

## SECTION - C

### TECHNICAL SPECIFICATIONS OF STORES AND DRAWINGS.

# Technical Specifications of Hydrogen Isotope Handling and Recovery System



INSTITUTE FOR PLASMA RESEARCH  
GANDHINAGAR, GUJARAT  
382428

## ANNEXURE-I

### Scheme and Features of Hydrogen Isotope Handling and Recovery System

#### **Introduction:**

The tritium handling system is required for the tritium left in the target chamber of a neutron generator after firing Deuterium beam over a titanium target which is bounded with 140 Ci of Tritium. Every-time we fire Deuterium beam some Tritium is released from the target into the chamber, which is termed as continuous release of Tritium. Along with it the tritium handling system should also be capable of handling full 140Ci tritium release from the target, called as Puff release in the document.

#### **Features of Tritium Handling and Recovery System:**

Tritium handling and recovery system (THRS) is installed to handle the tritium coming out of the tritium target due to the following two reasons, i.e. i) Continuous release and ii) Puff release(accidental scenario). The best suited technology which can be used is based upon the chemical getter bed technology for scavenging tritium out of the tritiated exhaust gas mixture from the target chamber.

Apart from tritium in the exhaust of the target chamber there is high probability of the presence of oxygen and other compounds in small quantity, as shown in table-1.

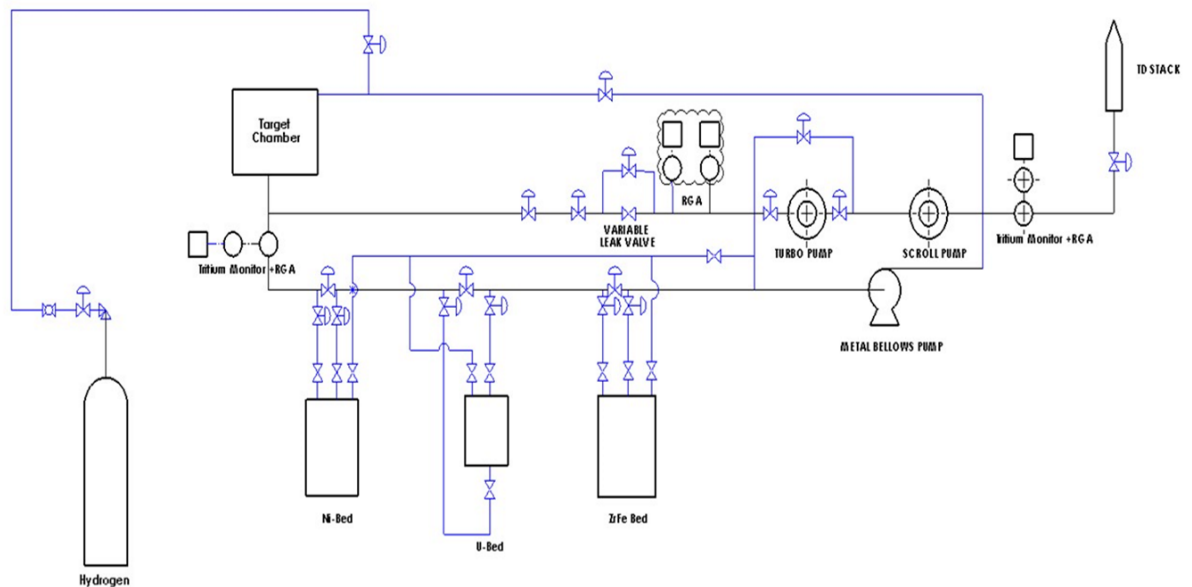
So, based upon the possible impurities we can choose the chemical getter bed material as Ni, U, and Zr-Fe, used to trap different species as shown in fig.1. THRS should be able to handle all of the tritium, i.e. 140 Ci expected to come out of the target. It should be able to handle at least 350 tritium target of 140 Ci each. Therefore beds should be sized accordingly.

**Table: 1 Probable Impurity Composition in the Exhaust of the Tritium Handling and Recovery System**

Possible Impurity Composition							At operational condition.		
Components in dry air		Volume ratio = Molar ratio		Molar mass	Molar mass in air		Components present in 0.0058 mol,air, n		
		compared to dry air					0.0058		
Name	Formula	[mol/mol <sub>air</sub> ]	[vol%]	[g/mol],	[g/mol <sub>air</sub> ],	[wt%]	num. of mol in air, ni	grams in air	
				[kg/kmol]	[kg/kmol <sub>air</sub> ]				
Nitrogen	N <sub>2</sub>	0.78084	78.084	28.013	21.873983	75.52	0.004528872	0.09906447	
Oxygen	O <sub>2</sub>	0.20946	20.946	31.999	6.702469	23.14	0.001214868	0.00814262	
Argon	Ar	0.00934	0.934	39.948	0.373114	1.29	0.000054172	2.0212E-05	
Carbon dioxide	CO <sub>2</sub>	0.00033	0.033	44.01	0.014677	0.051	0.000001914	2.8092E-08	
Neon	Ne	0.00001818	0.001818	20.18	0.000367	0.0013	1.05444E-07	3.8698E-11	
Helium	He	0.00000524	0.000524	4.003	0.000021	0.00007	3.0392E-08	6.3823E-13	
Methane	CH <sub>4</sub>	0.00000179	0.000179	16.042	0.000029	0.0001	1.0382E-08	3.0108E-13	
Krypton	Kr	0.000001	0.0001	83.798	0.000084	0.00029	5.8E-09	4.872E-13	
Hydrogen	H <sub>2</sub>	0.0000005	0.00005	2.016	0.000001	0.000003	2.9E-09	2.9E-15	
Xenon	Xe	0.00000009	0.000009	131.293	0.000012	0.00004	5.22E-10	6.264E-15	
<b>Average molar mass of air</b>					<b>28.9647</b>			<b>0.005799981</b>	<b>0.16799472</b>
									<b>0.10722732</b>

Scheme of Operation of THRS- Before the firing, the target chamber should be fully evacuated in preparation. After firing, the scroll pump and molecular drag pumps should be used to pull down the vacuum through the getter beds causing any gases created in the firing to pass through the beds. If there is oxygen present, it should first come through the Nickel bed where the oxygen and perhaps other contaminants that may be harmful to other beds should be taken out and captured (see fig: 1). Following the Nickel bed should be a Uranium bed. According to our experiment schedule, a new target is supplied to the

target chamber every months, a higher number than expected, it would represent a total of 12 x 140 Ci. The purpose of the U bed is as a working bed to receive and to return any tritium back to say an Amersham bed for storage at the facility or for re-use by the accelerator. The uranium bed lends itself for pumping the tritium off and on many times. It should protect the Zirconium-iron bed the sole purpose of which is to make sure that it should scavenge any trace tritium that by-passes the U bed, protecting the stack and making sure that the atmospheric discharge is always within limits. All the getter beds, including the stand-by getter beds should have heaters, thermocouples and regeneration capability. THRS should be optimize to minimize tritium hold-up and speed up the tritium handling and clean up. Discharge to the stack should be monitored by a 1000 cc ion chamber, which should set alarm if high values are detected and should shut down the clean-up system. In this event helium should be injected into the loop and it should be circulated through the system and through the getter beds until the tritium levels are lowered to stackable levels.



**Figure 1: Detailed I & C diagram of THRS**

## **Scope of Work and Technical specification of Hydrogen Isotope handling and recovery system**

### **I. Scope of Work**

- (i) To design, fabricate and supply a Tritium Handling and Recovery System according to the Scheme and Features mentioned in Annexure-I and technical specifications in Section II. The system includes following main components:
  - (ii) Uranium getter beds/compatible getter bed for Tritium recovery
  - (iii) Zr-Fe getter beds
  - (iv) Ni getter beds
  - (v) Ion chambers
  - (vi) Vacuum System
  - (vii) Control & monitoring System
  - (viii) Residual Gas Analysers
  - (ix) Valves and Piping System
1. To install and integrate the THRS and demonstrate full functionality as per Factory Acceptance Test (FAT) criteria mentioned in the technical specifications below.
2. Final installation and Site Acceptance Testing (SAT) of THRS will take place at IPR, Gandhinagar, as mentioned in the technical specifications below. It should be done by vendor.
3. Printed copy of operation manual, installation guidelines, wiring diagrams and relevant information brochure must be supplied for the equipment along with the consignment.

### **II. Technical specifications**

1. Maximum inventory of Tritium :  $\geq 50,000$  Ci (140 Ci/per target)
2. Tritium Removal efficiency :  $\geq 99.5$  %
3. Getter beds :

#### **(i) Technical specifications of Ni Bed:**

##### **(a) Quantity: 01 no.**

- (b) Bed Type : Scavenger
- (c) Container type : Double containment
- (d) Getter Material : Nickel
- (e) Capacity : 0.5 g (O<sub>2</sub>) with  $\geq 0.02$ g O<sub>2</sub>/gNi
- (f) Material of vessel of Primary Container & Secondary Container : Stainless Steel
- (g) Max permissible He Leak rate of both the containers :  $\leq 1 \times 10^{-8}$  sml/s
- (h) Temperature monitor and control should be provided
- (i) Heat Shields should be provided and heating should be uniform
- (j) Safety interlock should be provided to protect the getter beds against pressure and temperature failure.
- (k) Setting for Maximum Temperature limit should be provided.
- (l) Stand by Ni bed (As optional)

#### **(ii) Technical Specification of Uranium Bed:**

##### **(a) Quantity : 01 No.**

- (b) Bed Type : Scavenger
- (c) Container type : Double containment
- (d) Getter Material : Uranium/Compatible for tritium recovery
- (e) Tritium handling Capacity :  $\geq 50,000$  Ci
- (f) Material of vessel of Primary Container & Secondary Container : Stainless Steel
- (g) Max permissible He Leak rate of both the containers :  $\leq 1 \times 10^{-8}$  sml/s

- (h) Temperature monitor and control should be provided
- (i) Heat Shields should be provided and heating should be uniform
- (j) Safety interlock should be provided to protect the getter beds against pressure and temperature failure.
- (k) Setting for Maximum Temperature limit should be provided.
- (l) Stand by U-Bed (As Optional).

**(iii) Technical Specification of Zr-Fe Bed**

- (a) Quantity : 02 No.**
- (b) Bed Type : Scavenger
- (c) Container type : Double containment
- (d) Getter Material : ZrFe
- (e) Capacity : 5 E-11g (H) with  $\geq 200 \text{ cm}^3$  hydrogen /g of Zr-Fe
- (f) Material of vessel of Primary Container & Secondary Container : Stainless Steel
- (g) Max permissible He Leak rate of both the containers :  $\leq 1 \times 10^{-8} \text{ sml/s}$
- (h) Temperature monitor and control should be provided
- (i) Heat Shields should be provided and heating should be uniform
- (j) Safety interlock should be provided to protect the getter beds against pressure and temperature failure.
- (k) Setting for Maximum Temperature limit should be provided.
- (l) Stand by Zr-Fe bed should be provided

**4. Technical Specification of Ion chamber**

**Ion Chamber: 01**

**Location: at Exit of THRS**

- Volume : 1000 cc
- Minimum Measurable :  $< 1 \mu\text{Ci/m}^3$  of Tritium
- Measurement Type : Measure ions with a biased Anode
- Detection volume Type : Solid Wall – maximum sensitivity
- Flow rate: 500 cc/s to 1500 cc/
- Leak Tightness :  $1 \times 10^{-8} \text{ sml/s}$

External Gamma source Signal should be provided.

Carry over protection should be provided.

Chamber should be Electro polished

Ion chamber should be calibrated and calibration certificate should be provided

Ion Chamber should have following features:

1. Auto Zeroing
2. Digital Range Indication
3. Dual set point Alarms
4. Visual and Audible local alarm
5. Remote Alarm,
6. RS232 Output
7. Gamma compensation
8. It should have Real Time Measurement

**Ion Chamber: 02**

**Location: at Exit of THRS**

- Volume: 10 cc
- Minimum Measurable:  $< 0.1 \text{ mCi/m}^3$  of Tritium
- Measurement Type: Measure ions with a biased Anode
- Detection volume Type: Virtual Wall – low activity hang up

Flow rate: 0.5 to 1 L/s  
Leak Tightness:  $1 \times 10^{-8}$  sml/s  
External gamma source signal should be provided.  
Carry over protection should be provided.  
Chamber should be Electro polished  
External Gamma source signal should be provided  
Ion chamber should be calibrated and calibration certificate should be provided  
Ion Chamber should have following features:

1. Auto Zeroing
2. Digital Range Indication
3. Dual set point Alarms
4. Visual and Audible local alarm
5. Remote Alarm,
6. RS232 Output
7. Gamma compensation
8. It should have Real Time Measurement

5. Technical Specification of Vacuum system

- (a) Vacuum system should be oil free
- (b) Base vacuum :  $1-5 \times 10^{-9}$  mbar
- (c) Input voltage :  $230 \pm 10\%$  V,  $50 \pm 5\%$  Hz
- (d) Compression Ratio:  $1 \times 10^4$  (for H<sub>2</sub>)
- (e) Cooling system : Air cooling
- (f) Suitable pressure measuring gauges with controller, display unit and safety interlocks should be provided.

6. Technical specification of RGA

- a. Mass range: 1 to 100 amu
- b. Detector type: Faraday cup
- c. Filament: Compatible to tritium environment
- d. Filament Degas, over pressure protection required
- e. Computer interface: RS-232 / RS -485 / ETHERNET
- f. Spare Filament Sets for RGA: 4 Nos.
- g. Spare Ionizer Kit: 1 No.
- h. Operating pressure range:  $1 \times 10^{-4}$  to  $1 \times 10^{-9}$  torr

7. Metallic bellow sealed pump should be provided.

8. All valves should be high quality leak valves and they should be bellow sealed with automatic control.

9. All inter connection tube should be 316 L stainless steel and it should be assembled according to ASME B31.3

10. All the Electrical equipment of THRS should be located in the process cabinet, neatly wired up and with easy access to fuses.

11. Technical Specification of Control, Monitoring and safety interlock system.

- Control system should be PLC/PXIe based or better
- Control System should have following status, control and monitors.
  1. Level of incoming tritium
  2. Level of outgoing tritium
  3. Status and control of all valves
  4. Status and control of all pumps

5. Status and control of temperature of all the getter beds
  6. Status and monitoring of pressure in all getter beds and THRS.
  7. Value major (Oxygen, CO, CO<sub>2</sub>) impurities present in the chamber
- Control system should have following safety system to protect the getter beds.
    8. System should able to protect the U-bed and Zr-Fe from the contaminant of Oxygen and other impurities in normal operation condition as well as accidental condition.
    9. System should able to protect the all three getter beds from vacuum fail.
    10. System should give the alarm in case of high value of tritium detected in Ion chamber-2
  - Remote access to control system should be provided.
  - THRS should be in sealed cabinet with air flushing arrangement.

## 12. Acceptance Tests :

### **A. Factory Acceptance Test (FAT) criteria**

**Following factory acceptance test should be carried out in presence of IPR representative/representatives.**

- All getter bed and vessel and pipelines should be evacuated and helium leak tested to  $1 \times 10^{-8}$  smls
- Each vessel shall be pressure tested with helium according to their design parameter.
- All getter beds shall be evacuated and temperatures raised to their operating parameters and thermocouples & heater (with standby) shall be shown to perform well and to indicate correctly
- The process system pipeline shall be pressure and leak tested as per specification.
- Motors should be checked for direction of rotation and smooth operation.
- Pumps shall be operated making sure performance meets the specifications and that they are free from unusual vibration.
- Indicator lights shall be checked to make sure that they are all performing correctly and indicate the condition of the system.
- Alarm settings shall be confirmed and shall be achievable.
- Flows shall be observed and confirmation made that predicted flows can be achieved.
- To check the manual operation of all the valve and it shall perform as per the specifications.
- To check and confirm the all automatic operational functions perform reliably and predictably
- Integrated system shall be tested with Hydrogen gas to check system performance by monitor the Hydrogen level at entry and exit of the system.
- System shall be tested with simulated fault condition for cooling, valve operation, vacuum, temperature etc.

### **B. Site Acceptance Test (SAT) criteria**

**Following site acceptance test should be carried out by vendor at IPR.**

- All getter bed and vessel and pipelines should be evacuated and helium leak tested to  $1 \times 10^{-8}$  smls
- All getter bed shall be evacuated and temperature raised to their operating parameter and thermocouples & heater (with standby) shall be shown to perform well and indicate correctly
- The process system pipe line shall be pressure and leak tested as per specification.
- Motors should be checked for direction of rotation and smooth operation.
- Pumps shall be operated making sure performance meets the specifications and that they are free from unusual vibration.

- Indicator lights shall be checked to make sure that they are all performing correctly and indicate the condition of the system.
- Alarm settings shall be confirmed and shall be achievable.
- Flows shall be observed and confirmation made that predicted flows can be achieved.
- To check the manual operation of all the valve and it shall perform as per the specifications.
- To check and confirm the all automatic operational functions perform reliably and predictably.
- System shall be tested with Hydrogen gas to check system performance by monitor the Hydrogen level at entry and exit of the system
- Operation and routine maintenance training shall be provided.



## COMPLIANCE STATEMENT

**Note – Please specify the exact technical value (wherever necessary) and avoid writing comply/yes in the vendor’s offered specification.**

Section No	IPR specification	Vendor Specification	Vendor Remarks
<b>I</b>	<p><b>Scope of Work</b></p> <ul style="list-style-type: none"> <li>(i) To design, fabricate and supply a Tritium Handling and Recovery System according to the Scheme and Features mentioned in Annexure-I and technical specifications in Section II. The system includes following main components:</li> <li>(ii) Uranium getter beds/compatible getter bed for Tritium recovery</li> <li>(iii) Zr-Fe getter beds</li> <li>(iv) Ni getter beds</li> <li>(v) Ion chambers</li> <li>(vi) Vacuum System</li> <li>(vii) Control &amp; monitoring System</li> <li>(viii) Residual Gas Analysers</li> <li>(ix) Valves and Piping System</li> </ul> <ol style="list-style-type: none"> <li>1. To install and integrate the THRS and demonstrate full functionality as per Factory Acceptance Test (FAT) criteria mentioned in the technical specifications below.</li> <li>2. Final installation and Site Acceptance Testing (SAT) of THRS will take place at IPR, Gandhinagar, as mentioned in the technical specifications below. It should be done by vendor.</li> <li>3. Printed copy of operation manual, installation guidelines, wiring diagrams and relevant information brochure must be supplied for the equipment along with the consignment.</li> </ol>		
<b>II</b>	<p><b>Technical specifications of THRS</b></p> <ol style="list-style-type: none"> <li>1. Maximum inventory of Tritium : Total : <math>\geq 50000</math> Ci (140 Ci/per target)</li> <li>2. Tritium Removal efficiency : <math>\geq 99.5</math> %</li> <li>3. Getter beds :</li> </ol>		
<b>III</b>	<p><b>Technical specifications of Ni Bed:</b></p> <ol style="list-style-type: none"> <li>(a) Quantity: 01 no.</li> <li>(b) Bed Type : Scavenger</li> </ol>		

	(c) Container type : Double containment		
	(d) Getter Material : Nickel		
	(e) Capacity : 0.5 g (O <sub>2</sub> ) with $\geq 0.02\text{g O}_2/\text{gNi}$		
	(f) Material of vessel of Primary Container & Secondary Container : Stainless Steel		
	(g) Max permissible He Leak rate of both the containers : $\leq 1 \times 10^{-8}$ sml/s		
	(h) Temperature monitor and control should be provided		
	(i) Heat Shields should be provided and heating should be uniform		
	(j) Safety interlock should be provided to protect the getter beds against pressure and temperature failure.		
	(k) Setting for Maximum Temperature limit should be provided.		
	(l) Stand by Ni bed (As optional)		
<b>IV</b>	<b>Technical Specification of Uranium Bed:</b>		
	(a) <b>Quantity : 01 No.</b>		
	(b) Bed Type : Scavenger		
	(c) Container type : Double containment		
	(d) Getter Material : Uranium/Compatible for tritium recovery		
	(e) Tritium handling Capacity : $\geq 50,000$ Ci		
	(f) Material of vessel of Primary Container & Secondary Container : Stainless Steel		
	(g) Max permissible He Leak rate of both the containers : $\leq 1 \times 10^{-8}$ sml/s		
	(h) Temperature monitor and control should be provided		
	(i) Heat Shields should be provided and heating should be uniform		
	(j) Safety interlock should be provided to protect the getter beds against pressure and temperature failure.		
	(k) Setting for Maximum Temperature limit should be provided.		
	(l) Stand by U-Bed (As Optional).		
<b>V</b>	<b>Technical Specification of Zr-Fe Bed</b>		
	(a) <b>Quantity: 02 No.</b>		
	(b) Bed Type: Scavenger		
	(c) Container type: Double containment		
	(d) Getter Material: ZrFe		
	(e) Capacity: 5 E-11g (H) with $\geq 200$ cm <sup>3</sup> hydrogen /g of Zr-Fe		
	(f) Material of vessel of Primary Container & Secondary Container : Stainless Steel		
	(g) Max permissible He Leak rate of both the containers		

	(h) Temperature monitor and control should be provided		
	(i) Heat Shields should be provided and heating should be uniform		
	(j) Safety interlock should be provided to protect the getter beds against pressure and temperature failure.		
	(k) Setting for Maximum Temperature limit should be provided.		
	(l) Stand by Zr-Fe bed should be provided		
<b>VI</b>	<b>Technical Specification of Ion chamber</b>		
	<b>Ion Chamber: 01</b>		
	<b>(a) Location: at Entry of THRS</b>		
	(b) Volume :1000 cc		
	(c) Minimum Measurable :		
	(d) Measurement Type : Measure ions with a biased Anode		
	(e) Detection volume Type : Solid Wall – maximum sensitivity		
	(f) Flow rate: 500 cc/s to 1500 cc/		
	(g) Leak Tightness :1 x 10 <sup>-8</sup> sml/s		
	(h) External Gamma source Signal should be provided.		
	(i) Carry over protection should be provided.		
	(j) Chamber should be Electro polished		
	(k) Ion chamber should be calibrated and calibration certificate should be provided		
	(l) Ion Chamber should have following features:		
	1. Auto Zeroing		
	2. Digital Range Indication		
	3. Dual set point Alarms		
	4. Visual and Audible local alarm		
	5. Remote Alarm,		
	6. RS232 Output		
	7. Gamma compensation		
	8. It should have Real Time Measurement		
<b>VII</b>	<b>Ion Chamber: 02</b>		
	<b>(a) Location: at Exit of THRS</b>		
	(b) Volume:		
	(c) Minimum Measurable:		
	(d) Measurement Type: Measure ions with a biased Anode		

	(e) Detection volume Type: Virtual Wall – low activity hang up		
	(f) Flow rate:0.5 to 1 L/s		
	(g) Leak Tightness:		
	(h) External gamma source signal should be provided.		
	(i) Carry over protection should be provided.		
	(j) Chamber should be Electro polished		
	(k) External Gamma source signal should be provided		
	(l) Ion chamber should be calibrated and calibration certificate should be provided		
	(m) Ion Chamber should have following features:		
	1. Auto Zeroing		
	2. Digital Range Indication		
	3. Dual set point Alarms		
	4. Visual and Audible local alarm		
	5. Remote Alarm,		
	6. RS232 Output		
	7. Gamma compensation		
	8. It should have Real Time Measurement		
<b>VIII</b>	<b>Technical Specification of Vacuum system</b>		
	(a) Vacuum system should be oil free		
	(b) Base vacuum : $1-5 \times 10^{-9}$ mbar		
	(c) Input voltage : $230 \pm 10\%$ V, $50 \pm 5\%$ Hz		
	(d) Compression Ratio: $1 \times 10^4$ (for H <sub>2</sub> )		
	(e) Cooling system : Air cooling		
	(f) Suitable pressure measuring gauges with controller, display unit and safety interlocks should be provided.		
<b>IX</b>	<b>Technical specification of RGA</b>		
	(a) Mass range: 1 to 100 amu		
	(b) Detector type: Faraday cup		
	(c) Filament: Compatible to tritium environment		
	(d) Filament Degas, over pressure protection required		
	(e) Computer interface: RS-232 / RS -485 / ETHERNET		
	(f) Spare Filament Sets for RGA: 4 Nos.		

	(g) Spare Ionizer Kit: 1 No.		
	(h) Operating pressure range: $1 \times 10^{-4}$ to $1 \times 10^{-9}$ torr		
<b>X</b>	<b>Metallic bellow sealed pump should be provided.</b>		
<b>XI</b>	<b>All valves should be high quality leak valves and they should be bellow sealed with automatic control.</b>		
<b>XII</b>	<b>All inter connection tube should be 316 L stainless steel and it should be assembled according to ASME B31.3</b>		
<b>XIII</b>	<b>All the Electrical equipment of THRS should be located in the process cabinet, neatly wired up and with easy access to fuses.</b>		
<b>XIV</b>	<b>Technical Specification of Control, Monitoring and safety interlock system.</b>		
	➤ Control system should be PLC/PXIe based or better		
	➤ Control System should have following status, control and monitors.		
	1. Level of incoming tritium		
	2. Level of outgoing tritium		
	3. Status and control of all valves		
	4. Status and control of all pumps		
	5. Status and control of temperature of all the getter beds		
	6. Status and monitoring of pressure in all getter beds and THRS.		
	7. Value major (Oxygen, CO, CO <sub>2</sub> ) impurities present in the chamber		
	➤ Control system should have following safety system to protect the getter beds.		
	8. System should able to protect the U-bed and Zr-Fe from the contaminant of Oxygen and other impurities in normal operation condition as well as accidental condition.		
	9. System should able to protect the all three getter beds from vacuum fail.		
	10. System should give the alarm in case of high value of tritium detected in Ion chamber-2		
	➤ Remote access to control system should be provided.		
	➤ THRS should be in sealed cabinet with air flushing arrangement.		
<b>XV</b>	<b>Acceptance Tests :</b>		
	<b>Factory Acceptance Test (FAT) criteria</b>		
	<b>Following factory acceptance test should be carried out in presence of IPR representative/representatives.</b>		

	➤ All getter bed and vessel and pipelines should be evacuated and helium leak tested to $1 \times 10^{-8}$ smls		
	➤ Each vessel shall be pressure tested with helium according to their design parameter.		
	➤ All getter beds shall be evacuated and temperatures raised to their operating parameters and thermocouples & heater (with standby) shall be shown to perform well and to indicate correctly		
	➤ The process system pipeline shall be pressure and leak tested as per specification.		
	➤ Motors should be checked for direction of rotation and smooth operation.		
	➤ Pumps shall be operated making sure performance meets the specifications and that they are free from unusual vibration.		
	➤ Indicator lights shall be checked to make sure that they are all performing correctly and indicate the condition of the system.		
	➤ Alarm settings shall be confirmed and shall be achievable.		
	➤ Flows shall be observed and confirmation made that predicted flows can be achieved.		
	➤ To check the manual operation of all the valve and it shall perform as per the specifications.		
	➤ To check and confirm the all automatic operational functions perform reliably and predictably		
	➤ Integrated system shall be tested with Hydrogen gas to check system performance by monitor the Hydrogen level at entry and exit of the system.		
	➤ System shall be tested with simulated fault condition for cooling, valve operation, vacuum, temperature etc.		
<b>Site Acceptance Test (SAT) criteria</b>			
<b>Following site acceptance test should be carried out by vendor at IPR.</b>			
	➤ All getter bed and vessel and pipelines should be evacuated and helium leak tested to $1 \times 10^{-8}$ smls		
	➤ All getter bed shall be evacuated and temperature raised to their operating parameter and thermocouples & heater (with standby) shall be shown to perform well and indicate correctly		
	➤ The process system pipe line shall be pressure and leak tested as per specification.		
	➤ Motors should be checked for direction of rotation and smooth operation.		
	➤ Pumps shall be operated making sure performance meets the specifications and that they are free from unusual vibration.		

	➤ Indicator lights shall be checked to make sure that they are all performing correctly and indicate the condition of the system.		
	➤ Alarm settings shall be confirmed and shall be achievable.		
	➤ Flows shall be observed and confirmation made that predicted flows can be achieved.		
	➤ To check the manual operation of all the valve and it shall perform as per the specifications.		
	➤ To check and confirm the all automatic operational functions perform reliably and predictably.		
	➤ System shall be tested with Hydrogen gas to check system performance by monitor the Hydrogen level at entry and exit of the system		

Authorized Signatory

Official Seal & Date