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.

* 1 rem = 10 m Sv
\# Such as T, volatile activated structure, corrosion products, and erosion dust. Or, from liquid and gas leaks.
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:

- 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 and 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

R – recycle

C – clear slightly-irradiated materials

B – burn long-lived radionuclides in fusion devices
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

ARIES-CS Components

Temporary Storage

~500 m below ground surface

5 m below ground surface

Class A Repository

Class C Repository

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

Original Components → Replacement Components

Final Inspection and Testing

Blanket & Divertor Fabrication and Assembly

Temporary Storage

Replaceable Components (@ 3.3 FPY)

Material Segregation

CI > 1

Slightly Radioactive Materials (CI < 1)

Commercial Market

Extracted Radionuclides (to be Burned)

Recycling Facility

Ore Mines & Mills

Nuclear Industry

Fusion Devices

Fresh Supply (as needed)

During Operation

After Decommissioning
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.