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None

**Acronyms and Abbreviations**

<u>Acronym/Abbreviation</u>	<u>Definition</u>
10 CFR	Title 10 of the Code of Federal Regulations
ANS	American Nuclear Society
ANSI	American National Standards Institute
IF	irradiation facility
ISA	Integrated Safety Analysis
IU	irradiation unit
LCO	limiting condition of operation
LSSS	limiting safety system setting
LWPS	light water pool system
NGRS	noble gas removal system
PCLS	primary closed loop cooling system
PSB	primary system boundary
PVVS	process vessel vent system
RCA	radiologically controlled area
RPF	radioisotope production facility
RVZ1	RCA ventilation system Zone 1
RVZ2	RCA ventilation system Zone 2
SHINE	SHINE Medical Technologies, Inc.
SL	safety limit
SNM	special nuclear material
TOGS	TSV off-gas system
TSV	target solution vessel

**CHAPTER 14**

**TECHNICAL SPECIFICATION**

14a1 HETEROGENEOUS REACTOR TECHNICAL SPECIFICATIONS

The SHINE Medical Technologies, Inc. (SHINE) facility is not a heterogeneous reactor facility; therefore, this section does not apply.

## 14a2 IRRADIATION FACILITY TECHNICAL SPECIFICATIONS

This section encompasses the technical specifications for the processes involving special nuclear material (SNM), radioisotopes, and chemicals inside the irradiation facility (IF).

In accordance with the requirements of Title 10 of the Code of Federal Regulations (10 CFR) 50.34 (a)(5), this section identifies the variables and conditions that will likely be the subjects of technical specifications for the SHINE facility. These may change with the operating license application. These variables and conditions are based on the preliminary design of the SHINE facility. The technical specifications will be submitted with the operating license application.

These proposed variables have been identified on the premise that this material presents a sound framework upon which a final, complete set of technical specifications can be provided with the operating license application.

### 14a2.1 INTRODUCTION

The format and content of the technical specifications will be written with the guidance provided in American National Standards Institute (ANSI)/American Nuclear Society (ANS) 15.1, "The Development of Technical Specifications for Research Reactors" (ANSI/ANS, 2007). The technical specifications for non-power reactors include the categories in 10 CFR 50.36 for production and utilization facilities.

Normal operation of the SHINE facility within the limits of technical specifications will not result in off-site radiation exposure in excess of 10 CFR 20 guidelines.

## 14a2.2 SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

Safety limits (SLs) will be placed on important process variables as necessary to reasonably preserve the integrity of the primary system boundary (PSB) and prevent the uncontrolled release of radioactivity. For the SHINE IF, the PSB is the target solution vessel (TSV), TSV dump tank, TSV off-gas system (TOGS), and associated piping and components. SLs may also be established for the character and quality of the target solution.

Limiting safety system settings (LSSSs) are settings for automatic protective devices related to those variables having significant safety functions. These settings ensure that automatic protective action will correct the abnormal situation before an SL is exceeded.

Refer to Table 14a2-1 for the SLs and LSSSs associated with the PSB. The justifications for the variables chosen are given in the section/subsection listed in the Table 14a2-1.

### 14a2.3 LIMITING CONDITIONS FOR OPERATION

Limiting conditions of operations (LCOs) are derived from the safety analyses and are implemented administratively or by control and monitoring circuitry to ensure safe operation of the irradiation facility. The LCOs are the lowest functional capability or performance level required for safe operation of the irradiation facility.

Table 14a2-1 shows LCOs associated with the irradiation facility. The justifications for the variables chosen are given in the sections listed in the table.

#### 14a2.4 SURVEILLANCE REQUIREMENTS

Surveillance requirements will be provided in the technical specifications.

#### 14a2.5 DESIGN FEATURES

Design features that will be provided in the technical specifications are the features of the SHINE facility, such as materials of construction and geometric arrangements that would have a significant effect on safety if these features were altered or modified. The requirements of 10 CFR 50.36(c)(4) are specified here as they pertain to the above referenced processes (see Table 14a2-1).

## 14a2.6 ADMINISTRATIVE CONTROLS

Administrative controls will be provided in the technical specifications.

Examples of the proposed subjects of administrative controls are provided below:

### Procedures

Written procedures shall be established, implemented, and maintained covering activities described in the following Programs.

### Programs

- Criticality-safety
- ALARA (includes use of accelerator and hot cell audible and visual warnings)
- Procurement and use of transport and waste containers
- Fire protection (includes installed and transient combustible loading, performance of hot work, deuterium source vessel integrity, fire watch requirements, use and storage of flammable and combustible liquids and gasses)
- Solvent control (includes control of process residence times, solvent quality control, and solvent solution sampling and analysis)
- Tritium control (includes inventory control and sampling)
- Light water coolant activity monitoring
- Chemical control

**Table 14a2-1 SHINE Facility Proposed Parameters for Technical Specifications**  
(Sheet 1 of 10)

Chapter/ Section/ Subsection Reference per ANSI/ANS-1 5.1-2007	Section Name	SLs and LSSS	Basis
2	SLs and LSSS		
2.1	SLs	<ul style="list-style-type: none"> <li>• TSV power</li> <li>• Uranium concentration</li> <li>• Uranium enrichment</li> <li>• Quantities of radioactive materials</li> </ul>	<p>13a2.1.8/13a2.2.8 Large undamped power oscillations</p> <p>13a2.1.2/13a2.2.2 Insertion of excess reactivity</p> <p>13a2.1.11/13a2.2.11 PSB System interaction events</p> <p>13b.2.4 Critical equipment malfunction</p> <p>13b.2.5 Inadvertent nuclear criticality in the radioisotope production facility</p> <p>13b.2.6 Radioisotope production facility fire</p>
2.2	Limiting Safety System Settings	<ul style="list-style-type: none"> <li>• TSV LSSS</li> <li>a. TSV cover gas hydrogen concentration high</li> <li>b. TSV neutron flux high, source range</li> <li>c. TSV neutron flux high, high range</li> </ul>	<p>13a2.1.2/13a2.2.2 Excess reactivity</p> <p>13a2.1.8/13a2.2.8 Large undamped power oscillations</p> <p>13a2.1.9/13a2.2.9 Detonation and deflagration in primary system boundary</p>

**Table 14a2-1 SHINE Facility Proposed Parameters for Technical Specifications  
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Chapter/  
Section/  
Subsection  
Reference  
per  
ANSI/ANS-1  
5.1-2007

	Section Name	LCO or Condition	Basis
3	LCOs		
3.1	TSV and Target Solution Parameters	<ul style="list-style-type: none"> <li>• Target solution parameters:               <ul style="list-style-type: none"> <li>a. Precipitation catalyst concentration</li> <li>b. Uranium concentration</li> <li>c. Uranium enrichment</li> <li>d. Fission product activity based on the maximum number of cycles prior to target solution cleanup</li> </ul> </li> <li>• TSV parameters and operational constraints:               <ul style="list-style-type: none"> <li>a. High fill flow rate</li> <li>b. Maximum bulk temperature</li> <li>c. Minimum bulk temperature</li> <li>d. Void coefficient design value</li> <li>e. Temperature coefficient design value</li> </ul> </li> </ul>	<p>13a2.1.2/13a2.2.2 Excess reactivity</p> <p>13a2.1.8/13a2.2.8 Large undamped power oscillations</p> <p>13a2.1.11/13a2.2.11 Primary system boundary interaction events</p>

**Table 14a2-1 SHINE Facility Proposed Parameters for Technical Specifications  
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Chapter/ Section/ Subsection Reference per ANSI/ANS-1 5.1-2007	Section Name	LCO or Condition	Basis
3.2	TSV Control and Safety Systems	<ul style="list-style-type: none"> <li>• TRPS: Required channels operable per Table 3.2.1</li> <li>Table 3.2.1 (Channel monitored, number of channels required, allowable value, nominal setpoint, permissible bypass or other conditions)                             <ul style="list-style-type: none"> <li>a. TSV cover gas hydrogen concentration high</li> <li>b. TSV neutron flux high, source range</li> <li>c. TSV neutron flux high, high range</li> <li>d. Loss of PCLS flow</li> <li>e. High PCLS temperature</li> <li>f. Primary closed loop cooling system (PCLS) low temperature</li> <li>g. ESFAS</li> <li>h. Manual</li> </ul> </li> </ul>	<p>13a2.1.2/13a2.2.2 Excess reactivity</p> <p>13a2.1.3/13a2.2.3 Reduction of cooling</p> <p>13a2.1.8/13a2.2.8 Large undamped power oscillations</p> <p>13a2.1.9/13a2.2.9 Detonation and deflagration in primary system boundary</p>

**Table 14a2-1 SHINE Facility Proposed Parameters for Technical Specifications  
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Chapter/ Section/ Reference per ANSI/ANS-1 5.1-2007	Section Name	LCO or Condition	Basis
3.2 (cont'd)	TSV Control and Safety Systems	<ul style="list-style-type: none"> <li>• TOGS</li> <li>a. TOGS operable and in operation (operable includes blowers, recombiner beds, and interlock with noble gas removal system [NGRS])</li> <li>b. Hydrogen monitoring indication</li> <li>c. Hydrogen concentration within limits</li> <li>• Safety system equipment               <ul style="list-style-type: none"> <li>a. TSV dump valves</li> <li>b. Neutron driver circuit breakers</li> <li>c. Neutron driver interlock with TSV fill operation</li> <li>d. Dump tank empty during startup and irradiation</li> <li>e. Fill valves</li> </ul> </li> </ul>	<p>13a2.1.5/13a2.2.5 Loss of off-site power</p> <p>13a2.1.11/13a2.2.11 Primary system boundary interaction events</p> <p>13b.2.1 Maximum hypothetical accident in the radioisotope production facility (RPF)</p>
3.3	Coolant Systems	<ul style="list-style-type: none"> <li>• Light water pool system (LWPS)               <ul style="list-style-type: none"> <li>a. Temperature upper limit and temperature lower limit</li> <li>b. Level</li> </ul> </li> </ul>	<p>13a2.1.2/13a2.2.2 Excess reactivity</p> <p>13a2.1.3/13a2.2.3 Reduction of cooling</p> <p>13a2.1.8/13a2.2.8 Large undamped power oscillations</p> <p>13a2.1.9/13a2.2.9 Detonation and deflagration in primary system boundary</p>

**Table 14a2-1 SHINE Facility Proposed Parameters for Technical Specifications  
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Chapter/ Section/ Subsection Reference per ANSI/ANS-1 5.1-2007	Section Name	LCO or Condition	Basis
3.4	Containment or Confinement	<ul style="list-style-type: none"> <li>• Tritium purification system (TPS) glove box system or confinement</li> <li>• IU and TOGS shielded cell confinement isolation valves</li> <li>• RPF confinement isolation valves</li> </ul>	<p>13a2.1.7/13a2.2.7 Mishandling or malfunction of equipment affecting the PSB</p> <p>13a2.1.12.2/13a2.2.12.2 Irradiation facility fires</p>
3.5	Ventilation Systems	<ul style="list-style-type: none"> <li>• Ventilation systems (RCA ventilation system Zone 1 [RVZ1]/RCA ventilation system Zone 2 [RVZ2])</li> <li>a. Isolation dampers</li> <li>b. Filters</li> <li>• Process vessel vent system (PVVS): Blowers operable</li> </ul>	<p>13a2.1.4/13a2.2.4 Mishandling or malfunction of target solution</p> <p>13a2.1.7/13a2.2.7 Mishandling or malfunction of equipment affecting the PSB</p> <p>13a2.1.12.3/13a2.2.12.3 TPS design basis accident</p> <p>13b.2.4 Critical equipment malfunction</p> <p>13a2.1.5/13a2.2.5 Loss of off-site power</p> <p>13a2.1.11/13a2.2.11 Primary system boundary interaction events</p>
3.6	Emergency Power	<ul style="list-style-type: none"> <li>• Emergency power system operable</li> </ul>	<p>13a2.1.5/13a2.2.5 Loss of off-site power</p> <p>13a2.1.11/13a2.2.11 Primary system boundary interaction events</p>

**Table 14a2-1 SHINE Facility Proposed Parameters for Technical Specifications**  
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Chapter/ Section/ Subsection Reference per ANSI/ANS-1 5.1-2007	Section Name	LCO or Condition	Basis
3.7	Radiation Monitoring Systems and Effluents	<ul style="list-style-type: none"> <li>• Noble gas storage tank activity</li> <li>• Target solution transfer decay time</li> <li>• Radiation monitoring systems               <ul style="list-style-type: none"> <li>a. Channels and interlocks with ventilation systems</li> <li>b. Monitoring equipment operable</li> </ul> </li> </ul>	<p>13b.2.4 Critical equipment malfunction</p> <p>13a2.1.4/13a2.2.4 Mishandling or malfunction of target solution</p> <p>13a2.1.7/13a2.2.7 Mishandling or malfunction of equipment affecting the PSB</p> <p>13a2.1.12.3/13a2.2.12.3 TPS design basis accident</p>
3.8	Experiments	N/A	N/A
3.9	Facility Specific LCOs	<ul style="list-style-type: none"> <li>• Criticality-safe sumps               <ul style="list-style-type: none"> <li>a. Sump pump operable</li> <li>b. Sump level detectors operable</li> </ul> </li> <li>• Radiological Integrated Control System (RICS)</li> </ul>	<p>13b.2.5 Inadvertent nuclear criticality in the radioisotope production facility</p> <p>13b.2.4 Critical Equipment Malfunction</p>

**Table 14a2-1 SHINE Facility Proposed Parameters for Technical Specifications**  
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Chapter/  
Section/  
Subsection  
Reference  
per  
ANSI/ANS-1  
5.1-2007

	Section Name	Design Features	Basis
5	Design Features		
5.1	Site and Facility Description	<ul style="list-style-type: none"> <li>Building design to resist external event such as airplane crash, tornados and tornado missiles, high winds, floods, seismic events</li> <li>Robust design of IU and TOGS shielded cells</li> <li>Pipe trench seals to mitigate the consequences of spills or leaks</li> <li>NGRS noble gas decay tank storage cell designed to mitigate the consequences of leaks; NGRS backflow preventer design; NGRS and gas decay tanks integrity</li> </ul>	<p>13a2.1.4/13a2.2.4 Mishandling or malfunction of target solution</p> <p>13a2.1.6/13a2.2.6 External events</p> <p>13a2.1.11/13a2.2.11 Primary system boundary interaction events</p> <p>13a2.1.12.1/13a2.2.12.2 Inadvertent exposure to neutrons from the neutron driver</p> <p>13b.2.3 External events</p> <p>13b.2.4 Critical equipment malfunction</p> <p>13a2.1.11/13a2.2.11 Primary system boundary interaction events</p> <p>13b.2.4 Critical equipment malfunction</p>

**Table 14a2-1 SHINE Facility Proposed Parameters for Technical Specifications  
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Chapter/  
Section/  
Subsection  
Reference  
per  
ANSI/ANS-1  
5.1-2007

	Section Name	Design Features	Basis
5.1 (cont'd)	Site and Facility Description	<ul style="list-style-type: none"> <li>Facility berms, cell, and vault configuration for chemical storage and processes</li> <li>TPS cell volume combined with TPS tritium inventory sufficient to maintain less than LFL assuming a tritium leak</li> <li>Robust TPS confinement system design; tritium transport containers</li> <li>Fire resistant construction of supercells, hot cells, tank enclosures, and process enclosures; three hour fire-rated barriers that separate fire areas</li> <li>Production facility biological shield; irradiation facility biological shield</li> </ul>	<p>13b.3 Analysis of accidents with hazardous chemicals</p> <p>13a2.1.7/13a2.2.7 Mishandling or malfunction of equipment affecting the PSB</p> <p>13a2.1.12.2/13a2.2.12.2 Irradiation facility fires</p> <p>13b.2.6 Radioisotope production facility fire</p> <p>13b.2.4 Critical equipment malfunction</p>

**Table 14a2-1 SHINE Facility Proposed Parameters for Technical Specifications  
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Chapter/ Section/ Subsection Reference per ANSI/ANS-1 5.1-2007	Section Name	Design Features	Basis
5.1 (cont'd)	Site and Facility Description	<ul style="list-style-type: none"> <li>RVZ1 ductwork robust design</li> </ul>	<p>13a2.1.4/13a2.2.4 Mishandling of target solution</p> <p>13a2.1.7/13a2.2.7 Mishandling or malfunction of equipment affecting the PSB</p>
5.2	TSV Coolant System Design	<ul style="list-style-type: none"> <li>Robust design of the TSV, TOGS, dump tank, piping and valves; and light water pool; dump tank elevation relative to the TSV</li> </ul>	<p>13a2.1.2/13a2.2.2 Excess reactivity</p> <p>13a2.2.1 Target solution spill in the irradiation operations area</p> <p>13a2.1.4/13a2.2.4 Mishandling or malfunction of target solution</p> <p>13a2.1.5/13a2.2.5 Loss of off-site power</p> <p>13a2.1.7 / 13a2.2.7 Mishandling or malfunction of equipment affecting the PSB</p> <p>13a2.1.9 / 13a2.2.9 Detonation and deflagration in primary system boundary</p>
5.3	Irradiation Unit	<ul style="list-style-type: none"> <li>Neutron driver access door interlock switch; thick walls in IU cell and shield plug</li> </ul>	<p>13a2.1.12.1/13a2.2.12.2 Inadvertent exposure to neutrons from the neutron driver</p>

**Table 14a2-1 SHINE Facility Proposed Parameters for Technical Specifications  
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Chapter/ Section/ Subsection Reference per ANSI/ANS-15. 1-2007	Section Name	Design Feature	Basis
5.4	Fissionable Material Storage	<ul style="list-style-type: none"> <li>Criticality safety design - TSV dump tank and RPF tanks; uranium storage; neutron absorber in tanks; criticality-safe containers, racks, sumps, vessels; concrete vault walls</li> </ul>	<p>13a2.1.2/13a2.2.2 Excess reactivity</p> <p>13b.2.5 Inadvertent nuclear criticality in the radioisotope production facility</p>

14a2.7 REFERENCES

**ANSI/ANS, 2007.** The Development of Technical Specifications for Research Reactors, American National Standards Institute, ANSI/ANS-15.1, 2007.

## 14b TECHNICAL SPECIFICATIONS OF PROCESSES OUTSIDE THE IRRADIATION FACILITY

This section encompasses the technical specifications for the processes involving special nuclear material (SNM), radioisotopes, and chemicals outside the IF produced from licensed materials.

In accordance with the requirements of 10 CFR 50.34 (a)(5), this section identifies the variables and conditions that will likely be the subjects of technical specifications for the SHINE facility. These may change with the operating license application. These variables and conditions are based on the preliminary design of the SHINE facility. The technical specifications will be submitted with the operating license application.

These proposed technical specifications have been formulated on the premise that this material presents a sound framework upon which a final, complete set of specifications can be developed with the operating license application.

### 14b.1 INTRODUCTION

The format and content of the Technical Specifications will be written with the guidance provided in ANSI/ANS 15.1 (ANSI/ANS 2007), NUREG-1537, and the Final ISG Augmenting NUREG-1537. The technical specifications for the facility outside the IF will comply with the regulations in 10 CFR 50.36 pertaining to a fuel reprocessing facility, as required by the Final ISG Augmenting NUREG-1537.

## 14b.2 SAFETY LIMITS AND LIMITING SAFETY SYSTEM SETTINGS

### 14b.2.1 SAFETY LIMITS FOR PROCESSING IRRADIATED SPECIAL NUCLEAR MATERIAL OUTSIDE OF THE REACTOR

For irradiated SNM outside of the TSV, SLs are derived for criticality accident prevention based on the Nuclear Criticality Safety Program, and also from an Integrated Safety Analysis (ISA). Limits are specified, using the double-contingency principle, to avoid a criticality accident. Limits are set with a conservative margin.

For irradiated SNM outside of the TSV, appropriate limits are imposed pursuant to 10 CFR 50.36(c)(1) to ensure that fission products will be controlled to prevent excessive releases from the containment components, systems, or structures, particularly those structures, systems, and components containing large inventories of byproduct material.

### 14b.2.2 SAFETY LIMITS FOR PROCESSING UNIRRADIATED SPECIAL NUCLEAR MATERIAL OUTSIDE OF THE IRRADIATION FACILITY

Limits are specified, using the double-contingency principle, to avoid a criticality accident. Limits are set with a conservative margin.

### 14b.2.3 SAFETY LIMITS FOR RADIOCHEMICAL PROCESSING

Safety limits for radiochemical processing are developed to maintain operations within limits pursuant to 10 CFR 50.36 to protect the staff and the public. The amount of radiation is limited so as not to exceed the shielding and confinement capabilities of the systems and components in which the materials are processed or stored.

### 14b.2.4 SAFETY LIMITS FOR CHEMICAL PROCESSING

Safety limits for chemical processing with hazardous chemicals that are conducted coincident to operations with SNM or radioactive material are developed in accordance with 10 CFR 50.36.

### 14b.2.5 LIMITING SAFETY SYSTEM SETTINGS

For each process variable or parameter for which a SL is specified, and for which monitoring instruments are used, a protective operating limit is set to avoid exceeding the SL. This LSSS is calculated to provide a conservative margin below the SL and to account for overall measurement uncertainty, operating characteristics of control systems, and accuracy of control instrumentation. LSSSs will be established, as much as possible, to ensure adequate safety margins for each of the processes described above.

Refer to Table 14a2-1 for the SLs and LSSSs associated with the processes outside the irradiation facility.

### 14b.3 LIMITING CONDITIONS FOR OPERATION

LCOs are derived from the ISA and are administrative or engineered controls in addition to LSSSs that are put in place to ensure that operations are maintained within safe limits.

The LCOs will include the features discussed in the following subsections as appropriate. Refer to Table 14a2-1 for the LCOs associated with the processes outside the irradiation facility.

#### 14b.3.1 PRIMARY PROCESS COMPONENTS AND SYSTEMS

Processing SSCs and procedures that are designed and constructed to ensure that processing is conducted safely will have LCOs established for each of the processes defined in Section 14b.2 above.

#### 14b.3.2 CONTAINMENT AND CONFINEMENT

A confinement system is required as a result of the ISA and is defined as an LCO, pursuant to 10 CFR 50.36(c)(1).

#### 14b.3.3 VENTILATION SYSTEMS

The ISA prescribes the need for certain ventilation configurations, they are listed as an LCO pursuant to 10 CFR 50.36(c)(1).

#### 14b.3.4 EMERGENCY ELECTRICAL POWER

The ISA prescribes the need for emergency electrical power, the power supply is listed as an LCO pursuant to 10 CFR 50.36(c)(1).

#### 14b.3.5 RADIATION MONITORING SYSTEMS AND EFFLUENTS

Radiation monitoring systems and limits on effluents are specified as they pertain to the above-referenced processes, pursuant to 10 CFR 50.36(c)(1).

14b.4 SURVEILLANCE REQUIREMENTS

Surveillance requirements will be provided in the technical specifications.

## 14b.5 DESIGN FEATURES

Design features that will be provided in the technical specifications are the features of the SHINE facility, such as materials of construction and geometric arrangements that would have a significant effect on safety if these features were altered or modified. The requirements of 10 CFR 50.36(c)(4) are specified here as they pertain to the above referenced processes. Refer to Table 14a2-1 for the design features associated with the processes outside the irradiation facility

14b.6 ADMINISTRATIVE CONTROLS

See Section 14a2.6 for examples of Administrative Controls that will be in use at the SHINE Facility.

The remaining administrative controls will be provided in the technical specifications.

14b.7 REFERENCES

**ANSI/ANS, 2007.** The Development of Technical Specifications for Research Reactors, American National Standards Institute, ANSI/ANS-15.1, 2007