FIRE Plasma Facing Component Costing Studies

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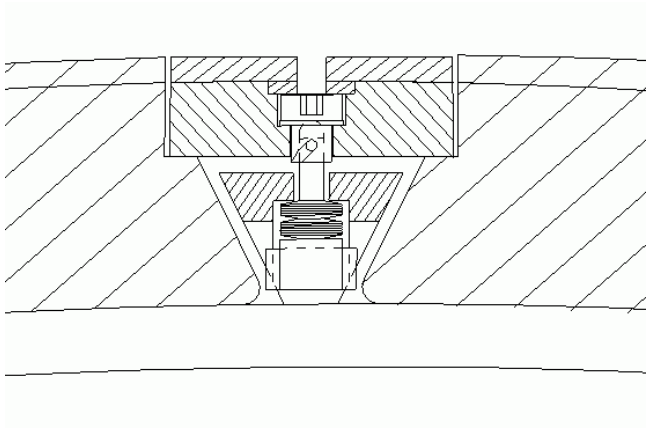
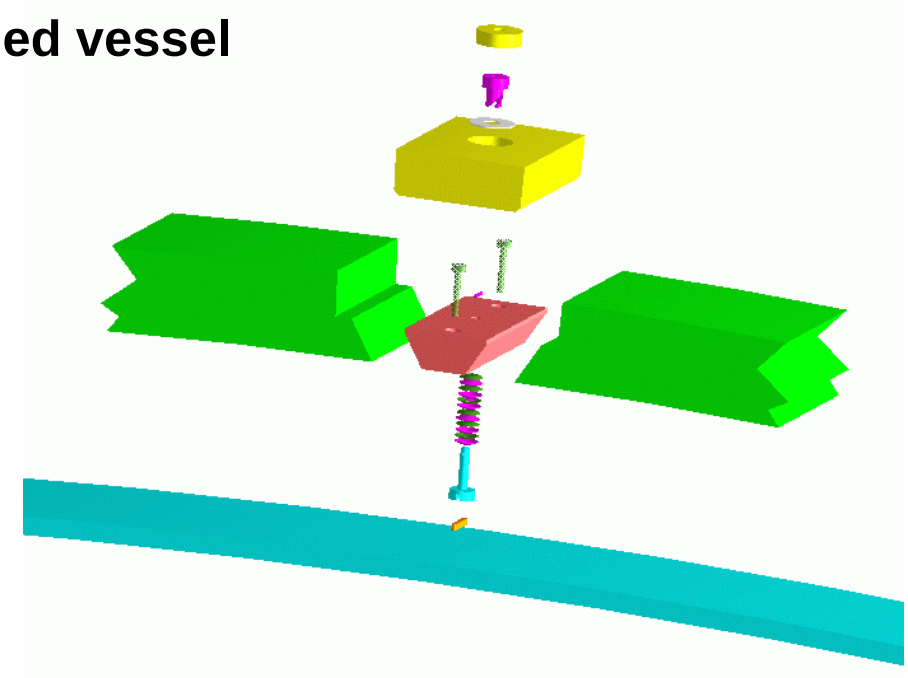
First Wall Tile Concept for Costing

U.S. Industrial Team

- 40-mm thick CuCrZr plates with 5-mm thick plasma-sprayed beryllium armor
- Wedge-shaped SS316LN rails bolted to vessel, provide mechanical support
- Rails include captive fastener hardware for loading thermal interface contacts with cooled vessel





Baffle Plate Design Concept for Costing

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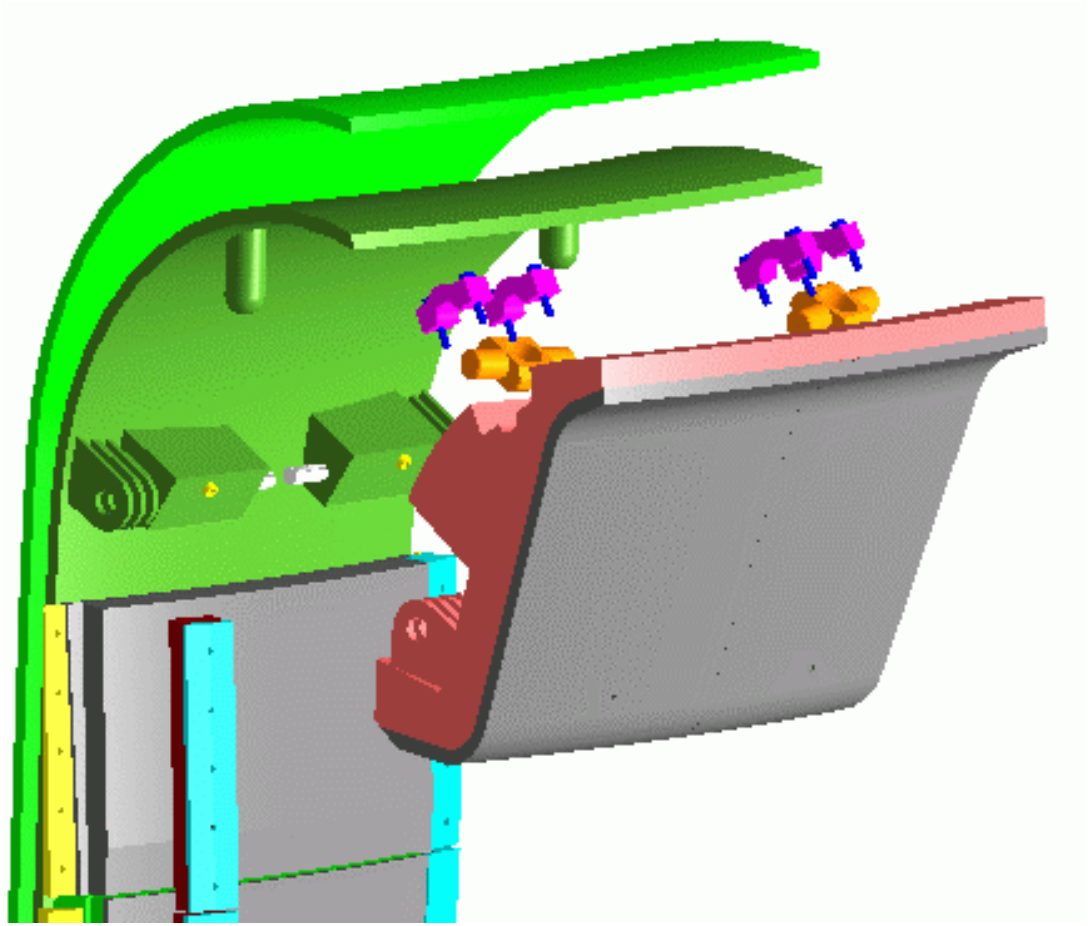
- Passively cooled CuCrZr forging with W-brush armor for erosion control
- Attached to vessel using upper pins/rotating sockets and lower shear plates/pins
- HIP-bond armor over entire baffle surface using single perimeter e-beam weld



Outer Divertor Design Concept for Costing

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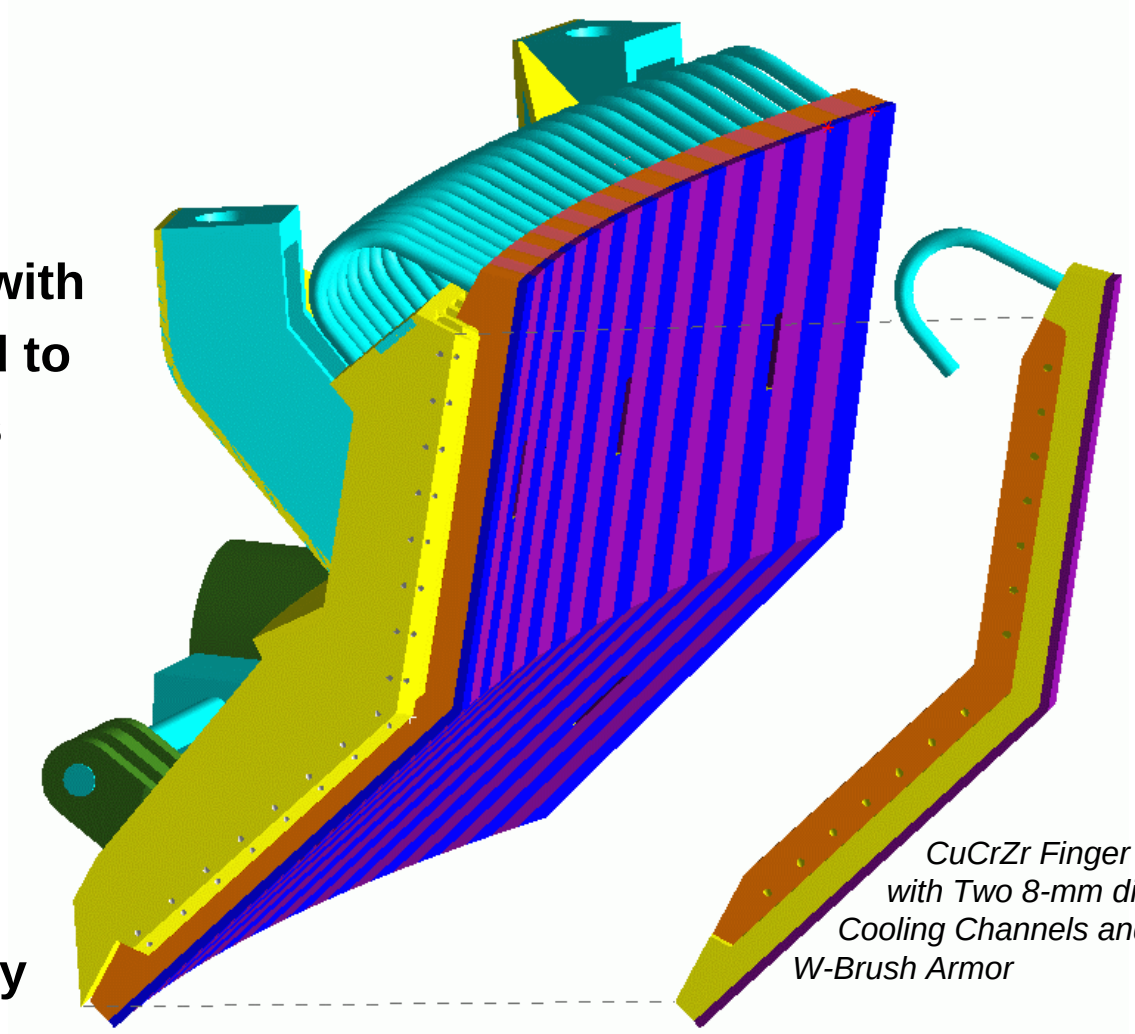
- SS316LN backplate for structural support and coolant manifolding
- 24 CuCrZr finger plates with W-brush armor, attached to backplate using roll pins
- Actively cooled using concentric pipe feed through divertor ports
- HIP-bond armor using separate canister welds around each finger plate
- HHF cycle plates to verify joint prior to integration



CuCrZr Finger Plate with Two 8-mm dia Cooling Channels and W-Brush Armor

Cost Summary for Passively Cooled Baffle and Inner Divertor

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WBS No.	Title	Est. cost	Recommended Contingency		Total
		($K)	(%)	($K)	($K)
1.1	**Plasma Facing Components - Ulrickson / Driemeyer**	**53,100**			**63,600**
1.1.1	First Wall	10,800	20%	2,200	13,000
	- Nonrecurring	2,400	20%	500	2,900
	- Recurring	8,400	20%	1,700	10,100
1.1.2	Outer Divertor Modules	21,400	20%	4,200	25,600
	- Nonrecurring	4,800	20%	900	5,700
	- Recurring	16,600	20%	3,300	19,900
1.1.3	Baffles	7,500	20%	1,400	8,900
	- Nonrecurring	1,700	20%	300	2,000
	- Recurring	5,800	20%	1,100	6,900
1.1.4	Inner Divertor Plates	4,100	20%	800	4,900
	- Nonrecurring	1,100	20%	200	1,300
	- Recurring	3,000	20%	600	3,600
1.1.5	Limiters & Armor	1,400	20%	300	1,700
	- Nonrecurring	400	20%	100	500
	- Recurring	1,000	20%	200	1,200
1.1.6	Wall Conditioning	3,600	20%	700	4,300
	- Nonrecurring	600	20%	100	700
	- Recurring	3,000	20%	600	3,600
1.2.4	Outer Passive Plates	4,300	20%	900	5,200
	- Nonrecurring	1,400	20%	300	1,700
	- Recurring	2,900	20%	600	3,500

Starting Material Costs

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PART NAME	MATERIAL	PRODUCT FORM	UNIT WGT/LEN	# TO MAKE	SCRAP RATE	MATERIAL NEED	MATERIAL UNIT COST	MATERIAL COST
			(kg or m)		(%)	(kg or m)	($/kg)	($ CY99)
FIRST WALL ELEMENTS 1.1.1								
Outer FW Plates	CuCrZr	plate	28	142	5	4,240	14.33	60,760
Inner FW Plates	CuCrZr	plate	45	142	5	6,770	14.33	97,015
Outer Attachment Rails	316L	plate	2	142	5	340	3.50	1,190
Inner Attachment Rails	316L	plate	3	142	5	390	3.50	1,365
Rail Cover Plates	CuCrZr	plate	3	426	5	1,400	14.33	20,062
Outer PS Beryllium Armor	Be	powder	1	142	10	150	1,100	165,000
Inner PS Beryllium Armor	Be	powder	2	142	10	240	1,100	264,000
Misc First Wall Items	all	all					5% extra	9,020
TOTAL 1.1.1							**TOTAL**	**618,411**
OUTER DIVERTOR MODULES 1.1.2								
Gundrilled Front Plates	CuCrZr	plate	577	34	5	20,590	14.33	295,057
HIP-Can Close-out Covers	OFHC Cu	plate	16.3	34	5	580	5.20	3,016
Cooling Channel Close-out	CuCrZr	plate	1.2	34	5	40	14.33	573
Helical Wire Inserts	In 625	spring	30.5	34	10	1,140	15.47	17,638
Backing Plate / Manifold	316L	plate	672	36	5	25,390	3.50	88,865
Finger Tube Stubs	316L	Seamless Tube	0.12	2040	5	250	68.80	17,200
Water Feed Lines	316L	Concentric Pipe	93.1	36	5	3,520	16.80	59,136
Attachment Structure	316L	plate	1.2	432	5	570	3.50	1,995
Tungsten Brush Armor	W-Rods	3-mm-dia	5.3	34	5	2,572,209	0.26	676,748
Misc Outer Divertor Items	all	all					5% extra	24,174
TOTAL 1.1.2							**TOTAL**	**1,184,402**

Starting Material Costs, Con't

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PART NAME	MATERIAL	PRODUCT FORM	UNIT WGT/LEN	# TO MAKE	SCRAP RATE	MATERIAL NEED	MATERIAL UNIT COST	MATERIAL COST
			(kg or m)		(%)	(kg or m)	($/kg)	($ CY99)
BAFFLE STRUCTURES 1.1.3								
Starting Material	CuCrZr	hand forging	801	40	5	33,640	16.69	561,487
HIP-Can Close-out Covers	OFHC Cu	plate	13	40	5	540	5.20	2,808
Attachment Structure	316L	plate	1	432	5	570	3.50	1,995
Tungsten Brush Armor	W-Rods	3-mm-dia	4	40	5	2,387,279	0.26	628,093
Misc Inner Divertor Items	all	all					5% extra	28,315
TOTAL 1.1.3							**TOTAL**	**1,222,698**
INNER DIVERTOR PLATES 1.1.4								
Starting Material	CuCrZr	plate	93	40	5	3,890	14.33	55,744
HIP-Can Close-out Covers	OFHC Cu	plate	4	40	5	160	5.20	832
Attachment Rails	316L	plate	3	40	5	120	3.50	420
Rail Cover Plates	CuCrZr	plate	3	60	5	200	14.33	2,866
Tungsten Brush Armor	W-Rods	3-mm-dia	1	40	5	688,296	0.26	181,091
Misc Inner Divertor Items	all	all					5% extra	2,850
TOTAL 1.1.4							**TOTAL**	**243,803**
OUTER PASSIVE PLATES 1.2.4								
Starting Material	CuCrZr	plate	231	37	5	8,970	14.33	128,541
Attachment Rails	316L	plate	6	40	5	260	3.50	910
Rail Cover Plates	CuCrZr	plate	7	60	5	410	14.33	5,875
Outer PS Beryllium Armor	Be	powder	8	37	10	320	1,100	352,000
Misc Passive Plate Items	all	all					5% extra	6,473
TOTAL 1.2.4							**TOTAL**	**493,799**

Unit Cost Summary for PFC Elements

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	First Wall	Outer Div	Baffle	Inner Div	Passive Plates
Armor Form	*PS-Be*	*W-Brush*	*W-Brush*	*W-Brush*	*PS-Be*
Number Modules	284	40	37	37	37
Module Area (m2)	0.10	0.49	0.48	0.14	0.43
Yield	90%	80%	86%	86%	86%
Starting Material Cost ($K)	943	1,452	943	253	299
Recurring Fab Cost ($K)	5,500	9,564	2,550	1,018	1,311
Armor Joining Cost ($K)	948	3,311	1,457	1,127	819
Unit Fab Cost ($K)	22.7	259.8	78.7	29.8	43.5
Unit Armor Join ($K)	2.0	82.8	39.4	30.5	13.5
Unit Armor Mtl ($K)	1.4	15.6	15.7	4.5	8.6
Total Unit Cost ($K)	26.0	358.2	133.8	64.8	65.6

Summary and Plans

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- **Active cooling increases unit cost by factor of 3 (baffle vs. outer divertor)**
- **Develop revised baffle unit cost for active cooling (Comparable to outer divertor unit costs)**
- **Inner divertor plates may be adequately cooled through thermal contact with cooled first wall**
  - **Further analysis is needed to verify temperatures**
  - **Requires alternate attachment concept to first wall tiles with fewer thermal interfaces**
  - **This would eliminate cooling interface complications in this restricted area**