Preliminary Moderator Reflector Assembly Thermal Hydraulic Summary

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Purpose

- Preliminary MRA Thermal Hydraulic analyses were performed on many subcomponents
- This document summarizes those analyses and processes the results for use in interfaces and for comparison to requirements

Water Cooled Components Summary

Inlet	Flow (GPM)	Inlet T (C)	Total dP (psi)	Reflector dP (psi)	Backbone dP (psi)	Total Heat Load (W)	Reflector Heat Load (W)	Backbone Heat Load (W)	Total Water Heat Load (W)	Reflector Water Heat Load (W)	Backbone Water Heat Load (W)	Outlet	Flow (GPM)	Outlet T (C)	Notes - Scaling factor of 1.046 on all backbone loads to account that neutronic simulation was done with 95% SS, 5% h2o shielding
Upper Premoderator	7.5	35	5.70	2.53	3.17	11198	6648	4550	3001	2977	24	Upper	15	40.9	Also cools backbone upper shield block, upper block and jumper elbow while flowing through backbone loop 4
Upper Reflector	7.5	35	11.37	8.20	3.17	12681	8131	4550	415	391	24				Also cools backbone upper shield block, upper block and jumper elbow while flowing through backbone loop 4
Lower Premoderator	7.5	35	3.46	2.08	1.38	10770	7912	2858	4190	4159	31				Also cools backbone lower block while flowing through backbone loop 2 and loop 3 lower
Lower Reflector	7.5	35	9.22	7.70	1.52	10981	8128	2853	383	357	26	Lower	30	39.3	Also cools backbone lower block while flowing through backbone loop 1 and loop 3 lower
Backbone	15	35	1.64		1.64	12547		12547	135		135				Cools backbone middle block while flowing through loop 3 upper

Heat Load Comparison

Component	CFD Heat Load (W)	Neutronics Heat Load (W)	Difference (%)
Upper Reflector Assembly	14779	14651	0.87
Lower Reflector Assembly	16040	15928	0.70
Backbone Assembly	27357	30098	9.10

- Combines results of Reflector and Backbone thermal hydraulic analyses
- Pressure drops and heat loads added to inform interface to process systems
- All water loops meet requirement of pressure drop less than 15 psi

Hydrogen Loop Summary

Component	Flow Rate (kg/s)	Tin(K)	Pin(bar)	L(m)	ID(m)	Bends	Heat Load(W)	Flow Speed (m/s)	Reynolds Number	dP/L (Pa/m)	dP/Bend (Pa)	Tout(K)	dP (Pa)	Pout(bar)	Mass (kg)
Inlet to Upper Moderator	0.037	18.34	14.08	3.57	0.014	4	5.00	3.26	192474	508.98	99.0	18.35	2211	14.06	0.041
Upper Moderator	0.037	18.35	14.06				411.12					19.66	2300	14.04	0.018
Upper Moderator to Lower Moderator	0.037	19.66	14.04	1.57	0.014	4	5.00	3.32	215119	517.77	100.7	19.67	1214	14.02	0.018
Lower Moderator	0.037	19.67	14.02				446.67					20.98	1060	14.01	0.024
Lower Moderator to CMS	0.037	20.98	14.01	5.00	0.014	4	5.00	3.38	239265	527.60	102.6	21.00	3048	13.98	0.055

- Moderator thermal hydraulic analysis boundary conditions will be updated during final design to reflect current CMS design
- Moderator heat loads in this table include neutronic heat loads for transfer lines – will be divided properly during final design
- Pressure drop of hydrogen tube sections calculated using Darcy-Weisbach Equation and equivalent length for 90° bends

Heat Load Comparison

Component	CFD Heat Load (W)	Neutronics Heat Load (W)	Difference (%)
Cylinder Moderator	392.27	390.44	0.468
Tube Moderator	394.08	393.04	0.494

- Combines results of moderator thermal hydraulic analyses and updated CMS design
- MRA hydrogen pressure drop of 0.098 bar meets requirement of less than 0.1 bar

Summary

- MRA water and hydrogen loop analyses combined to provide information for interfaces and requirement confirmation
- Generally good agreement between heat loads calculated in neutronics analysis and heat loads mapped for thermal hydraulic analysis
  - Exception is the backbone, where the homogenous neutronics geometry did not match the more detailed thermal hydraulics geometry
- All water loops and the MRA hydrogen loop meet pressure drop requirements derived from their respective interfaces