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SECOND TARGET STATION (STS) PROJECT

Interface Sheet for Cryogenic Moderator System and Moderator Reflector Assembly

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1/4/2023

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE US DEPARTMENT OF ENERGY

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Approvals

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PREPARED BY Jim Janney	PROJECT Second Target Station	DOCUMENT NUMBER: S01020500-IST10148

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Revision	Description
00	Initial Release

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1. PURPOSE

This document defines the interfaces between Cryogenic Moderator System and Moderator Reflector Assembly. The required hydrogen state necessary for desired neutron beam performance from the moderators is described as well as the expected proton beam loads imposed on the hydrogen and surrounding structures. The interface described in this document will provide guidance to the design of the Cryogenic Moderator System and Moderator Reflector Assembly.

2. SCOPE

The scope of this document is the interface between Cryogenic Moderator System and Moderator Reflector Assembly. No parent Interface Control Document exists since both systems are within Target Systems. The required hydrogen state necessary for desired neutron beam performance from the moderators is described as well as the expected proton beam loads imposed on the hydrogen and surrounding structures. Further description of the hydrogen supplied to the moderators and the physical interface between the systems will be provided in future revisions of this document.

2.1 INTERFACING PARTS OR COMPONENTS

No.	Components (Moderator Reflector Assembly)		Components (Instrument Systems)	
	Name	Functional reference Number	Name	Functional reference Number
1	Cryogenic Moderator System	S03030000-M8U-8800-A001	Moderator Reflector Assembly	S03040000-M8U-8800-A001

3. ACRONYMS AND DEFINITIONS

CMS Cryogenic Moderator System
ICD Interface Control Document
IS Interface Sheet
MRA Moderator Reflector Assembly
SSC Structure, System or Component
STS Second Target Station
WBS Work Breakdown Structure

4. REFERENCES

4.1 DOCUMENTS APPLICABLE TO THE INTERFACING SSCS

Ref	Document Titles	Document Control System Location
[1]	S03030000-SR0001-R00 System Requirements Document for CMS	/Neutron Sciences/Second Target Station (STS)/S03 – Target Systems/S0303 – Cryogenic Moderator Systems
[2]	S03040000-SR0001-R00 System Requirements Document for MRA	/Neutron Sciences/Second Target Station (STS)/S03 – Target Systems/S0304 – Moderator Reflector Assembly
[3]	Preliminary Moderator Optimization Report	Unreleased

5. INTERFACE DEFINITION

5.1 TECHNICAL DESCRIPTION OF THE INTERFACE

The purpose of the Second Target Station (STS) Cryogenic Moderator System (CMS) [1] is to supply liquid hydrogen to the 2 moderators such that the hydrogen state within the moderator is maintained for acceptable neutronics performance from the Moderator Reflector Assembly (MRA) [2] given the neutronic heating of the hydrogen and surrounding structures by the proton beam. This document describes both the required hydrogen state and calculated neutronic heating for both moderators and serves as a basis for preliminary design of the CMS.

The CMS will aim to maintain the hydrogen state within the moderators as near as possible to the parameters used in the preliminary Moderator Reflector Assembly (MRA) neutronics analyses – temperature of 20 K, density of 72.9 kg/m3, and parahydrogen fraction of 100% [3]. Previous neutronics analyses have shown the moderator performance to be much less sensitive to the moderator hydrogen temperature and density compared to the sensitivity to the parahydrogen fraction. In general, moderator performance increases as temperature decreases and density increases, but for small variations the effect is not significant. Therefore, the CMS will supply hydrogen such that the average hydrogen temperature in the moderator is 20K or less and the average hydrogen density in the moderator in 72.9 kg/m3 or greater as seen in Table 1.

Previous neutronics analyses have shown the moderator performance to be quite sensitive to the moderator para hydrogen fraction, especially for the lower tube moderator, as seen in Figures 1 and 2. The equilibrium parahydrogen concentration is a function of temperature and at 20K is 99.86% parahydrogen. Back conversion of parahydrogen to orthohydrogen by neutron interactions in the moderator will drive the parahydrogen concentration to be slightly less than the equilibrium concentration. Therefore, the CMS will provide an average parahydrogen concentration of 99.8% or greater in the moderator. This parahydrogen concentration is reasonably achievable for the CMS and results in minimal loss to neutronic performance in both moderators. The requirements for hydrogen state within the moderator will be revisited once the MRA geometry is finalized at the beginning of final design; however, significant changes to these preliminary requirements are not expected.

The neutronic heat loads to the hydrogen and surrounding structures from the proton beam must be removed by the CMS while maintaining stable hydrogen state and operation. The neutronic heat loads were calculated based on MCNP analysis of the MRA preliminary design. The heat loads are divided into heating directly in the hydrogen and heating to the aluminum moderator vessels and invar piping. The heating directly in the hydrogen is directly proportional to the parahydrogen to orthohydrogen back conversion rate and will be used to determine expected parahydrogen fractions.

5.2 INTERFACE DATA

Table 1. STS CMS Preliminary Parameters

Moderator	Maximum Temperature (K)	Minimum Density (kg/m3)	Minimum Parahydrogen Fraction	Hydrogen Heat Load (W)	Structure Heat Load (W)	Total Heat Load (W)
Top, Cylinder	20	72.9	0.998	166.39	244.73	411.12
Bottom, Tube	20	72.9	0.998	228.04	218.62	446.67

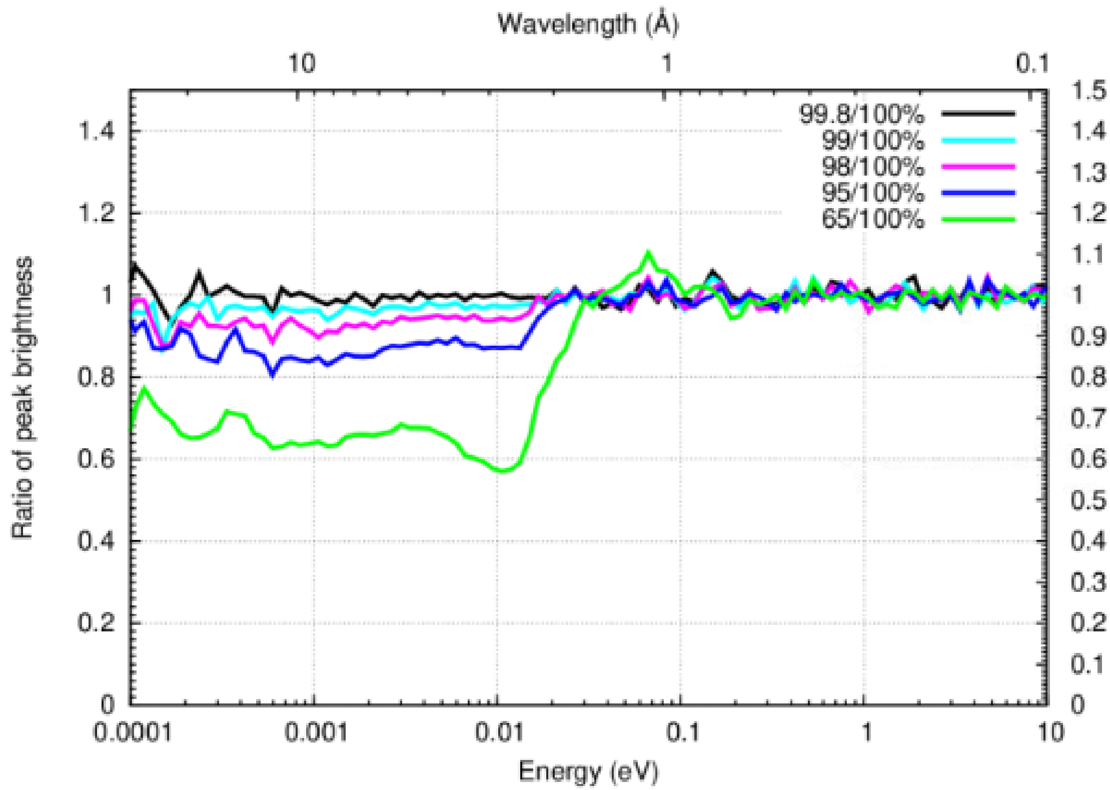

Figure 1. Cylindrical Moderator Peak Brightness Ratio vs. Energy for Various Parahydrogen Fractions

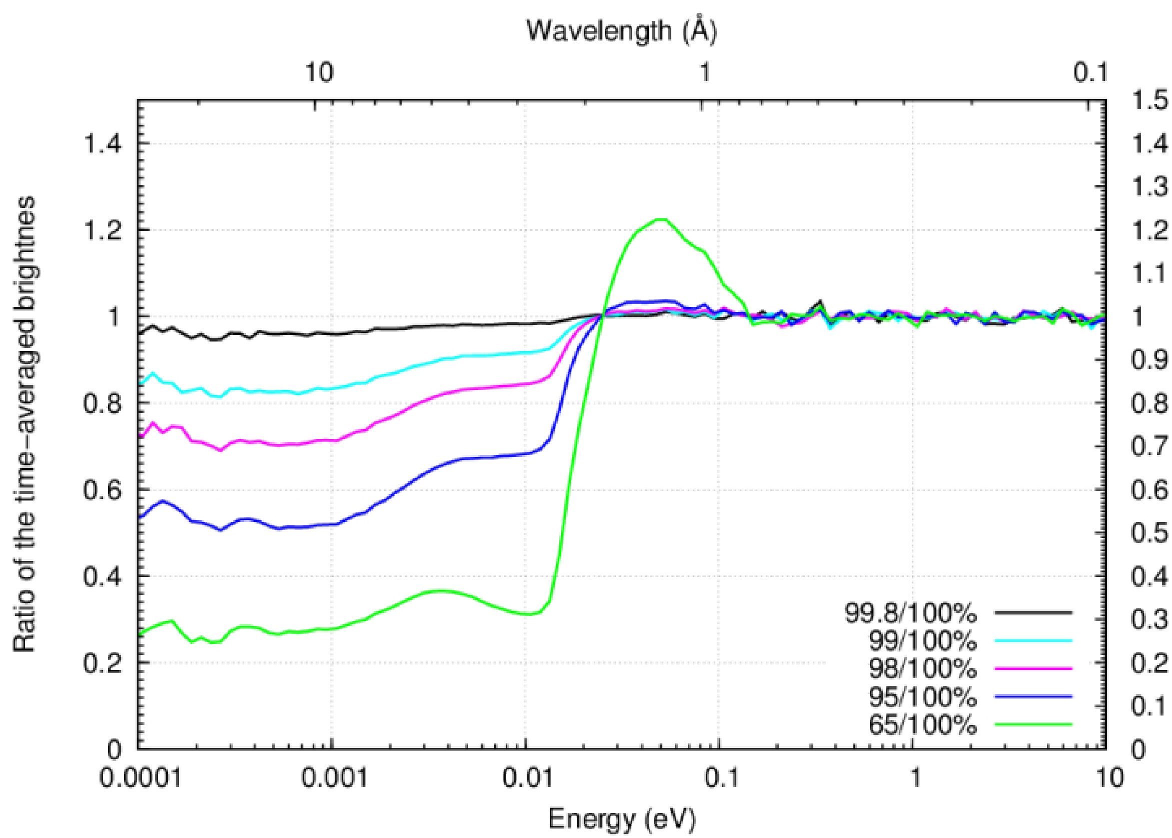

Figure 2. Tube Mod. Time-Averaged Brightness Ratio vs. Energy for Various Parahydrogen Fractions