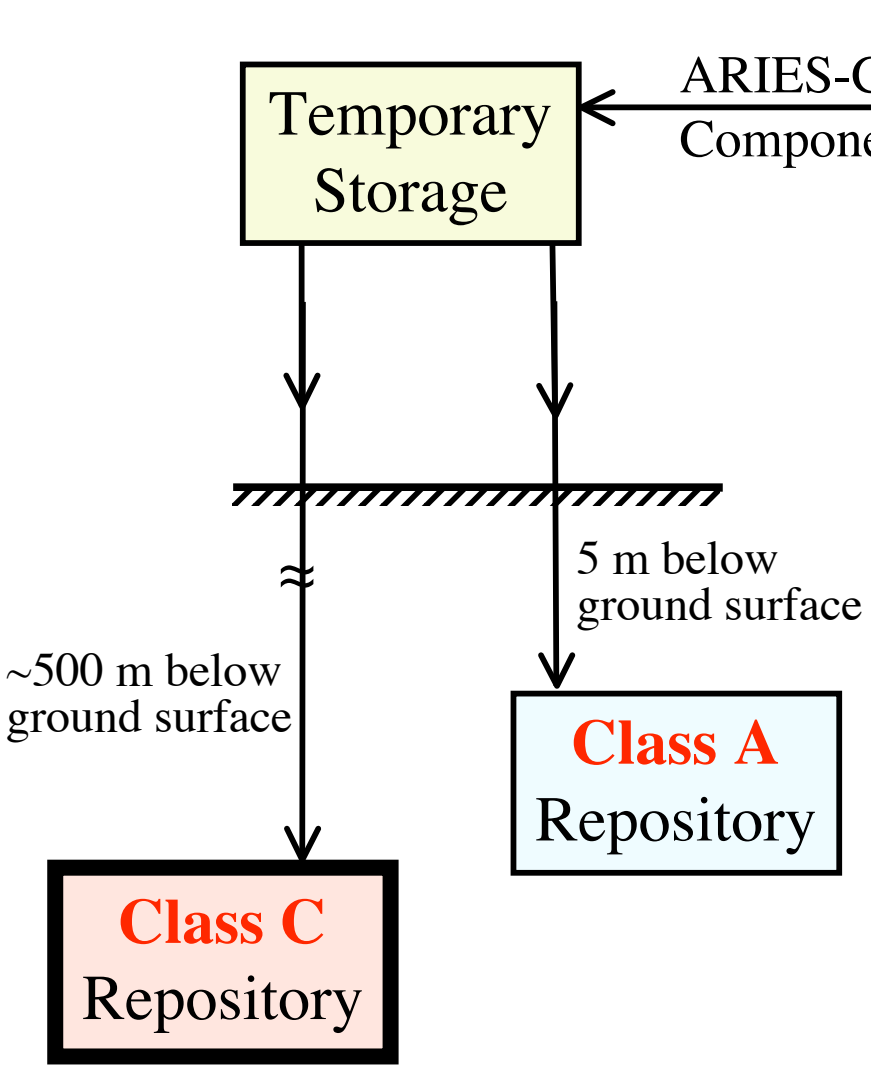


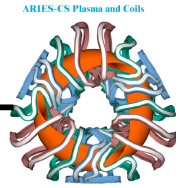


Tokamak waste volume halved over 10 y study period

Stellarator waste volume more than halved over 25 y study period

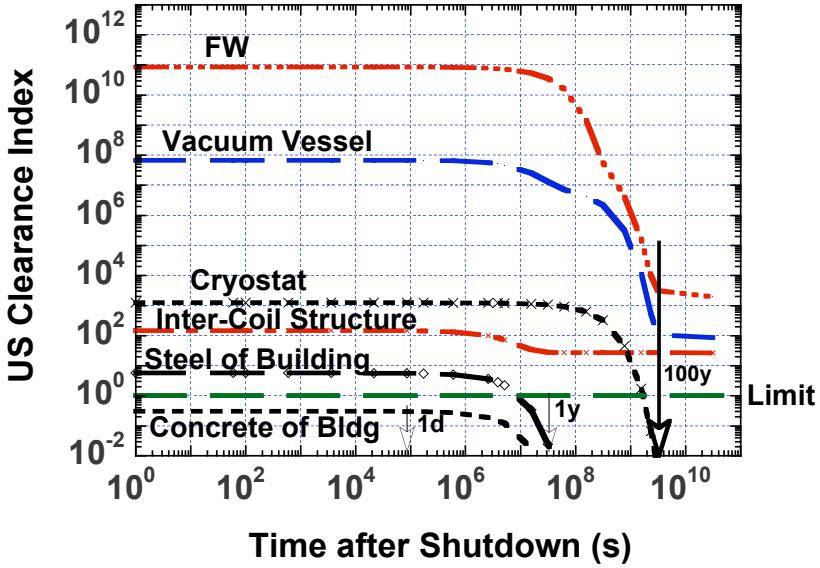
ARIES-CS Waste Classification for Geological Disposal

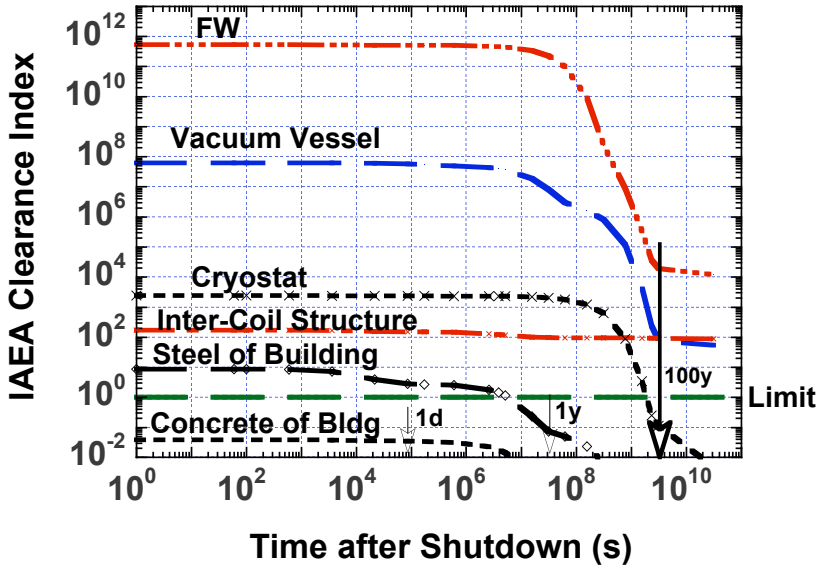


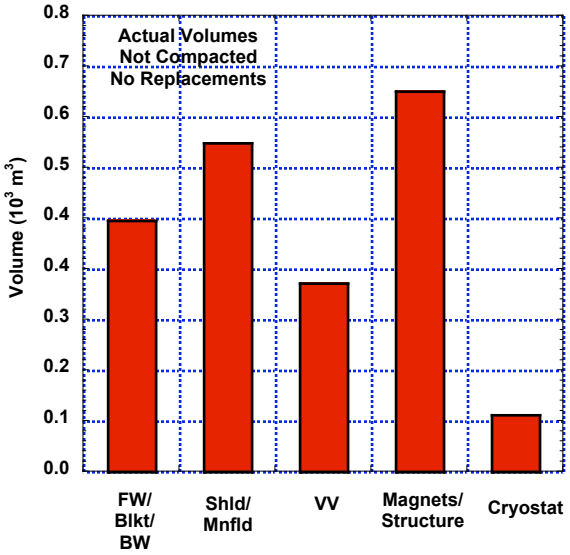


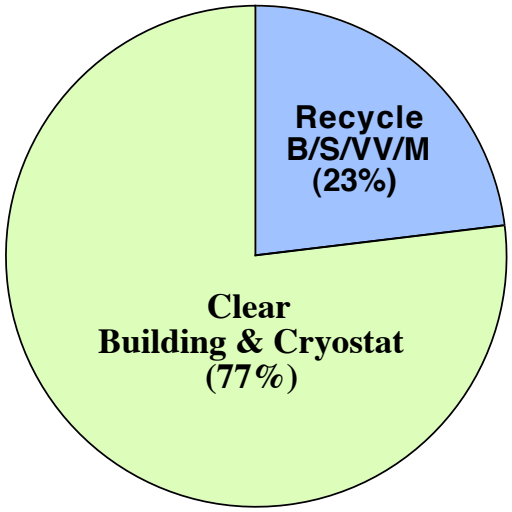
	Class C	Class A	Clear?
FW/Blkt/BW	√		
Shield/Manifolds	√		
VV		√	
Magnets:			
WP		√	
External structure		√	
Inter-coil structure		√	
Cryostat		√	√
Confinement Building		√	√

Only Cryostat and Confinement Building can be Cleared in < 100 y after Decommissioning

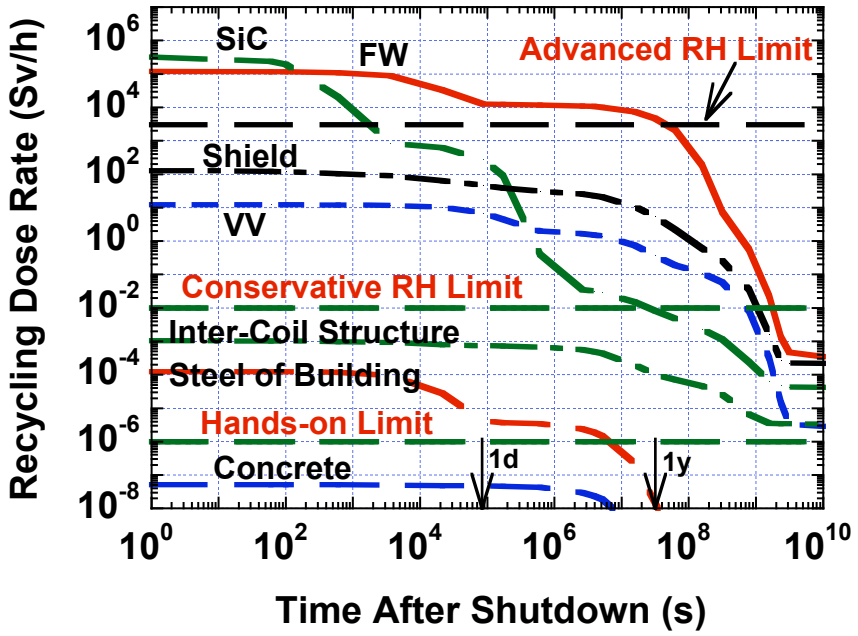






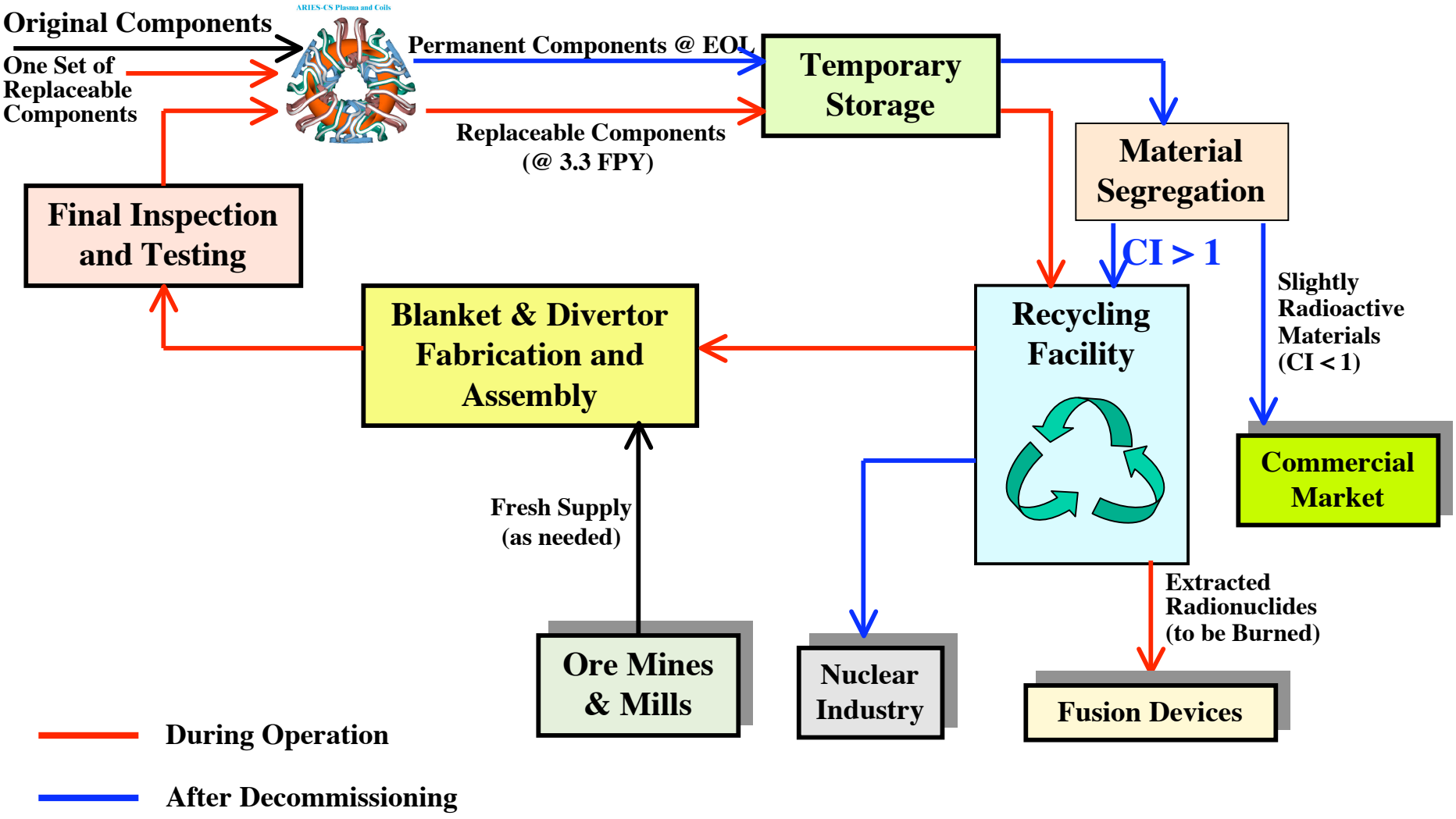


All ARIES-CS Components can be Recycled Using Advanced and Conventional Equipments

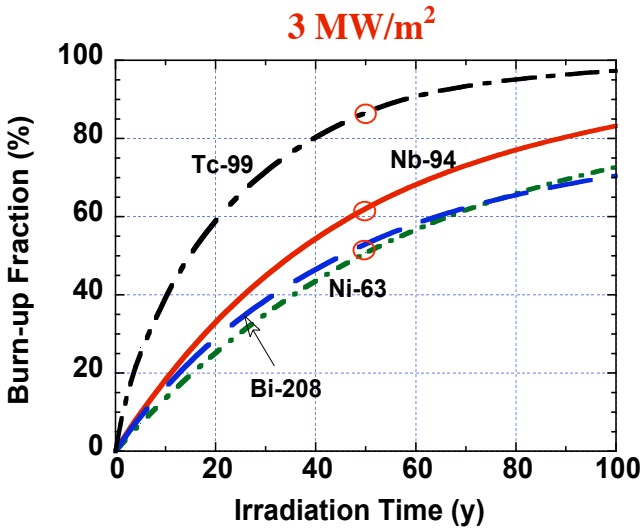


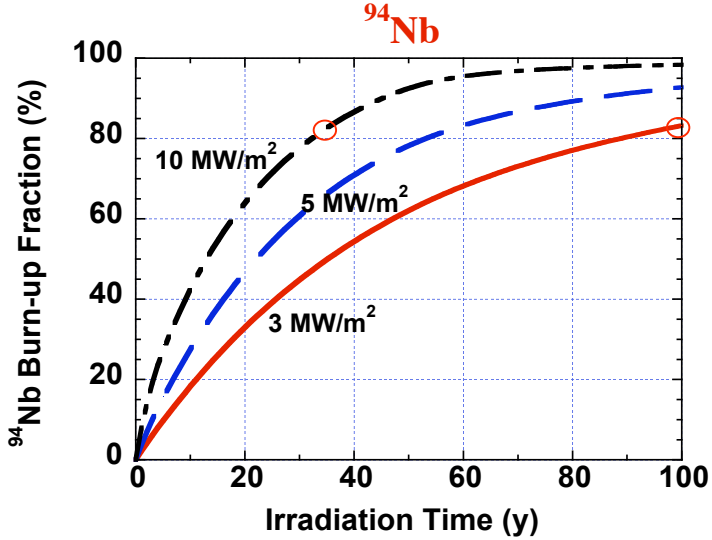
- Advanced equipment that handles 3000 Sv/h can recycle FW/blanket/BW, shield/manifolds, and VV in ~2 y after decommissioning.
- Conventional equipment can recycle magnet and cryostat shortly after shutdown.
- Hands-on recycling is feasible for confinement building in < 1 y.

Recommended Waste Management Scheme that Promotes Recycling & Clearance

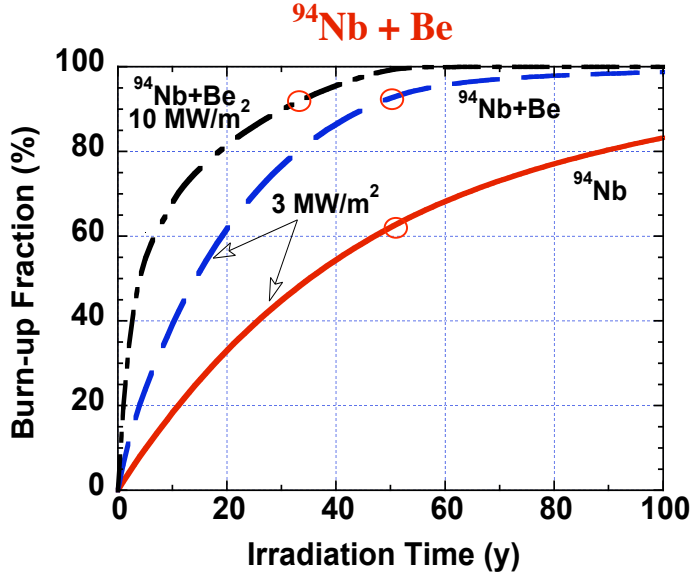


Burn Long-Lived Radioisotopes in Special Module to Avoid Deep Geological Burial





High NWL and Be enhance burn-up process



Recommended Change to ARIES Radwaste Top-Level Requirement

- **Current**:

  Generate no radwaste greater than Class C

- **Recommended**:

  Avoid geological burial, promote recycling/clearance, and minimize volume of active materials

- Recommended requirement helps earn public acceptance as government agencies and public ask for energy sources that:
  - are safe
  - generate little or no waste
  - do not deplete natural resources
  - have minimal environmental impact.