ENCLOSURE 1

SHINE TECHNOLOGIES, LLC

MEETING SLIDES FOR THE NOVEMBER 15TH, 2023 PUBLIC MEETING BETWEEN SHINE TECHNOLOGIES, LLC AND THE NRC

19 pages follow

Introduction to the SHINE Used Nuclear Fuel Recycling Pilot Facility

Outline

- Background on SHINE
- Technology Overview
  - Used Nuclear Fuel Recycling Process
  - Radionuclide Inventory and Risk
  - Safety Analysis Methodology
  - General Design Criteria
- Regulatory Strategy
  - Licensing Approach
  - On-Going Regulatory Analyses
  - Future Public Meeting Topics

SHINE

SHINE's Market-Driven Approach to Fusion

VISON: TRANSFORMING HUMANKIND THROUGH FUSION TECHNOLOGY

1 Inspect Industrial Components

Fusion 1.0
(solid target)

COMMERCIAL

2 Produce Medical Isotopes

Fusion 2.0
(gas target)
+
Radiochemical & Uranium Processing 1.0

COMMERCIAL, SCALING

3 Recycle Nuclear Waste

Fusion 3.0
3B: Transmutation w/fusion
+
3A: Radiochemical & Uranium Processing 2.0

DEVELOPING

4 Generate Fusion Power

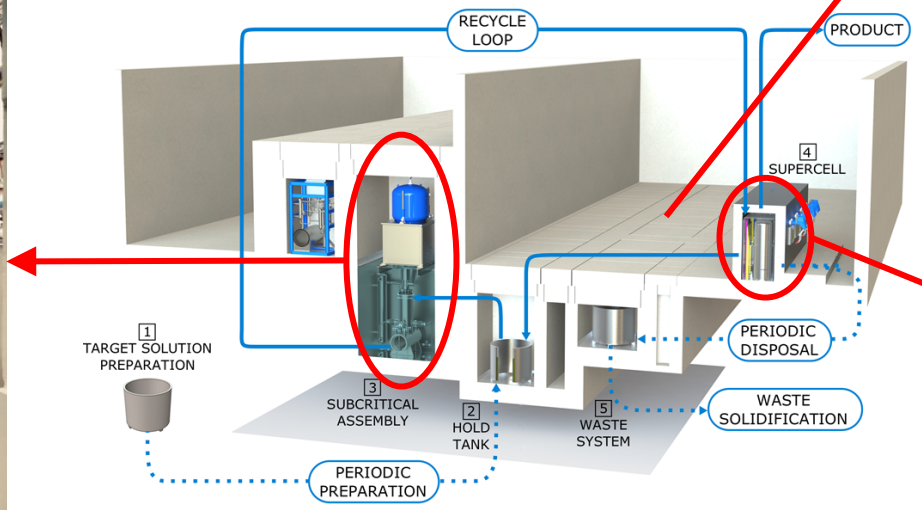
Fusion 4.0
(hot plasma)

R&D

SHINE

Phase 2: Isotope Production/Separation

- Licensed and constructed; installing process equipment
- Facility will produce ½ of U.S. Mo-99 demand
- Production Process:
  1. Irradiate aqueous LEU subcritical assembly with DT neutrons
  2. Up to 1 MW of fissions produced
     a. Mo-99 has a ~6% cumulative yield
  3. Transfer uranyl sulfate to hold tanks and then the “supercell”
     a. Mo-99 extraction, purification, QC, and packaging
  4. Final products shipped to customer



Licensing of SHINE Isotope Production/Separation Technology

- Licensing of the SHINE Mo-99 Facility required resolving similar regulatory gaps identified by the NRC Staff in SECY-09-0082
  - Development of a facility-specific safety analysis methodology (i.e., the SHINE Safety Analysis [SSA]) characterizing the risk of both the utilization facilities and production facility (Gap #5)
  - Establishing a program for the licensing of production facility operators (Gap #7)
  - Development of facility-specific general design criteria (Gap #9)
  - Development of facility-specific Technical Specifications (Gap #11)
    - Inclusive of all safety-related controls identified in the SSA

Construction Permit (CP) Application	
CP Application (Part 1) Submitted	March 2013
CP Application (Part 2) Submitted	May 2013
Issuance of Final Environmental Impact Statement (EIS)	October 2015
Issuance of Final Safety Evaluation Report (SER)	October 2015
Mandatory Hearing	December 2015
Issuance of CP	February 2016

Operating License (OL) Application	
OL Application Submitted	July 2019
Issuance of Final EIS Supplement	January 2023
Issuance of Final SER	February 2023

SHINE

Phase 3A: Used Nuclear Fuel (UNF) Recycling

ENABLING THE NEXT 100 YEARS OF CLEAN NUCLEAR ENERGY

- SHINE is developing a UNF recycling solution to:
  - Increase utilization of fission as a prominent source of carbon-free energy
    - Domestic supply of recycled uranium (RecU), mixed oxide (MOX), and (perhaps) high assay low enriched uranium (HALEU) fuel alternative
    - Reduce UNF volume and help answer, “what about the waste?”
- Leveraging unique capabilities
  - Licensing, construction, and commissioning of 10 CFR Part 50 facility
    - Irradiated uranium solution handling
    - Vacuum transfer, rad-tolerant valves, passive safety components, tritium handling systems, and remote operation capabilities
  - Radionuclide separation
- Phase 3B (transmutation) is outside the scope of this regulatory engagement

SHINE CEO and CTO with ANL and Orano staff at La Hauge facility

SHINE

Recycling Process Overview

COMBINING PROVEN INDUSTRIAL TECHNOLOGY WITH TARGETED INNOVATION

- Facility Goals:
  - Commercial-scale integrated technology and licensing demonstration
  - Sized to fully demonstrate economic potential
    - Process 100-200 metric ton of initial heavy metal (MTiHM) per year
    - Targeting fuel > 40 years old
- Key technology aspects have been proven for decades
  - SHINE is partnering with leaders in this space
- Starting with proven technologies to de-risk project
  - Radionuclide separation and handling
  - Head-end operations
    - Shearing
    - Dissolution
  - Liquid-liquid extraction
  - Gas and liquid waste handling
  - Criticality control

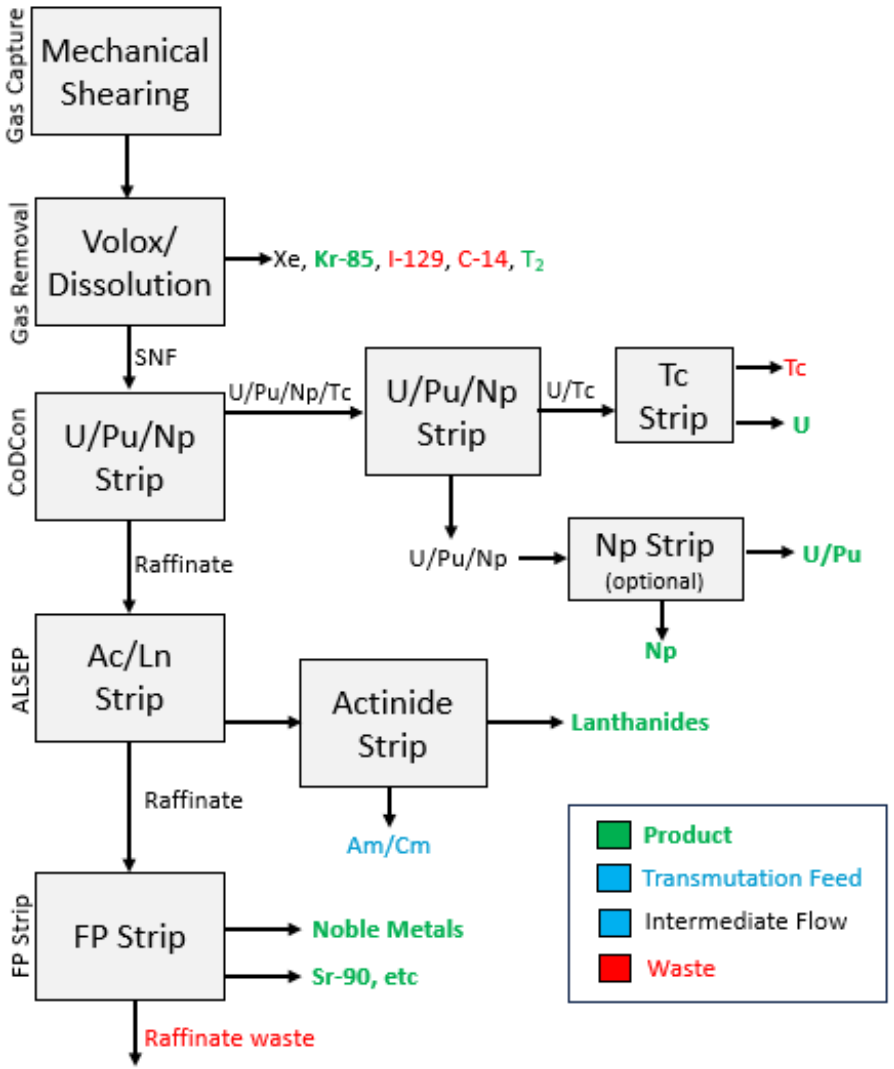
SHINE Mo-99 Facility subgrade piping installation

SHINE

Recycling Process Overview

IMPROVEMENTS FOR REGULATORY COMPLIANCE AND IMPROVED ECONOMICS

- Voloxidation for pre-processing fuel assemblies allows isolation of iodine/tritium to avoid liquid contamination
- CoDCon extraction to create RecU and U/Pu streams
  - Assessing crystallization techniques to reduce process volume
- Extract minor actinides from raffinate
  - Future transmutation targets and some commercial use
- Harvest critical minerals from fission products



Products Streams

- Product streams include:
  - MOX: light water reactor (LWR) or high assay low enriched uranium (HALEU) fuel
  - RecU: LWR fuel, after re-enrichment
  - Np-237: Pu-238 production (radio-battery)
  - Am-241: Industrial applications
  - Sr-90: Radio-battery applications, medical isotopes (as parent of Y-90 radiopharmaceutical)
  - Stable lanthanides and noble metals: Industrial applications
- Minor actinides and potentially Tc-99, I-129, and other long-lived fission products will be stored for future transmutation

Waste Streams

- Expected that greater than 95% of waste will be suitable for near-surface disposal
- Primary waste streams include volatile fission product capture media, cladding and end pieces, product extraction and purification media, and solidified raffinate
  - Cladding and end pieces will be compacted and encased in concrete prior to storage or disposal
  - Ion exchange columns and other separation media will be evaluated for stability of the waste form, free liquid, and radionuclide content prior to selection of the final waste form
- Undissolved solids, raffinate, effluent from column washes or purification steps, and spent nitric acid or solvent solutions will be solidified prior to disposal
  - Current facility baseline is to concentrate and solidify in a cementation process
  - Waste streams may also be blended for waste optimization

Radionuclide Inventories

- UNF Recycling Pilot Facility feed material:
  - PWR and BWR assemblies
  - Burnup less than 35 gigawatt-days per metric ton of initial heavy metal (GWd/MTiHM)
  - Decay following reactor discharge of 40 years or more
- Facility sized to process 100-200 MTiHM per year
- In-process inventory of approximately 1 MTiHM
- Solidified products and waste streams are stored separate from the main processing building
  - Minimizes risk to workers by reducing time near source terms with higher radiological consequences
  - Minimizes footprint and simplifies construction for areas of highest risk
  - Allows for optimization of storage segregation based on security and radiological risk

SHINE

Safety Analysis Methodology

OVERVIEW

- SHINE-specific, risk-based methodology similar to the guidance described in NUREG-1520, "Standard Review Plan for Fuel Cycle Facilities License Applications"
  - Semi-quantitative, with the use of indices to evaluate the likelihood and consequence of all accident scenarios identified in the process hazard analysis (PHA)
    - Hazard and operability studies (HAZOPs) and failure modes and effects analyses (FMEAs) on each individual process system or group of systems feeds into the PHA
  - Accident scenarios are grouped into accident categories
  - Controls are applied to ensure all accident scenarios meet an acceptable level of risk
  - Bounding accident scenarios in each accident category are then quantitatively evaluated for radiological or chemical consequence to ensure they are within the defined limits
- Nuclear criticality safety evaluations will be conducted for each fissile material operation
- With the feed material and size of pilot facility, very high consequence events are not expected

Safety Analysis Methodology

LICENSING BASIS

- The Accident Analysis Chapter of the Safety Analysis Reports (SARs) will include:
  - General descriptions of accident scenarios with potential consequences
  - Lists of all credited safety-related controls in each accident category
  - Detailed descriptions of the bounding accident scenarios in each accident category, including:
    - Accident description, initial conditions, sequence of event, list of credited safety controls, defined material at risk, transport parameters, and quantified consequences to the worker and public
  - Summaries of nuclear criticality safety evaluations and credited controls
- Credited safety-related controls will be included in the facility Technical Specifications

General Design Criteria

DOCUMENTS INFORMING DEVELOPMENT

- 10 CFR Part 50, Appendix A, “General Design Criteria for Nuclear Power Plants”
- 10 CFR § 70.64, “Requirements for New Facilities or New Processes at Existing Facilities”
- 10 CFR Part 72, Subpart F, “General Design Criteria”
- Proposed 10 CFR Part 50, Appendix P, “General Design Criteria for Fuel Reprocessing Plants”
- Proposed 10 CFR Part 50, Appendix Q, “Design Criteria for Protection of Fuel Reprocessing Plants and Licensed Materials Therein”

SHINE

General Design Criteria Categories

- Overall requirements
- Confinement systems
- Process safety
  - Reliability of safety-related controls, chemical protection, etc.
- Radiological protection
- Fissile material control
  - Security, material control and accounting (MC&A), and criticality safety

Licensing of SHINE's UNF Recycling Pilot Facility

- SHINE intends to license the UNF Recycling Pilot Facility in accordance with the two-step licensing process under 10 CFR Part 50
  - The UNF Recycling Pilot Facility meets definition (3) of "production facility" in 10 CFR § 50.2
  - SHINE intends to request a Class 103 license, in accordance with 10 CFR § 50.22
- SHINE intends to develop the SARs in accordance with the format and content guidance in Regulatory Guide 3.26, "Standard Format and Content of Safety Analysis Reports for Fuel Reprocessing Plants"
  - SHINE will supplement the guidance in Regulatory Guide 3.26 with more recent application content guidance for production facilities and fuel cycle facilities

Regulatory Analyses Being Performed by SHINE

- SHINE is currently reviewing all of Title 10, Chapter I, of the Code of Federal Regulations for applicability to the UNF Recycling Pilot Facility, identifying regulations as:
  - Applicable,
  - Not Applicable,
  - Applicable in Part, or
  - Requiring Exemption
- SHINE is also reviewing regulatory guidance (e.g., NUREGs and Regulatory Guides) for applicability to the UNF Recycling Pilot Facility
  - The review will identify the regulatory guidance that is applicable, as well as non-applicable regulatory guidance that may be used to supplement dated or non-existent regulatory guidance
- Each of the above regulatory analyses are expected to be topics of future public meetings between SHINE and the NRC staff

Topics of Future Pre-Application Meetings

- SHINE has currently identified the following topics as likely subjects of pre-application technical discussions with the NRC staff:
  - SHINE Process Overview
  - Applicable NRC Regulations and Regulatory Guidance
  - Construction Permit Application Content
  - General Design Criteria Development
  - Quality Assurance Program Description
  - Preliminary Plans for Coping with Emergencies
  - Development of the Environmental Report
  - Site Selection and Site Characterization
  - Approach to Radiological and Chemical Accident Analysis
  - Seismic Design Methodology
  - Transportation, Waste Storage, and Waste Classification


SHINE