Assessment of Power Core Parameters and Related Costs (Part-II)

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Contents

- Revised costing accounts (in 2004$):
  - **# 21: Structures & Site Facilities**
    - # 21.2: Reactor Building
  - **# 22: Reactor Plant Equipment**
    - # 22.1.5 Primary Structure
    - # 22.2 Main Heat Transfer & Transport System
  - **# 23: Turbine Plant Equipment**
  - **# 26: Heat Rejection System**

- Impact of dual-coolant on radial build and COE.

- References:
  - Documented costing algorithms: SPPS report, Section 3.2.3, Page 3-23.
  - Latest costing algorithms: R. Miller (Decysive Systems), private communications.

Account # 21.2
(Reactor Building)

$$\text{Cost (2004 M\$)} = [77.1\ (V^{\#}_{RB} / 80{,}000)^{0.62} \times \text{LSA Factor}] \times 1.256^{*}$$

ARIES-CS $V_{RB} \sim 2.1 \times 10^5\ m^3$. TBD.

ARIES-	**RS**	**AT**	**CS**
LSA	2	1	2
21.2 Reactor Bldg (M\$- 2004\$)	**~ 160**	**~ 100**	**~ 160**

Torus volume = 4-5% of building free volume (V_{RB}).
* 2004$ = 1992$ x 1.256, per Les.

Account # 22.1.5
(Primary Structure)

Cost (2004 M$) = [volume x steel density (7.8 gm/cm^3) x vol. fract. (0.95) x unit cost (~25 $/kg) x LSA Factor] x 1.256

Volume = 18.4% FPC volume

FPC volume = **actual** volume of FW + blanket + divertor + shield + VV + winding pack + coil structure (including bucking structure)

ARIES-	**RS**	**AT**	**CS**
LSA	2	1	2
21.1.5 Primary Str. (M$- 2004$)	**67**	**34**	**~ 80**

Account # 22.2
(Main Heat Transfer & Transport System)

P_{th} **and** power split between He and LiPb

3 sub-accounts (in 2004 M$):

22.2.1 for **Primary** coolant (LiPb or He): $234\ (P_{th} / 3500)^{0.55} \times 1.256$

22.2.2 for **Intermediate** coolant = 0

22.2.2 for **Secondary** coolant (He): $75\ (P_{th} / 3500)^{0.55} \times 1.256$

Highly pure He (no O, no N)

For **Dual-coolant system**, modify **Primary** coolant account:

$$234\ [(P_{th} \times \text{F-He} / 3500)^{0.55} + (P_{th} \times \text{F-LiPb} / 3500)^{0.55}] \times 1.256$$

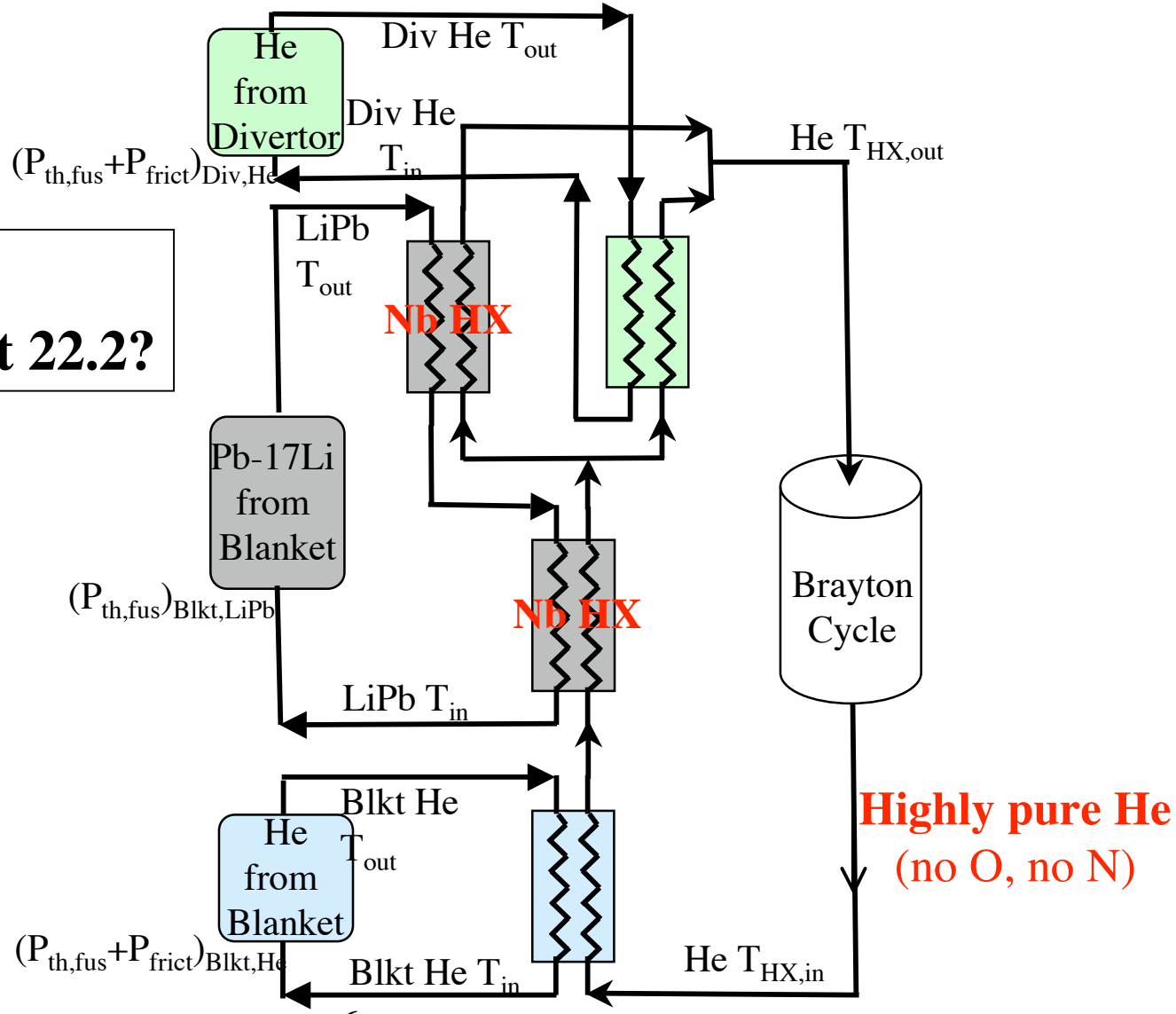
where F-He power fraction carried by He (= 42%. To be updated),
F-LiPb power fraction carried by LiPb (= 58%. To be updated).

ARIES-CS Coolant Routing

(R. Raffray - 11/05 ARIES Meeting)

4 HXs?

Impact on Account 22.2?



Account # 22.2 (Cont.)
(Main Heat Transfer & Transport System)

Per Siegfried:

- LiPb requires Nb HX
- Nb HX costs 0.012 M$ per (P_{th} x F-LiPb).

For ARIES-CS, Account 22.2 (in 2004 M$)=

$$[\ 234\ (\ P_{th}\ \text{x F-He}\ /\ 3500)^{0.55}$$

$$+\ 234\ (\ P_{th}\ \text{x F-LiPb}\ /\ 3500)^{0.55} + 0.01\ (P_{th}\ \text{x F-LiPb})$$

$$+\ 75\ (P_{th}\ /\ 3500)^{0.55}\ ]\ \text{x}\ 1.256$$

Impact of 4 HXs on Account 22.2 should be determined.

Account # 22.2 (Cont.)
(Main Heat Transfer & Transport System)

Account 22.2 (2004 M$): $[\ 234\ ((\ P_{th}\ \text{x F-He} / 3500)^{0.55} + (\ P_{th}\ \text{x F-LiPb} / 3500)^{0.55})$
$+ 0.01\ (P_{th}\ \text{x F-LiPb}) + 75\ (P_{th} / 3500)^{0.55}\ ]\ \text{x}\ 1.256$

ARIES-	**RS**	**ST**	**AT**	**CS**
LSA	2	2	1	2
Single or dual-coolant?	Single	**Dual**	Single	**Dual**
He:LiPb power	--	49:51	---	42:58
P_{th} (MW_{th})	2619	3373	1968	~ 2610
Cost (M$ - 2004$)	**293+30***	**450** (330 for single coolant) with intermediate loop)	**158**	**~ 440** (~290 for single coolant with intermediate loop)

* For V liner in outer loop.

ARIES-CS Recirculating Power

	MW_e	
Miscellaneous Power	~50	
He Pumping Power	28 + 97 div. + Blkt	(for 5 MW/m^2 peak)
Cryogenic Power	~5	
Total	**~180**	P_{Gross} ~1180 MW_e

Account # 23
(Turbine Plant Equipment)

Account 23 (2004 M$): $240.3 \left(P_{Gross} / 1200\right)^{0.83} \times 1.02^{\#} \times 1.256$ — Single coolant

Account 23 (2004 M$): $240.3 \left[\left(P_{Gross}\ \text{F-He} / 1200\right)^{0.83} + \left(P_{Gross}\ \text{F-LiPb} / 1200\right)^{0.83}\right] \times 1.02^{\#} \times 1.256$ — ARIES-ST dual coolant → Separate turbines

Does ARIES-ST formula apply to ARIES-CS?

ARIES-	**RS**	**ST**	**AT**	**CS**
Single or dual-coolant	Single	**Dual**	Single	**Dual**
He:LiPb power	--	49:51	---	42:58
P_{Gross} (MW_e)	1205	1518	1161	~1180
Cost (M$ - 2004$)	**309 + 48***	**426**	**303**	**~ 340 ???** (~ 300 for single coolant)

For spare parts.
* For Heat Rejection System.

Account # 26
(Heat Rejection System)

Account 26 (2004 M$): $61.4\ [(P_{th} - P_{Gross}) / 2300] \times 1.02^{\#} \times 1.256$

ARIES-	**RS**	**ST**	**AT**	**CS**
$\mathbf{P_{th}}$ (MW_{th})	2619	3373	1968	~ 2610
$\mathbf{P_{Gross}}$ (MW_e)	1205	1518	1161	~1180
Cost (M$ - 2004$)	**48**	**74***	**29**	**~ 50**

For spare parts.
* Includes waste heat from resistive coils.

Impact of Dual-Coolant on Radial Build and COE

Zone	Uniform Blanket	Non-uniform Blanket
FW/B/S/Mnfld Thick. (cm)	130	70
He Thickness (cm)	20 (15%)	9 (13%)

Impact on:

Major radius	0.5 - 1 m	↑ COE
Increase in FPC volume/mass	10-20%	↑ COE
He pumping power	~100 MW_e	↑ COE
Main Heat Transp. & Transf. Systems	~150 M$	↑ COE
Turbine Plant Equipment	~40 M$	↑ COE
η_{th}	~ same for dual or single coolant	

Dual-coolant helps solve MHD problems but increases COE by ~ 10 mills/kWh

Is advanced LiPb/SiC system more suitable for ARIES-CS?