Initial Activation Assessment for ARIES Compact Stellarator Power Plant

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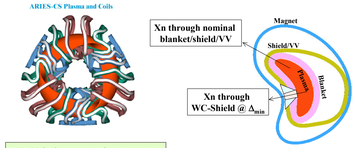
Objectives

- **Perform systematic activation assessment for interim ARIES-CS design.**
- **Evaluate:**
  - **Activity**
  - **Decay Heat**
- **Address waste-related issues:**
  - **Waste Disposal Rating**
  - **Breakdown of Class A and Class C waste**
  - **Any cleared materials?**

SiC- and FS-Based Systems Selected for Initial Activation Analysis

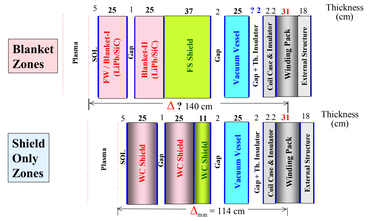
Breeder	Multiplier	Structure	FW/Blanket Coolant	Shield Coolant	VV Coolant
Internal VV:					
Flibe	Be	FS	Flibe	Flibe	H_2O
LiPb	**–**	**SiC**	**LiPb**	**LiPb**	**H_2O**
LiPb	**–**	**FS**	**He/LiPb**	**He**	**H_2O**
External VV:					
LiPb	–	FS	He/LiPb	He/B-H_2O	He
LiPb	–	FS	He/LiPb	He	He
Li	–	FS	He/Li	He	He

Analysis Performed at Two Radial Cross Sections

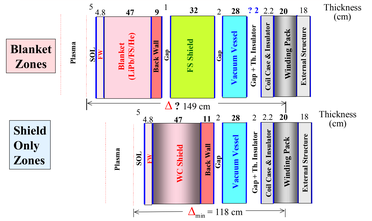


ARIES Compact Stellarator 3 Field Period Configuration

LiPb/SiC Radial Build



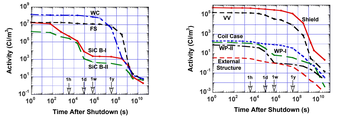
LiPb/FS/He Radial Build



Key Parameters for Activation Assessment

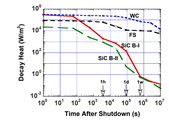
Average Neutron Wall Loading	**2 MW/m²**
Replaceable Component Lifetime	**6 FPY for SiC** **5 FPY for FS**
Permanent Component Lifetime	**40 FPY**
System Availability	**85%**

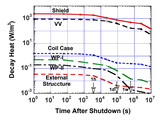
Activity



- At intermediate time following shutdown (1 d - 10 y), **SiC** offers 3-4 orders of magnitude lower activity compared to FS.
- **WC** filler generates highest activity.

Decay Heat





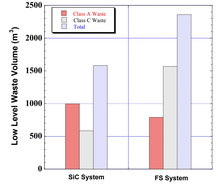
- **SiC** decay heat drops sharply after shutdown, a salient feature.
- **WC-shield** generates **10 - 1000 times higher decay heat** than FW/blanket @ 1 d after shutdown.
- If temperature during LOCA/LOFA exceeds limit, install **special loop** to transport decay heat from WC-shield to surroundings.

Waste Disposal Rating
(for Compacted Waste @ 100 y After Shutdown)

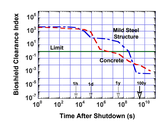
	SiC System	FS System
Replaceable Components:		
FW/Blanket-I	0.03	0.4
WC-Shield	0.8	0.6
Permanent Components:		
Blanket-II	0.06	---
Shield	0.5	0.7
Vacuum Vessel	0.02	0.05
Magnet	< 0.1	< 0.1

- WDR < 1 ⇒ **Class C Low Level Waste** (LLW).
- **SiC-FW/blanket, VV, and magnet** qualify as **Class A** LLW.

Breakdown of Class A and Class C Low Level Waste



Concrete Building can be Cleared Shortly after Plant Decommissioning



- Steel structure of building can be released after 20 y storage period.
- None of the internal components can be cleared from regulatory control.

Conclusions

- No major activation problems identified for SiC and FS systems.
- High decay heat identified for WC-shield
  - ⇒ Special loop will be installed to transfer decay heat to surroundings if temperature during accident exceeds limit.
- All radioactive wastes qualify as Class A and Class C LLW.
- None of ARIES-CS components can be cleared from regulatory control except building. Concrete and reinforced steel structure can be released to commercial market after ~0.5 y and ~20 y, respectively.