ENCLOSURE 2

SHINE MEDICAL TECHNOLOGIES, LLC

MEETING SLIDES FOR THE MARCH 4 AND 5, 2020 PUBLIC MEETING BETWEEN SHINE MEDICAL TECHNOLOGIES, LLC AND THE NRC

TRITIUM PURIFICATION SYSTEM (TPS) DESIGN CHANGE
PUBLIC VERSION

34 pages follow

Tritium Purification System (TPS) Design Change

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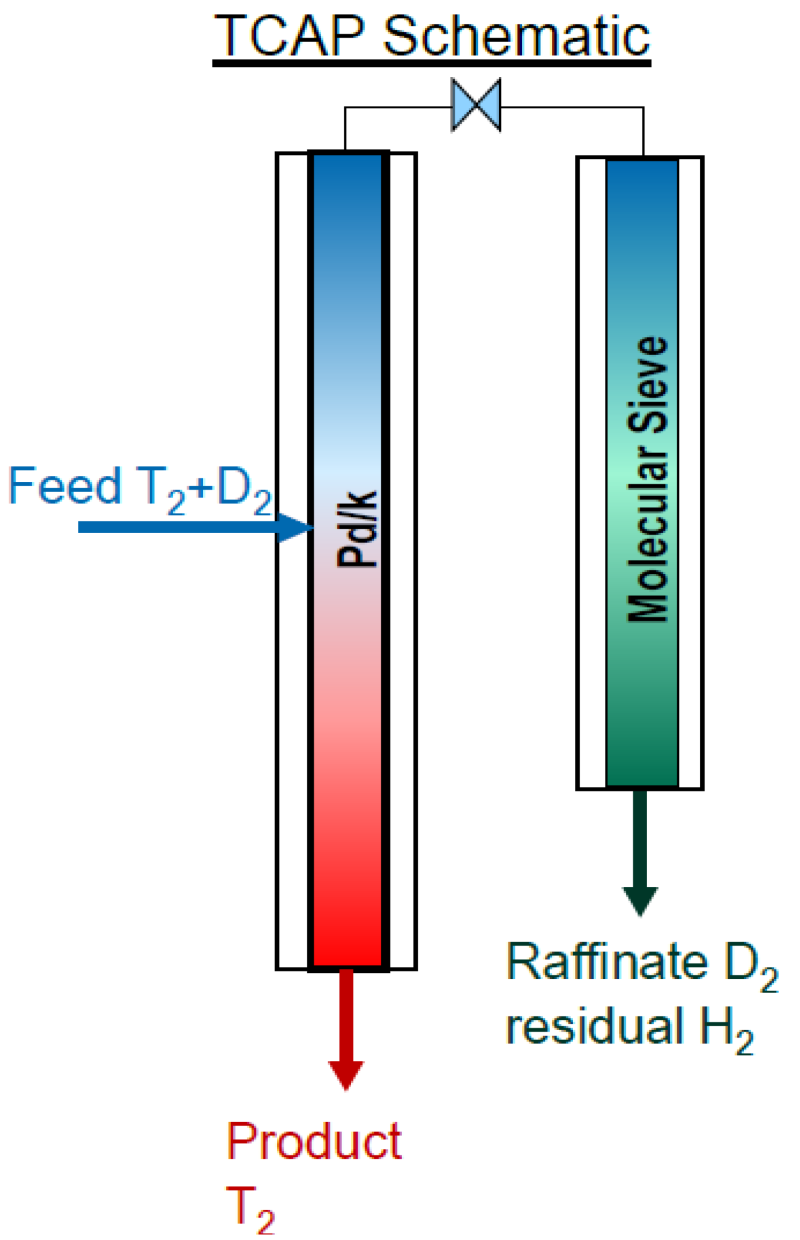
High-Level TPS Overview

TPS High Level Overview

- Neutron driver assembly system (NDAS) units accelerate a deuterium ion beam into a tritium gas target.
  - High tritium concentrations are required in the target to meet neutron production requirements, so a means to provide constant high purity tritium to the target is required.
- The tritium purification system (TPS) provides a constant supply of high purity tritium through isotopic separation of tritium and deuterium from NDAS target chamber exhaust.
- The core TPS technology for isotope separation is the thermal cycling absorption process (TCAP), which separates deuterium and tritium into high purity tritium and deuterium streams.
  - Supporting subsystems include impurity removal and glovebox cleanup subsystems.

TCAP Overview

1. Mixed tritium-deuterium gas is fed to the palladium-based separation column
2. The palladium-based column is heated while the molecular sieve column is cooled, moving gas between the columns, then the process is reversed
3. Tritium collects at the end of the palladium-based column, and deuterium collects at the end of the molecular sieve column
4. Operates in a batch process using a set of buffer volumes for continuous recovery and delivery from NDAS
5. High purity tritium is collected in a product tank
6. Tritium is delivered to NDAS units to keep high concentrations of tritium in the NDAS target chamber required to meet neutron output requirements



Drivers for Change to the TPS Design

- New design substantially improves reliability of system and reduces single-point operational failures
- Design improvements remove some accident scenarios in SHINE safety analysis and improve overall system safety
- Improved process equipment design reduces maintenance frequency and complexity

Current FSAR-Described TPS Design

Current FSAR-Described TPS Design

- One train of isotope separation equipment serves all eight NDAS units simultaneously.
- High purity tritium and deuterium are supplied to the accelerator TPS interface system (ATIS) header.
- The ATIS header supplies process equipment confined in ATIS interface gloveboxes to regulate the flow of gas into and out of each NDAS.
- A single glovebox cleanup system serves the main TPS glovebox and eight interface glovebox atmospheres.

Current FSAR-Described TPS Isotope Separation Process

- Vacuum pumps recover gas from above-ground NDAS exhaust return header.
- Liquid nitrogen cooled carbon bed captures impurities before TCAP inlet.
- TCAP separates mixed tritium and deuterium into pure tritium and deuterium streams.
- The TCAP tritium and deuterium streams are pumped to the ATIS header.
- Interface equipment (ATIS) regulates the flow of tritium to the NDAS target chamber and deuterium to the NDAS ion source from the ATIS header.
- A pump pushes gas from the NDAS target chamber exhaust back to vacuum pumps at the start of the isotope separation process through the ATIS header.

Current FSAR-Described TPS Glovebox Cleanup System

- The glovebox stripper system (GBSS) removes tritium contamination from the central TPS glovebox atmosphere and the eight interface glovebox atmospheres.
- The GBSS converts tritium to tritiated water and captures the tritiated water on molecular sieve beds.
- The GBSS recirculates the central TPS glovebox atmosphere and is single-pass for the eight interface gloveboxes using a continual purge to facility ventilation.
- The GBSS also treats waste gas from process line evacuations before and after equipment maintenance.

Current FSAR-Described TPS Layout

SRI

Current FSAR-Described TPS Layout

[ ] SRI

New TPS Design

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New TPS Design Overview

- Three train design replaces single train
- Removal of interface gloveboxes and above-ground tritium header
- External deuterium source for NDAS
- Improvements in glovebox cleanup system design and reliability
- Improvements in process equipment design and operating philosophy

Three Train Configuration

- Replaced the single isotope separation train with three trains
- Trains operate independently of each other; NDAS units remain independent of each other
- West wall of TPS room moved to ensure adequate space for TPS equipment
- Each train has dedicated equipment for glovebox atmosphere cleanup and process line evacuation
- Total facility tritium inventory unchanged

[ ] PROP/ECI

TPS Room Layout

SRI

Removal of Accelerator TPS Interface System (ATIS)

- Process lines run directly from the TPS room to each NDAS through subgrade penetrations, removing the need for interface gloveboxes above each IU cell.
- Removal of the ATIS interfaces and switch to subgrade penetrations removes the need for an above-ground tritium supply header.
- Process lines are guarded from mechanical impact within subgrade penetrations and through barriers installed around tubing from glovebox to subgrade penetrations.

Interface between TPS and NDAS

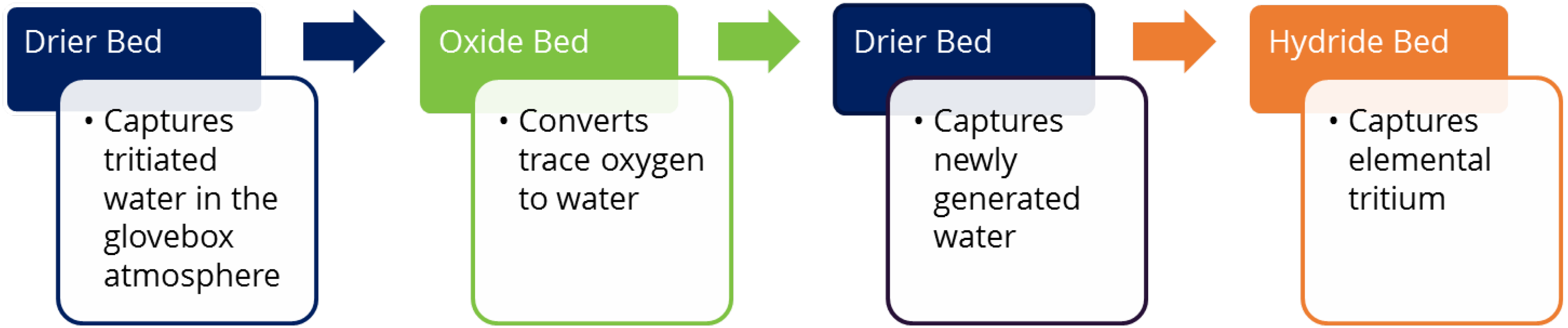
SRI

Deuterium Supply to NDAS

- Deuterium supply to NDAS provided through an external supply bottles instead of through the deuterium side of TCAP.
- Deuterium supplied to NDAS ion source exhausts to facility ventilation instead of recycling deuterium back to TCAP.
- Reduces load on isotope separation equipment, reducing component size and system complexity.

Glovebox Cleanup System Design

- New TPS design uses a secondary enclosure cleanup (SEC) system to clean glovebox atmospheres, separate from the process line evacuation equipment.
- Switched glovebox inert gas atmosphere from nitrogen to helium
- SEC design captures both tritiated water and elemental tritium rather than converting tritium to water for capture.
- Dedicated SEC system for each glovebox improves the reliability of TPS.



New Process Equipment

- Use of cryopumps instead of vacuum pumps, improving performance while reducing maintenance requirements
- A palladium-based permeator replaces activated carbon bed for impurity removal, improving operability and improving system safety
- TCAP deuterium stream directed to impurity treatment system instead of recycled to NDAS
- Flow controllers connect TPS directly to NDAS units, replacing the ATIS and associated header lines
- Process line evacuation separate from glovebox cleanup system, reducing normal contamination levels in gloveboxes and improves reliability of overall system

Summary of Safety Improvements

Safety Improvements with new TPS Design

- Improved design eliminates above ground tritium supply header and associated risk of damage to interface lines
- Removal of ATIS gloveboxes reduces maintenance challenges and potential worker dose
- Eliminates accident scenario related to unintended exothermic chemical reactions other than detonation with removal of activated carbon bed
- Improvements in process design and operation concepts reduce equipment failure modes and maintenance requirements, improves reliability and availability of system

Licensing Basis Impacts

Licensing Basis Impacts

- FSAR Chapter 1
  - Figures 1.3-1 and 1.3-2 updated to reflect moving west wall of TPS room
- FSAR Chapter 4
  - Figure 4a2.1-1 updated to reflect direct connections between TPS gloveboxes and the NDAS
  - Section 4a2.3 updated to reflect source of deuterium and update nominal flowrate values for tritium supply and mixed gas return
- FSAR Chapter 6
  - Figure 6a2.1-1 updated to reflect active and passive components of new TPS design
  - Table 6a2.1-2 updated to reflect new calculated unmitigated and mitigated dose results for the representative tritium confinement boundary design basis accident
  - Section 6a2.2 updated to describe new tritium confinement boundary and remove reference to ATIS
  - Figure 6a2.2-1 updated to remove connections to ATIS and update IU cell confinement boundary
  - Figure 6a2.2-2 updated to reflect new tritium confinement boundary for TPS and to add connection from the NDAS to RVZ1e

Licensing Basis Impacts

- FSAR Chapter 7
  - Section 7.4 updated to provide a description of the new IU Cell TPS Actuation safety function
  - Section 7.4 updated to remove ATIS components as primary confinement boundary components and add new TPS isolation valves to the listing of primary confinement boundary components
  - Section 7.4 updated to remove discussion of monitoring of the ATIS mixed gas return line, including associated operational bypasses, permissives, and interlocks
  - Table 7.4-1 updated to remove ATIS mixed gas return line tritium concentration as a monitored variable
  - Table 7.4-1 updated to replace the ATIS gas return line pressure with the TPS target chamber exhaust pressure as a monitored variable
  - Figure 7.4-1 updated to reflect new TRPS logic diagrams
  - Section 7.5 updated to provide a description of the new TPS Process Vent Isolation safety function
  - Section 7.5 updated to describe individual TPS train isolations
  - Table 7.5-1 updated to include individual glovebox tritium concentrations as monitored variables and to increase the analytical limit for tritium concentration in the TPS exhaust to facility stack from 80 $\mu Ci/m^3$ to 1 Ci/m^3

Licensing Basis Impacts

- FSAR Chapter 7 (continued)
  - Table 7.5-2 updated to reflect the fail safe component positions for new TPS components
  - Figure 7.5-1 updated to reflect new ESFAS logic diagrams
  - Figure 7.5-4 updated to reflect TPS isolation interface for radiologically controlled area (RCA) isolation
  - Section 7.7 updated to reflect new radiation monitoring locations with the TPS and associated actuation signals
- FSAR Chapter 8
  - Section 8a2.2 updated to include the TPS SEC system heaters as standby generator system (SGS) loads
  - Table 8a2.2-1 updated to remove GBSS blowers and heaters from the uninterruptible electrical power supply system (UPSS) load list and add TPS SEC system blowers to the list
  - Table 8a2.2-2 updated to remove GBSS blowers and heaters from the UPSS battery sizing and add TPS SEC system blowers to the sizing
- FSAR Chapter 9
  - Section 9a2.1 updated to reflect interface of the radiological ventilation systems with the new TPS design
  - Section 9a2.7 updated to reflect new TPS design, addressing the three train configuration and removal of the ATIS gloveboxes from the design

Licensing Basis Impacts

- FSAR Chapter 9 (continued)
  - Section 9a2.7 updated to replace the description of the ATIS header with a description of the subgrade process connections
  - Section 9a2.7 updated to replace the description of the GBSS with a description of the SEC system
  - Section 9a2.6 updated to describe the new tritium purification process sequence
  - Table 9a2.7-1 updated to reflect the modified interface of the TPS with the facility nitrogen handling system and add the interface of the TPS with the SGS
  - Table 9a2.7-2 updated to reflect the new TPS design nominal flow rates
  - Table 9a2.7-3 updated to reflect the new TPS design process equipment
  - Figure 9a2.7-1 updated to show the new TPS design process flow and isolation valve locations
  - Section 9b.7 updated to reflect the modified interface of the facility nitrogen handling system with the TPS
- FSAR Chapter 11
  - Section 11.1 updated to reflect the treatment of releases from the TPS via the SEC system
  - Table 11.1-5 updated to reflect the three train configuration of the new TPS design

Licensing Basis Impacts

- FSAR Chapter 13
  - Subsection 13a2.1.10 (Unintended Exothermic Chemical Reactions other than Detonation) updated to remove Scenario 2, which involved the ignition of the activated carbon bed in the TPS
  - Subsection 13a2.1.11 (System Interaction Events) updated to reflect the new TPS design in the loss of ventilation functional interaction description
  - Subsection 13a2.1.12 (Facility-Specific Events) updated to reflect the new TPS design in the description of initial conditions for accident scenarios involving the TPS, including replacing nitrogen with helium as the glovebox atmosphere inerting gas
  - Subsection 13a2.1.12 (Facility-Specific Events) updated to reflect the new TPS design within the TPS Scenario descriptions
  - Subsection 13a2.1.12 (Facility-Specific Events), TPS Scenario 5 (Release of Tritium into the IF due to TPS Interface Line Mechanical Damage) updated to reflect the scenario as not credible due to the subgrade routing of TPS process lines protected from mechanical damage
  - Subsection 13a2.2.10 (Unintended Exothermic Chemical Reactions other than Detonation) updated to remove Scenario 2, which involved the ignition of the activated carbon bed in the TPS

Licensing Basis Impacts

- FSAR Chapter 13 (continued)
  - Subsection 13a2.2.12 (Facility-Specific Events) updated to reflect the new TPS design in the sequence of events related to the release of tritium into an IU cell
  - Subsection 13a2.2.12 (Facility-Specific Events) updated to reflect the new TPS design in the sequence of events related to the tritium release into the TPS glovebox, including the three train configuration of the TPS gloveboxes
  - Subsection 13a2.2.12 (Facility-Specific Events) updated to increase the initial material at risk for the tritium release into the TPS glovebox from 236,000 Ci to 300,000 Ci
  - Subsection 13a2.1.12 (Facility-Specific Events) updated to remove the analysis of the tritium release into the irradiation facility, as the scenario, involving a break in the ATIS tritium header, was eliminated as a result of the new TPS design
  - Table 13a2.2-1 updated to reflect new public radiation transport terms (ARF x LPF) for the tritium release into the TPS glovebox event and remove the tritium release into the irradiation facility event
  - Table 13a2.2-2 updated to reflect new worker radiation transport terms (ARF x LPF) for the tritium release into the TPS glovebox event and remove the tritium release into the irradiation facility event
  - Table 13a3-1 updated to reflect new dose consequences for the tritium release into the TPS glovebox event and remove the tritium release into the irradiation facility event

Licensing Basis Impacts

- Technical Specifications
  - LCO 3.2.1 updated to include the IU Cell TPS Actuation in the table of TRPS Actuation Functions
  - LCO 3.2.2 updated to reflect the three train configuration of the new TPS design and to include the TPS Process Vent Isolation in the table of ESFAS Actuation Functions
  - LCO 3.3.3 updated to remove the [ ]PROP/ECI and the driver dropout [ ]PROP/ECI from the table of TRPS Interlocks
  - LCO 3.2.5 updated to reflect the removal of the ATIS, including the removal of the monthly channel check of the ATIS mixed gas return line tritium concentration monitors
  - LCO 3.4.1 updated to remove ATIS components as primary confinement boundary components and add new TPS isolation valves to the table of primary confinement boundary isolation valves and dampers
  - LCO 3.4.3 updated to reflect the three train configuration of the new TPS design and to identify new TPS isolation valves the in the table of TPS glovebox confinement valves
  - LCO 3.6.1 updated to reflect the three train configuration of the new TPS design
  - LCO 3.7.1 updated to reflect the three train configuration of the new TPS design and to identify radiation monitoring locations and setpoints within the new TPS

Licensing Basis Impacts

- Technical Specifications (continued)
  - LCO 3.8.7 updated to reflect the three train configuration of the new TPS design, to reflect replacing nitrogen with helium as the glovebox atmosphere inerting gas, and to reflect replacing monitoring of the glovebox atmosphere for oxygen concentration with monitoring the dew point
  - LCO 3.8.8 updated to reflect the three train configuration of the new TPS design and replacing the GBSS with the SEC system
  - LCO 3.8.9 updated to identify the TPS ventilation supply and exhaust dampers in the table of RCA isolation dampers
  - Program 5.5.4 updated to include protection from external impact damage of TPS-NDAS interface lines by either running of the lines in subgrade sleeves protected by rebar reinforced concrete or by mechanical guards on the above grade portions of the lines in the TPS room

Summary

Summary of the TPS Design Change

- New design substantially improves reliability of system and reduces single-point operational failures
- Design improvements remove some accident scenarios in SHINE safety analysis and improve overall system safety
- SHINE plans to submit revised licensing basis documents (i.e., Final Safety Analysis Report and Technical Specifications) the week of March 9th, 2020, reflecting the new TPS design