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| ICD-R Target Helium Cooling Purification System - PCool |
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|  | Name | Title |
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# Introduction

## Scope of the document

This document describes:

1. the interface requirements imposed on the Target Helium Cooling Purification System (The System) by the Target Primary Helium Cooling System (PCool)
2. the interface requirements imposed on the Target Primary Helium Cooling System by the Target Helium Cooling Purification System.

## Interface Interaction Diagram

Below is shown the interface interaction diagram. Interface requirements between systems highlighted in blue are describe in this document.

Figure 1: Interface interaction diagram

# Interface agreement

The interface requirements stated in this document are the only interface requirements agreed between The System and PCool.

## Interface requirements, The System – PCool

These interface requirements are requirements imposed on The System by PCool.

| ID | **Wheel-801** | **Oxygen concentration**  |
| --- | --- | --- |
| **Requirement** | The System shall remove oxygen (O2) in the PCool helium loop so that the concentration of oxygen < 20 ppmV. |
| **Rationale/Reference** | The oxygen concentration must be kept below the value stated above to avoid oxidation of tungsten target. |

| ID | **Wheel-802** | **Carbon dioxide concentration** |
| --- | --- | --- |
| **Requirement** | The System shall remove carbon dioxide (CO2) in the PCool helium loop so that the concentration of carbon dioxide < 20 ppmV. |
| **Rationale/Reference** | The carbon dioxide concentration must be kept below the value stated above to avoid oxidation of tungsten target. |

| ID | **Wheel-803** | **Water concentration** |
| --- | --- | --- |
| **Requirement** | The System shall remove water (including water containing deuterium and tritium) in the PCool helium loop so that the concentration of water is < 20 ppmV. |
| **Rationale/Reference** | The water concentration must be kept below the value stated above to avoid oxidation of tungsten target. |

| ID | **Wheel-804** | **Particulates concentration** |
| --- | --- | --- |
| **Requirement** | The System shall remove particulates in the PCool helium loop so that the concentration of particulate is < 0.1 µg/kg of helium. |
| **Rationale/Reference** | The concentration of particulates must be kept below the value stated above to avoid wear and tear of tungsten target. |

| ID | **Wheel-806** | **Capacity at start-up** |
| --- | --- | --- |
| **Requirement** | The System shall have a capacity to remove air impurities from the PCool helium loop from an impurity concentration corresponding to requirement THePur-204, “Residual air” in this document to a total impurity concentration < 1000 ppmV within 24 hours. |
| **Rationale/Reference** | To be able to keep the availability of the facility at the design availability it is essential that the air impurities are removed to the above stated concentration within the above state time. |

| ID | **PCool-701** | **Hydrogen concentration** |
| --- | --- | --- |
| **Requirement** | The System shall remove hydrogen including tritium (H2 + HT + T2) in the PCool helium loop so that the total concentration of hydrogen including tritium is < 580 ppmV. |
| **Rationale/Reference** | The total hydrogen concentration (H2 + HT + T2) must be kept below the value stated above so that the emission of tritium through leakage to the surroundings and thus the dose exposure contribution of tritium on the reference person <0.5 µSv/year. This is so that the total dose exposure on the reference person is within allowable limits [1]. Please note: The tritium production represents approximately 5.6 mole percent of the total hydrogen production. |

| ID | **PCool-702** | **Iodine concentration** |
| --- | --- | --- |
| **Requirement** | The System shall remove radioactive iodine (I2) in the PCool helium loop so that the concentration of radioactive iodine is < 0.15 ppbV. |
| **Rationale/Reference** | The radioactive iodine concentration must be kept below the value stated above so that the emission of radioactive iodine through leakage to the surroundings and thus the dose exposure contribution of iodine on the reference person <0.5 µSv/year. This is so that the total dose exposure on the reference person is within allowable limits [1]. Please note: The production of radioactive iodine represents approximately 7.7 mole percent of the total iodine production. |

| ID | **PCool-703** | **Water concentration** |
| --- | --- | --- |
| **Requirement** | The System shall remove water including tritiated water (H2O + HTO + T2O) in the PCool helium loop so that the concentration of water is < 10 ppmV. |
| **Rationale/Reference** | The water concentration must be kept below the value stated above so that the emission of tritiated water through leakage to the surroundings and thus the dose exposure contribution of tritiated water on the reference person is so low so that the total dose exposure on the reference person is within allowable limits [1]. |

| ID | **PCool-704** | **Particulates concentration** |
| --- | --- | --- |
| **Requirement** | The System shall remove particulates in the PCool helium loop so that the concentration of particulate is within the limits:< 0.001 µg particulates per kg/helium with a size > 5 µm< 0.002 µg particulates per kg/helium with a size 1-5 µm< 0.01 µg particulates per kg/helium with a size < 1 µm |
| **Rationale/Reference** | It is anticipated that radioactive nuclides will adsorb or chemically bind to particulates. It is therefore necessary to remove particulate to a level below the values stated above [1]. |

| ID | **PCool-705** | **Impurities concentration** |
| --- | --- | --- |
| **Requirement** | The System shall remove impurities in the PCool helium loop so that the total concentration of impurities in the helium loop is < 1000 ppmV. |
| **Rationale/Reference** | By keeping the total amount of impurities in PCool below the value stated above reduces the risk of unforeseen operational disturbances which otherwise could be caused by too high level of impurities. |

| ID | **PCool-708** | **Temperature**  |
| --- | --- | --- |
| **Requirement** | The system shall be able to handle a temperature of the helium withdrawn from PCool ranging from +20 to +60°C. |
| **Rationale/Reference** | The helium withdrawn from PCool ducted to The System may differ in temperature from +20 to +60°C during different operational conditions. |

| ID | **PCool-709** | **Pressure**  |
| --- | --- | --- |
| **Requirement** | The System shall be able to operate with a PCool pressure between approximately 0.7 – 1.1 MPa. |
| **Rationale/Reference** | Pressure span value based on the design pressure in PCool during operation [2]. |

| ID | **PCool-710** | **Flow**  |
| --- | --- | --- |
| **Requirement** | The System is allowed to withdraw a helium flow from PCool of 0-1% by weight per second of the total amount of helium in PCool. |
| **Rationale/Reference** | The value stated above corresponds to approximately 0-260 g/s. Exceeding this value may lead to transient instabilities in PCool. |

## Interface requirements, PCool – The System

These interface requirements are requirements imposed on PCool by The System.

| ID | **THePur-201** | **Amount of tritium released** |
| --- | --- | --- |
| **Requirement** | The amount of tritium released to the PCool helium loop must be < 3 mg/hour |
| **Rationale/Reference** | The system is designed to remove the calculated 1.5 mg/hour of tritium released to the PCool helium loop with a safety margin of +100% which equals 3 mg/hour. |

| ID | **THePur-202** | **Amount of Iodine released** |
| --- | --- | --- |
| **Requirement** | The total amount of radioactive iodine released to the PCool helium loop must be < 0.17 µg/hour |
| **Rationale/Reference** | The system is designed to remove the calculated 0.017 µg/hour of radioactive iodine released to the PCool helium loop with a safety margin of 10 times this value which equals 0.17 µg/hour. |

| ID | **THePur-203** | **Particulates concentration** |
| --- | --- | --- |
| **Requirement** | The helium withdrawn from PCool to The System shall contain:< 0.001 µg particulates per kg/helium with a size ≥5 µm< 0.1 µg particulates per kg/helium with a size < 5 µm |
| **Rationale/Reference** | The System is equipped with a HEPA filter with a removal efficiency of > 99.97 per cent of particulates with a size > 0.3 µm. To avid clogging the HEPA filter with large particulates > 5 µm these should to a large extent already be removed in the PCool system. |

| ID | **THePur-204** | **Residual air** |
| --- | --- | --- |
| **Interface** | The amount of non helium gases (e.g. nitrogen, air, carbon dioxide etc.) in the PCool helium at each start-up occasion, where other gases than helium have been introduces into the PCool system, must be reduced so that the amount of each non helium gas is:< 7.5 g of nitrogen< 2.3 g of oxygen< 0.13 g of argon< 0.05 g of water< 0.005 g of carbon dioxide< 0.01 g of other gases than those mentioned abovebefore the PCool helium is allowed to enter The System. |
| **Rationale/Reference** | The capacity of The System is designed to remove 90 g of humid air (20°C, 40% relative humidity) from the PCool helium before consumables (getters) must be renewed. To maintain an interval of 12-18 months between each cycle where consumables are renewed, and with 5 start-ups per year, a maximum amount of residual air in the PCool system at each start-up is limited to 10 g of humid air per occasion. This corresponds to the amount stated above. |

| ID | **THePur-205** | **Leakage to surroundings** |
| --- | --- | --- |
| **Requirement** | The leakage of contaminated helium from PCool to the surroundings must be < 25 g/24 hours at normal operation. |
| **Rationale/Reference** | The leakage of contaminated helium from PCool to the surroundings is calculated to 20 g/24 hours at normal operation. The System is designed for a maximum leakage corresponding to the calculated leakage + 25%. |

| ID | **THePur-206** | **Connection (tie-in point)** |
| --- | --- | --- |
| **Requirement** | The connections (tie-in points) for The System to PCool shall be a strait seamless pipe SS316L or equivalent Ø 20 × 1.5 mm with a length 100<length<200 mm.One connection (gas inlet to The System) shall be located upstream the helium inlet connection on the Shaft, but downstream the blower, and one connection (gas outlet from The System) shall be located downstream the particle filter which is located downstream the helium outlet connection on the Shaft. |
| **Rationale/Reference** | Using a seamless pipe enables different options for the connection such as orbital welding or Swagelok couplings. |

# References

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| [1] | T. Hansson, General safety objectives for ESS, ESS-0000004 |
| [2] | J. Harborn, SDD-req Target Cooling ESS-0012524 |

# List of Abbreviations

| Abbreviation | Definition |
| --- | --- |
| PCool | Target Primary Helium Cooling System |
| THePur | Target Helium Cooling Purification System |
| Wheel | Target Wheel Drive and Shaft (when used as requirement identifier) |
| FS | Fluid systems |
| ppmV | parts per million by volume |
| ppbV | parts per billion by volume |
| ICD | Interface Control Document |
| ICD-R | Interface Control Document - Reference |

# Document Revision history

| Revision | Reason for revision | Date |
| --- | --- | --- |
| 1.0 | New document | 2015-11-11 |
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