Science & Technology Facilities Council ISIS	Technical Specification

ISIS Design Division | Science and Technology Facilities Council | Rutherford Appleton Laboratory | Harwell Campus | Didcot | OX11 OQX

Document Title:	Specification for TS1 Hydrogen Cryogenic Moderator		
Used On:	TS1 Project TRAM assembly		
Document No:	ISIS-TS1-UPG-MOD-Sp-0002	**Issue No:**	1

Issue	Date	Change Description	Auth	Check	App
1		Initial Issue	-	-	-

1 Introduction

1.1 Purpose

This document details the requirements for the provision of the hydrogen cryogenic moderator assembly that is used on the Target Station 1 (TS1) project Target, Reflector and Moderators (TRAM) assembly.

1.2 ISIS Neutron & Muon Source

The ISIS pulsed neutron and muon source at the Rutherford Appleton Laboratory in Oxfordshire is a world-leading centre for research in the physical and life sciences. It is operated by the Science and Technology Facilities Council (STFC) on behalf of UK Research and Innovation (UKRI). The suite of neutron and muon instruments gives unique insights into the properties of materials on the atomic scale. The facility supports a national and international community of more than 3000 scientists for research into subjects ranging from clean energy and the environment, pharmaceuticals and health care, through to nanotechnology and materials engineering, catalysis and polymers, and on to fundamental studies of materials.

Figure 1 - An aerial photograph of the ISIS Facility

1.3 Equipment Location

The Hydrogen cryogenic moderator as shown in figures 2 and 3 is situated within the reflector assembly at the core of ISIS TS1. The purpose of moderators is to reduce the energy of the neutrons being released from the target to a suitable level for the receiving scientific instruments conducting various studies. The liquid hydrogen moderator operates with a flow of liquid hydrogen at 8 bar and with a temperature of 20K. The hydrogen moderator is built up in three layers of safety containment due to the explosive nature of hydrogen.

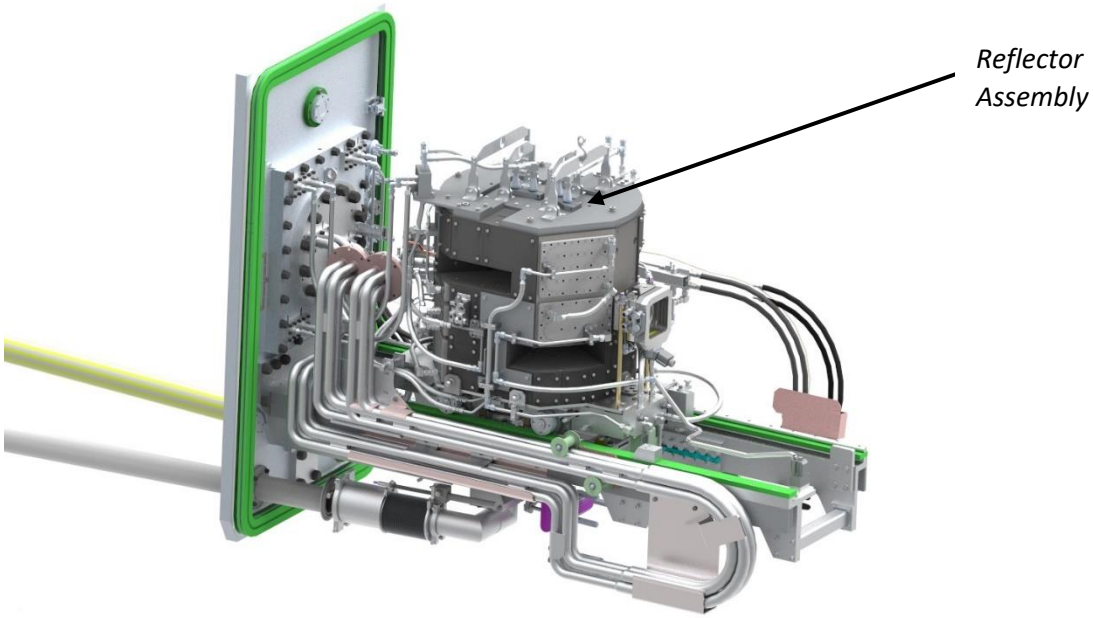

Figure 2 – UKRI STFC, ISIS, TS1 Project, Target\ Reflector \ Moderator assembly (TRAM).

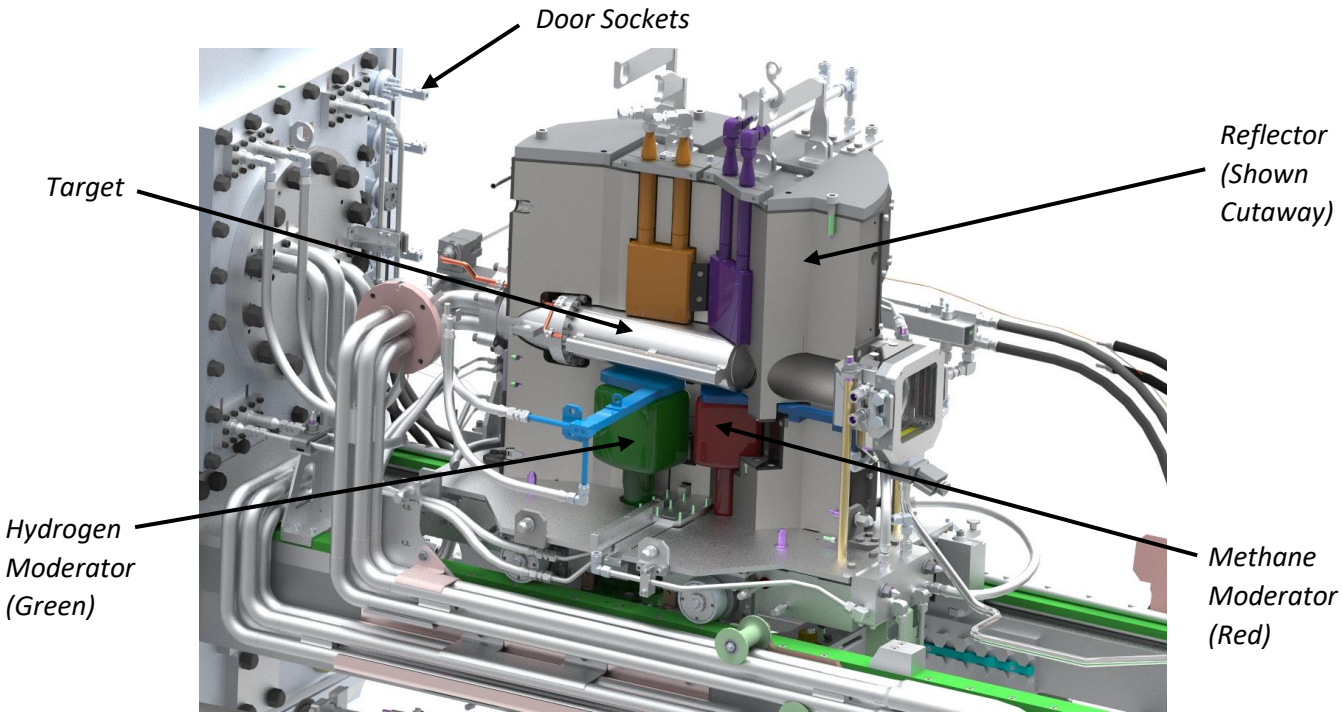

Figure 3 – Sectional view of the Reflector assembly to illustrate the positioning of the Cryogenic Hydrogen moderator.

1.4 Mountings & Connections

The moderator is assembled on the TRAM support frame by remote handling equipment within an active cell. It is located by the frame dowels and retained by remote handling bolts. The pressure connections are made by using quick connect remote chain clamps using all metal seals. The temperature sensing thermocouples are connected to the door socket via a remote handling plug. The hydrogen moderator has an external tertiary containment bellow which shields the pressure connection. A retractable bellow assembly is extended over the pressure seal and is connected with half clamps and diamond shaped aluminium seals.

2 Scope of Supply

The requirement is for the supply of a cryogenic hydrogen moderators to the detailed component drawings provided along with the requirement, to the dimensions, tolerances and specifications laid out in the technical drawings, as specified in Appendix 1. The specification of the moderator are detailed in section 5, below. The supplier shall also provide a sample token of each type of material used in the production of the moderator assemblies. This may be in a variety of forms (to be discussed and agreed upon contract placement) including for example material off-cuts.

The Supplier will also provide a summary report and quality documentation pack as detailed in section 6.1.1.

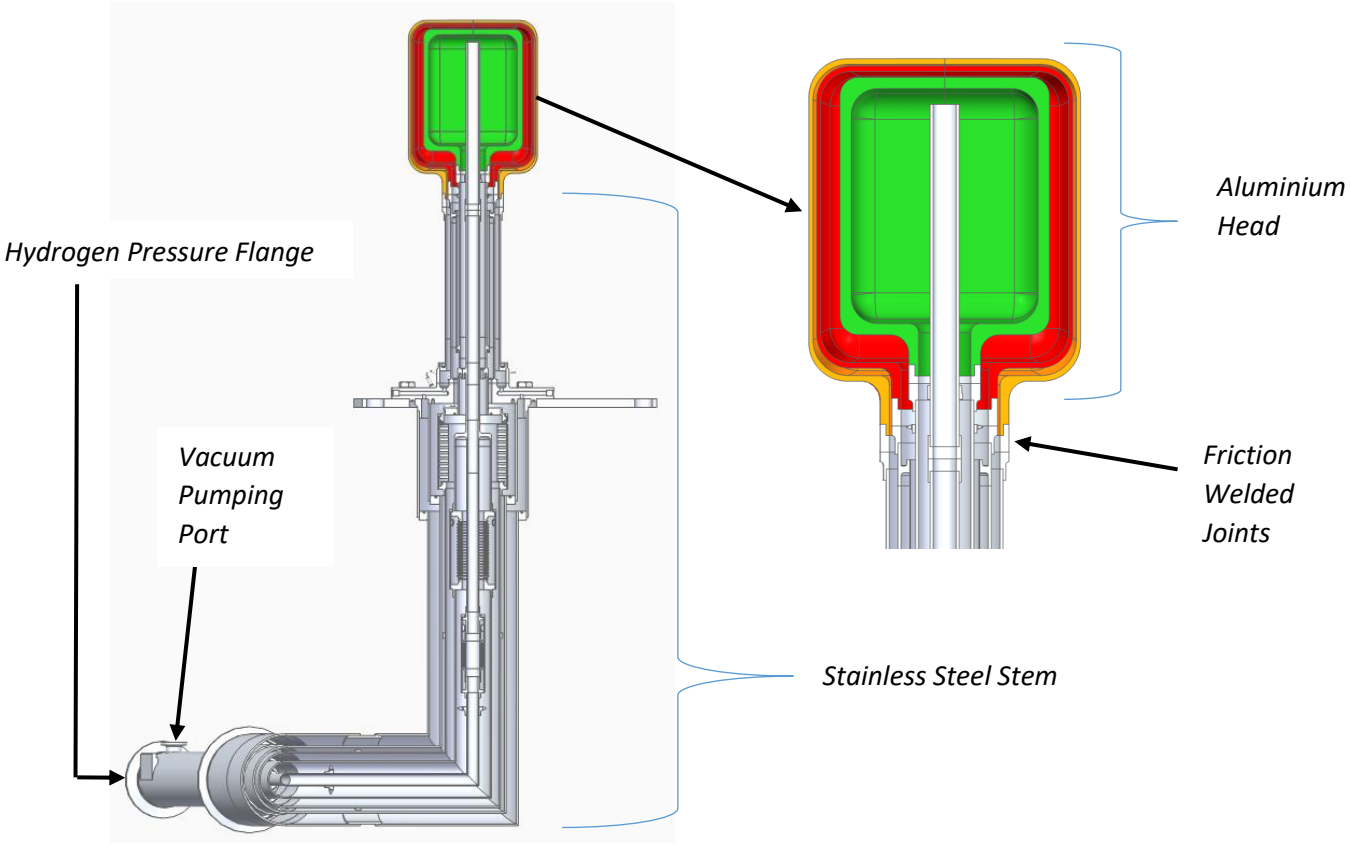

Figure 5 – Sectional views of the Hydrogen Moderator. It consists of a triple vessel assembly, the inner shown in green contains liquid hydrogen, and the intermediate shell shown in red is the vacuum containment vessel. The other tertiary vessel shown in orange, provides a secondary containment and is filled with helium gas.

3 Deliverables

- One liquid hydrogen moderator as shown in figure 5, to drawing SI-5621-100.
- Summary report and quality documentation pack (as detailed in 6.1.1).
- All associated tooling.

3.1 Additional Deliverables

Following successful installation of one liquid methane moderator, UKRI – STFC may wish to purchase one additional liquid methane moderator. Bidders are requested to provide a price for this additional liquid methane moderator, to be awarded at UKRI - STFC's discretion.

4 Items to be provided by UKRI - STFC

For the Hydrogen moderator

- One friction welded joint blank to drawing SI-5621-294 (Hydrogen flow).
- One friction welded Joint blank to drawing SI-5621-176 (Hydrogen return).
- Two friction welded joint blank to drawing SI-5621-293 (Vacuum & Tertiary Blanks).
- Two E type thermocouples as per stated on drawing SI-5621-166.
- One bellow to drawing SI-5621-143.
- One bellow to drawing SI-5621-149.
- One bellow to drawing SI-5621-157.

5 Material Parameters

The hydrogen moderator head vessels are to be manufactured using Aluminium AW – 5083-0/H111 grade material for the vessel shells. The stems are to be constructed in Stainless steel with 316L the preferred grade. However, should 316L stock be unavailable, then 304L would be acceptable. A substitution of the type must be made with the full knowledge and prior agreement of UKRI – STFC. The aluminium vessels are joined to the stainless vessels by using friction welded joints. As mentioned in section 4. The material grades for the friction joints are stated on the drawings, should the supplier suggest an alternative grade, UKRI - STFC should be notified at the tender stage in order to check suitability and provide written formal approval.

6 General Requirements

6.1 Documentation

6.1.1 Documentation Requirements

Upon delivery, a quality documentation pack will need to be provided, covering;

- Certification of conformity for materials used in the construction
- Inspection reports for each item confirming compliance with dimensions, tolerances and notes specified on the detailed drawings;
- Material data sheets providing mechanical property data such as tensile strength, density, yield stress and hardness
- Thermal, Pressure and Vacuum testing results

6.2 Quality Control

Due to the nature of the environment where these items will operate, the constraints on their performance and the planned length of service, it is imperative that UKRI – STFC receives components of appropriate quality. It is therefore expected that any quality management plans and systems detailed in documentation provided, will be followed and that the Supplier takes their responsibility for quality seriously.

6.3 Dimensions

The dimensions of each plate are provided in the technical drawings, listed in the Associated Documents section.
The items have been designed and detailed for TIG welding process in mind to fabricate the assemblies allowances can be added in order for additional machining processes to achieve specific features or tighter tolerances.

6.4 Cleaning

All surfaces are to be free from dents, scratches, marks and discolouration. The moderators are vacuum insulted cryogenic vessels and should be cleaned with a suitable and compatible cleaning agent to remove surface oils, greases and cutting-fluids.

All stainless welds are to be cleaned, pickled with a suitable pickling paste, passivated, rinsed and dried.

6.5 Testing

There are three testing methods that are required to be undertaken at various stages during moderator construction. These are as follows.

- **Thermal shock testing** – To check the integrity of welds and friction welded joints by submersion of joints in liquid nitrogen and checking the joints with a vacuum leak test.
- **Vacuum Leak testing** – To check welds and material porosity by evacuating the internal space and purging external joints and surface with helium gas. Leak rate should normally be no greater than 10-6 mbar litres per second.
- **Pressure Testing** – Internal volumes that are subjected to internal pressure are to be tested to test pressure with gas as stated on the drawing.

On completion of moderator manufacture, the moderator is required to be tested with the presence of a UKRI - STFC witness to the steps stated in the TS1 Moderator Pressure and Leak Test Document, a template will be supplied by UKRI - STFC. All test results to be recorded in this document and to be provided to UKRI - STFC on moderator delivery.

6.6 Tooling

The supplier is required to develop and manufacture tooling to ensure dimensional accuracy during moderator construction. For the final assembly as stated by note 8 on drawing SI-5621-100 a setting jig would be required to position items 10 & 4 relative to each other prior to welding. This jig is to be purchased and retained by STFC- UKRI on completion of the moderator assembly.

7 Delivery

The delivery of the moderators to UKRI - STFC is the responsibility of the Supplier. The Supplier shall take every practicable step to ensure safe and damage-free delivery, using appropriate packaging.

Delivery date

The required date for delivery of the completed moderators, any associated items and all documentation is no later than 1st May 2020.

7.1 Delivery location

ISIS Facility, UK Research & Innovation - Science and Technology Facilities Council
Rutherford Appleton Laboratory, Harwell Oxford
OX11 0QX
UK

8 Appendix 1 – List of provided drawings

8.1 Associated Documents

This technical specification shall be read in conjunction with the following technical drawings.

Drawings beginning SI-5621-XXX in the list below are designated as Hydrogen moderator drawings.

#	Level	Drawing Number	Revision	Drawing Title	Quantity
1	1 - ASSEMBLY DRW	SI-5621-100	A	HYDROGEN MODERATOR	1
2	1	SI-5621-101	A	TUBE AG	1
3	1	SI-5621-102	A	FLANGE	1
4	1	SI-5621-105	A	TUBE AH	2
5	1 – ASSEMBLY DRW	SI-5621-106	A	HYDROGEN MODERATOR, LOWER	1
6	2	SI-5621-107	A	INNER BOSS	1
7	2	SI-5621-108	A	SPACER	2
8	2	SI-5621-109	A	RING	1
9	2	SI-5621-110	A	RING	1
10	2	SI-5621-111	A	INNER JOINT	1
11	2	SI-5621-112	A	TUBE AL	1
12	2	SI-5621-113	A	TUBE AI	1
13	2	SI-5621-114	A	TUBE AK	1
14	2	SI-5621-115	A	INNER JOINT	1
15	2	SI-5621-116	A	TUBE AM	1
16	2	SI-5621-117	A	INNER CONE	1
17	2	SI-5621-118	A	TUBE AJ	1
18	2	SI-5621-119	A	VACUUM FLANGE	1
19	2	SI-5621-120	A	TUBE AN	1
20	2	SI-5621-121	A	INNER JOINT	1
21	2	SI-5621-122	A	WELD RING	1
22	1	SI-5621-123	A	TUBE AE	1
23	1	SI-5621-221	A	TUBE AF	1
24	1	SI-5621-222	A	TUBE AD	1
25	1	SI-5621-223	A	TUBE AC	1
26	1	SI-5621-224	A	TUBE AB	1
27	1 – ASSEMBLY DRW	SI-5621-270	A	HYDROGEN ASSEMBLY, UPPER	1
28	2	SI-5621-129	A	WELD FLANGE	1
29	2	SI-5621-131	A	TUBE JOINT	1
30	2	SI-5621-132	A	TUBE U	1
31	2	SI-5621-133	A	TUBE AA	1
32	2	SI-5621-138	A	MOUNTING PLATE WELD RING	1
33	2	SI-5621-139	A	TUBE P	2
34	2 – ASSEMBLY DRW	SI-5621-142	A	BELLOWS ASSEMBLY	1

35	3	SI-5621-143	A	BELLOWS	1
36	3	SI-5621-144	A	BELLOWS RESTRAINT	1
37	3	SI-5621-145	A	WELD FLANGE	1
38	3	SI-5621-156	A	BELLOWS MOUNT	1
39	2 – ASSEMBLY DRW	SI-5621-148	A	BELLOWS ASSEMBLY	1
40	3	SI-5621-146	A	STRAIGHT ADAPTOR 2	1
41	3	SI-5621-149	A	BELLOWS	1
42	3	SI-5621-150	A	WELD FLANGE	2
43	3	SI-5621-151	A	STRAIGHT ADAPTOR 1	1
44	3	SI-5621-152	A	BELLOWS RESTRAINT	1
45	2 – ASSEMBLY DRW	SI-5621-155	A	BELLOWS ASSEMBLY	1
46	3	SI-5621-154	A	BELLOWS MOUNT 1	1
47	3	SI-5621-157	A	BELLOWS	1
48	3	SI-5621-158	A	BELLOWS MOUNT 2	1
49	3	SI-5621-159	A	BELLOWS RESTRAINT 1	1
50	2	SI-5621-160	A	TUBE J	1
51	2	SI-5621-161	A	TUBE I	1
52	2	SI-5621-162	A	WELD RING	1
53	2	SI-5621-163	A	TUBE L	1
54	2	SI-5621-164	A	TUBE K	1
55	2 – ASSEMBLY DRW	SI-5621-165	A	HYDROGEN MODERATOR, TOP OUTER ASSEMBLY	1
56	3 – ASSEMBLY DRW	SI-5621-166	A	HYDROGEN MODERATOR, TOP INNER ASSY	1
57	4	SI-5621-093	A	MOUNTING BUSH	1
58	4	SI-5621-167	A	BUSH, TUBE SUPPORT	1
59	4 – ASSEMBLY DRW	SI-5621-169	A	HYDROGEN FLOW TUBE ASSEMBLY	1
60	5	SI-5621-170	A	TUBE A	1
61	5	SI-5621-171	A	BUSH, TUBE SUPPORT	1
62	5	SI-5621-172	A	TUBE B	1
63	5	SI-5621-173	A	SPACER	1
64	5	SI-5621-174	A	TUBE C	1
65	5	SI-5621-292	A	FRICTION WELDED JOINT H2	1
66	6	SI-5621-294	A	FRICTION WELDED JOINT - HYDROGEN FLOW BLANK	1
67	4 – ASSEMBLY DRW	SI-5621-175	A	HYDROGEN VESSEL ASSY	1
68	5	SI-5621-177	A	HYDROGEN VESSEL B	1
69	5	SI-5621-178	A	HYDROGEN VESSEL	1
70	5	SI-5621-179	A	TUBE D	1
71	5	SI-5621-291	A	FRICTION WELDED JOINT - H2 RET	1
72	6	SI-5621-176	A	FRICTION WELDED JOINT H2 RET BLANK	1
73	4 – ASSEMBLY DRW	SI-5621-180	A	PLATE ASSEMBLY	1
74	5	SI-5621-181	A	BUNG	2

75	5	SI-5621-182	A	PLATE	1
76	5	SI-5621-183	A	THERMOCOUPLE FEEDTHROUGH	2
77	5	SI-5621-256	A	PLATE	1
78	5	SI-5621-260	A	THERMOCOUPLE CLAMP ASSEMBLY	1
79	6	SI-5621-261	A	MOUNTING BLOCK	1
80	6	SI-5621-262	A	THERMOCOUPLE CLAMP	1
81	4	SI-5621-186	A	TUBE G	1
82	4	SI-5621-187	A	SPACER	1
83	4	SI-5621-188	A	TUBE E	1
84	4	SI-5621-191	A	THERMOCOUPLE CLAMP	1
85	4	SI-5621-193	A	BUSH, TUBE SUPPORT	1
86	4	SI-5621-194	A	BUSH, TUBE SUPPORT	1
87	4	SI-5621-195	A	TUBE F	1
88	4	SI-5621-271	A	HYDROGEN VACUUM CAN	2
89	4	SI-5621-282	A	FRICTION WELDED JOINT ASSY VAC	1
90	5	SI-5621-293	A	FRICTION WELDED JOINT 3 BLANK	1
91	3	SI-5621-197	A	MOUNTING BUSH	1
92	3	SI-5621-198	A	MOUNTING BUSH	1
93	3	SI-5621-199	A	TUBE H	1
94	3	SI-5621-272	A	HYDROGEN TERTIARY CAN	2
95	3	SI-5621-281	A	FRICTION WELDED JOINT - TERT	1
96	2	SI-5621-202	A	SPACER	2
97	2	SI-5621-203	A	FLANGE, VACUUM END	1
98	2	SI-5621-204	A	TUBE M	1
99	2	SI-5621-206	A	TUBE O	1
100	2	SI-5621-207	A	WELD RING	1
101	2	SI-5621-208	A	SPACER	2
102	2	SI-5621-209	A	TUBE N	1
103	2	SI-5621-211	A	TUBE Q	1
104	2	SI-5621-212	A	WELD RING	1
105	2	SI-5621-213	A	TUBE R	1
106	2	SI-5621-214	A	TUBE Y	1
107	2	SI-5621-215	A	TUBE S	1
108	2	SI-5621-216	A	TUBE T	1
109	2	SI-5621-217	A	TUBE V	1
110	2	SI-5621-218	A	TUBE W	1
111	2	SI-5621-219	A	TUBE X	1
112	2	SI-5621-220	A	TUBE Z	1