

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

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**ARIES-CS Project Meeting**

January 23, 2006

UCSD



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- Revised costing accounts (in 2004\$):
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  - # 23: Turbine Plant Equipment
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- 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)

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

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

**ARIES-**

**LSA**

21.2 Reactor Bldg (M\$- 2004\$)

**RS**

2

**~ 160**

**AT**

1

**~ 100**

**CS**

2

**~ 160**

# Torus volume = 4-5% of building free volume ( $V_{\text{RB}}$ ).

\* 2004\$ = 1992\$ x 1.256, per Les.



# Account # 22.1.5 (Primary Structure)

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

$$\text{Volume} = 18.4\% \text{ FPC volume}$$

$$\text{FPC volume} = \text{actual volume of FW + blanket + divertor + shield + VV} \\ + \text{winding pack + coil structure (including bucking structure)}$$

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:

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

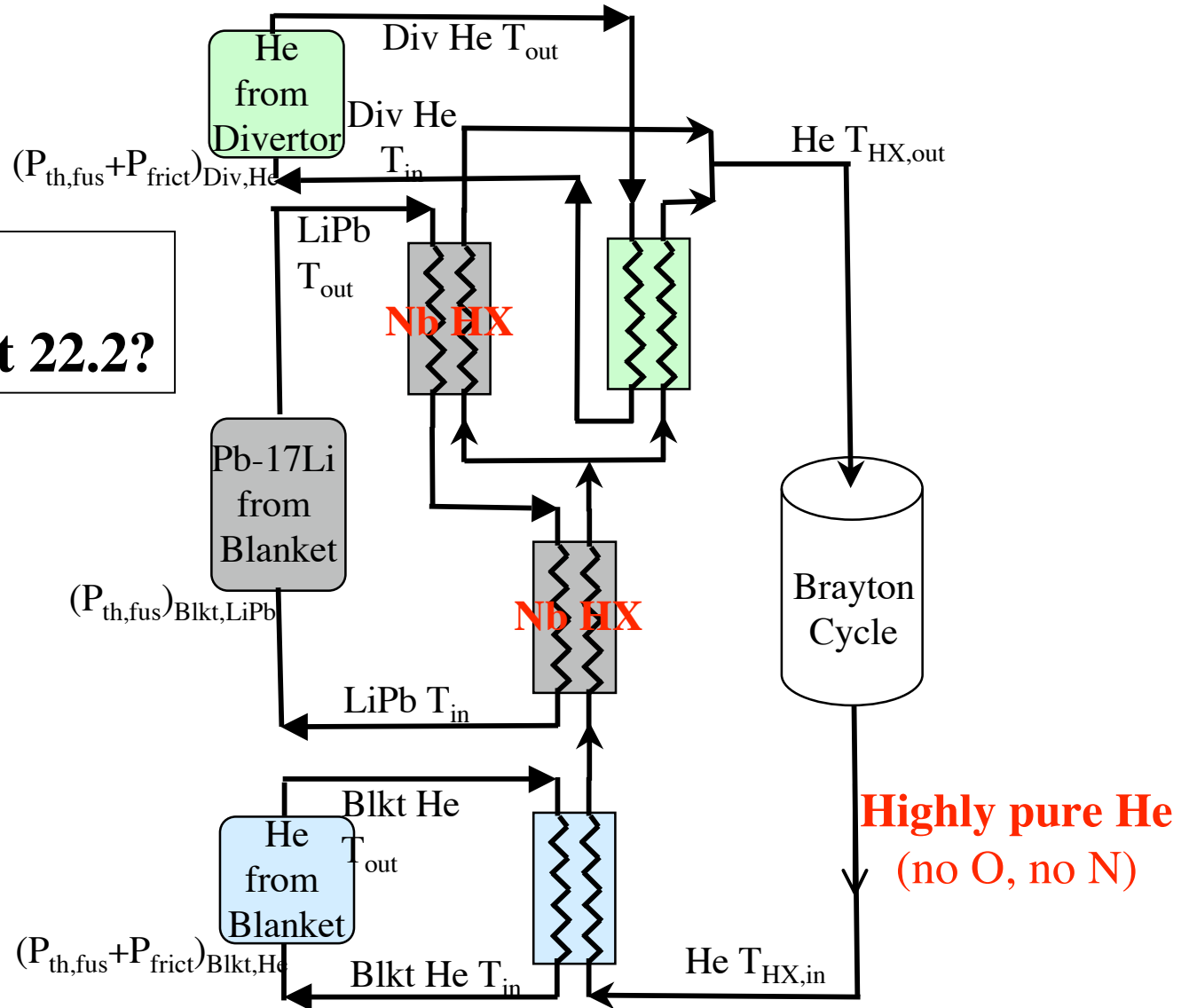
where **F-He** power fraction carried by He (= 42%. To be updated),  
**F-LiPb** power fraction carried by LiPb (= 58%. To be updated).

# ARIES-CS Coolant Routing

(R. Raffray - 11/05 ARIES Meeting)

4 HXs?

Impact on Account 22.2?



**Highly pure He  
(no O, no N)**



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

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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\$)=**

$$\begin{aligned} & [ 234 ( P_{th} \times F\text{-He} / 3500 )^{0.55} \\ & + 234 ( P_{th} \times F\text{-LiPb} / 3500 )^{0.55} + 0.01 ( P_{th} \times F\text{-LiPb} ) \\ & + 75 ( P_{th} / 3500 )^{0.55} ] \times 1.256 \end{aligned}$$

**Impact of 4 HXs on Account 22.2 should be determined.**



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

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

<b>ARIES-</b>	<b>RS</b>	<b>ST</b>	<b>AT</b>	<b>CS</b>
<b>LSA</b>	2	2	1	2
<b>Single or dual-coolant?</b>	<b>Single</b>	<b>Dual</b>	<b>Single</b>	<b>Dual</b>
<b>He:LiPb power</b>	--	49:51	---	42:58
<b>P<sub>th</sub> (MW<sub>th</sub>)</b>	2619	3373	1968	~ 2610
<b>Cost (M\$ - 2004\$)</b>	<b>293+30*</b>	<b>450</b> <small>(330 for single coolant) with intermediate loop)</small>	<b>158</b>	<b>~ 440</b> <small>(~290 for single coolant with intermediate loop)</small>

\* For V liner in outer loop.





# ARIES-CS Recirculating Power

$\text{MW}_e$

**Miscellaneous Power**

~50

**He Pumping Power**

28 + 97 (for 5 MW/m<sup>2</sup> peak  $\square$ )  
div. + Blkt

**Cryogenic Power**

~5

**Total**

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~180

$\square$   $P_{\text{Gross}} \sim 1180 \text{ MW}_e$



# Account # 23

## (Turbine Plant Equipment)

Account 23 (2004 M\$):  $240.3 (P_{\text{Gross}} / 1200)^{0.83} \times 1.02^{\#} \times 1.256$

Single coolant

Account 23 (2004 M\$):  $240.3 [(P_{\text{Gross}} \text{ F-He} / 1200)^{0.83} + (P_{\text{Gross}} \text{ F-LiPb} / 1200)^{0.83}] \times 1.02^{\#} \times 1.256$

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
$P_{\text{Gross}}$ (MW <sub>e</sub> )	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)

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

<b>ARIES-</b>	<b>RS</b>	<b>ST</b>	<b>AT</b>	<b>CS</b>
$P_{th}$ (MW <sub>th</sub> )	2619	3373	1968	~ 2610
$P_{Gross}$ (MW <sub>e</sub> )	1205	1518	1161	~1180
<b>Cost</b> (M\$ - 2004\$)	<b>48</b>	<b>74*</b>	<b>29</b>	<b>~ 50</b>

# 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/Mnflld Thick. (cm)	130	70
He Thickness (cm)	20 (15%)	9 (13%)

## Impact on:

Major radius	0.5 - 1 m	<input type="checkbox"/>	↑	COE
Increase in FPC volume/mass	10-20%	<input type="checkbox"/>	↑	COE
He pumping power	~100 MW <sub>e</sub>	<input type="checkbox"/>	↑	COE
Main Heat Transp. & Transf. Systems	~150 M\$	<input type="checkbox"/>	↑	COE
Turbine Plant Equipment	~40 M\$	<input type="checkbox"/>	↑	COE
<input type="checkbox"/> <sub>th</sub>	~ 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?**