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## INSPECTION PROCEDURE 89025

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### ASSESSMENT OF DRYER AND YELLOWCAKE PACKAGING OPERATIONS

Effective Date: July 26, 2024

PROGRAM APPLICABILITY: IMC 2801

#### 89025-01 INSPECTION OBJECTIVES

- 01.01 To establish the inspection program for dryer and yellowcake packaging operations at conventional, heap leach, and in-situ recovery (ISR) uranium mills licensed and regulated under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 40.
- 01.02 To determine if dryer and yellowcake packaging operations are protective of workers, members of the public, and the environment.
- 01.03 To determine if dryer and yellowcake packaging operations comply with U.S. Nuclear Regulatory Commission (NRC) license and regulatory requirements.

#### 89025-02 INSPECTION REQUIREMENTS

Conduct performance-based inspections with an emphasis on risk significant activities that have an impact on safety and the environment. As described in Inspection Manual Chapter (IMC) 2801, using a performance-based, risk-informed approach focuses inspector attention on activities important to the safety of the worker and the public, and the protection of the environment.

##### 02.01 Specific Inspection Requirements to Meet Objectives.

To meet the objectives of this Inspection Procedure (IP), the inspector shall conduct the following minimum inspection activities:

- a. To the extent possible, perform in-office preparations before the onsite inspection effort. Preparations should include a review of the site's license, license application, and routine reports submitted to the NRC since the last inspection. Determine if any significant changes have been made to the licensee's dryer and yellowcake packaging operations since the last inspection.
- b. Conduct one or more site tours to verify that critical dryer equipment, support systems, alarms, interlocks, ventilation systems, and enclosures are functioning as required by the license, license application, and site procedures. Verify that process parameters such as dryer temperature and pressures are within license and procedural limits.

- c. Observe one or more critical activities such as routine dryer and yellowcake packaging operations, system maintenance activity, routine interlock tests, or operator walkdowns to ensure that the licensee has established and implemented procedures for these activities. The observed activities should be rotated during subsequent inspections.
- d. Verify through a limited records review that the licensee is monitoring and recording pertinent data as required by the license and site procedures. Verify that any negative operational trends have been identified and addressed by the licensee.
- e. Determine if any significant changes in dryer or yellowcake packaging operations have been made since the last inspection. If so, ensure that the changes have been appropriately evaluated and implemented by the licensee using its performance-based license (Safety and Environmental Review Plan [SERP] review process) or license amendment.

## 02.02 Performance-based/Risk-informed Inspections

The NRC has identified the risks associated with uranium recovery and 11e.(2) byproduct material operations. These risks are documented in NUREG-2150, "A Proposed Risk Management Framework," and NUREG-CR/6733, "A Baseline Risk-Informed, Performance-Based Approach for In-Situ Leach Uranium Extraction Licensees." These activities include yellowcake dryer operations and accidents, excessive occupational exposures under certain dryer and drumming accident scenarios, and environmental contamination.

In summary, the inspector shall verify compliance primarily through observations of site conditions, observations of work activities, interviews with workers, demonstrations by workers, and reviews of critical records. The inspector shall focus attention on the most important, risk-significant activities and the results of the licensee's efforts.

## 89025-03 INSPECTION GUIDANCE

This section provides information to assist the inspector in meeting the inspection requirements.

### 03.01 General Discussion of Dryer and Yellowcake Packaging Operations

After the precipitation process, the yellowcake slurry is transferred to a thickener tank where the slurry is settled, washed, filtered, and dewatered. At this point, the slurry is 30 to 50 percent solids. The slurry can either be transported offsite to a different uranium recovery facility to process the slurry into dried yellowcake, or the slurry may be filter-pressed to remove additional water, dried, and packaged onsite.

Two kinds of yellowcake dryers are used: multi-hearth dryers and vacuum dryers. Older mills may use gas-fired multi-hearth dryers. These dryers typically dry the yellowcake product at about 400 degrees Celsius (°C) or above. Because of the high temperatures involved, any organic contaminants in the yellowcake (e.g., oil or grease) will be completely burned off and will exit the system as dryer off-gas. Newer ISR facilities typically use vacuum yellowcake dryers, and the drying occurs at a relatively low temperature of about 150°C. In a vacuum dryer, the heating system is isolated from the yellowcake, so no radioactive materials are entrained in the heating system or its exhaust. The heating system may consist of heated oil that is pumped through a jacket

that surrounds the drying chamber. The drying chamber that contains the yellowcake slurry remains under a vacuum. Therefore, any potential leak would cause air to flow into the chamber. The radiation protection program requirements typically vary based on the type of dryer and the drying temperatures.

As the yellowcake slurry is heated, the moisture in the slurry is flashed off as a vapor. This vapor is passed to a filter bag house which is located on top of the dryer shell. The baghouse removes particulates, while the solids from the filter baghouse are returned to the dryer for packaging. The condensed water vapor drains to a tank and is transferred for further processing and/or disposal. Vacuum pumps are used to create a vacuum on the entire system.

The dried yellowcake product is removed from the bottom of the dryer and packaged in drums for eventual shipment offsite. The packaging area normally has a baghouse dust collection system to protect personnel and to minimize yellowcake release. Air from the baghouse dust collection system is typically routed to the dryer off-gas line and scrubber. During drum loading, the drum is normally kept under negative pressure via a drum hood with a suction line. The drum hood transports any released particulates to a baghouse dust collector. The filtered air from the baghouse may join the dryer off-gas and is passed through the scrubber.

Worker exposures are mostly related to the processes used to transfer the yellowcake from the vacuum dryer to drums for shipping or during replacement of bag filters. Drums removed from the dryers are allowed to vent for a few days before the drum is sealed. This helps to prevent over-pressurization of the drums.

a. Detailed Discussion of Multiple Hearth Dryers

Multiple hearth dryers are gas-fired dryers (furnaces) that operate at high temperatures (in excess of 400°C) to remove water from the yellowcake slurry. The dryers are generally configured as a series of hearths (usually six) stacked up in a single diameter cylinder. Because of the high temperatures, some of the organic contaminated in the slurry will be completely burned up and other contaminants will be part of the airborne effluent exiting the system as an off-gas. The airborne effluent will contain some particulate uranium oxide, so the effluent must exit the system and pass through a water-cooled scrubber to capture the uranium oxide particulate before exiting the plant via a system stack. Scrubber systems are usually highly effective (90 to 99 percent) at removal of the uranium oxide from the airborne effluent. Failure or reduced efficiency of the scrubber can significantly add to the radioactive. Pressure gauges installed on each level of the multiple hearth dryer should be monitored as a drop in pressure which could indicate a drop in efficiency of the scrubbers and conversely an increase in pressure which could be an early warning sign of potential explosive conditions. An explosion or leakage from the dryer or the associated piping could disperse yellowcake into the dryer room and expose workers to respirable soluble and insoluble uranium particles. This exposure could create significant unplanned doses to the lung and bone surfaces for the exposed personnel. Employees can also be exposed to heavy metals because of dryer failure.

## b. Detailed Discussion of Vacuum Dryers

Vacuum dryers operate at lower temperatures (usually around 150°C) and rather than the yellowcake being part of the dryer/heating system as it is with the multiple hearth dryer the heating system for vacuum dryers is separate from the yellowcake, so no radioactive material is present in the heating system of the dryer. The dryer chamber is maintained under a vacuum using vacuum pumps, so that any potential leakage results in air flow into the dryer chamber.

As the yellowcake slurry is heated, the moisture in the slurry is flashed off as a vapor. This vapor is passed to a filter bag house which is located at the top of the dryer shell. The baghouse removes particulates, while the solids from the filter baghouse are returned to the dryer for packaging. The condenser water vapor drains to a tank and is transferred for further processing or disposal.

### 03.02 Review of Key Attributes

The inspector should verify during an inspection of dryer and yellowcake packaging operations that:

- Annual yellowcake production does not exceed the limit specified in the license.
- Emergency instructions have been established for yellowcake spills, transportation events, and other accidents involving the dryer and yellowcake material.
- Interlocks have been established to ensure alarms are activated or equipment safely shut down when operational parameters are exceeded. Interlocks may include both automatic actions or manual action in response to an alarm or abnormal condition.
- All workers assigned to drying and packaging operations have received specialized instruction on equipment operation and radiation safety.
- After filling, ensure that the drums are staged to allow for venting of internal pressures (see NRC Information Notice 99-01, revision 1).
- After filling, ensure yellowcake drums are washed down to remove surface contamination.

### 03.03 Radiation Protection Controls

Uranium is radiologically and chemically toxic. Regulations and license conditions require the licensee to establish radiation protection controls for worker protection. Verify the following radiation protection controls have been implemented:

- Licensee has established controls for both internal and external monitoring commensurate with the work to be performed.
- Dosimeters have been assigned to workers as needed to monitor for external exposures to radioactive material.
- Bioassay program has been established and implemented in accordance with regulatory, license, and procedural requirements.

- Bioassay samples are being collected from dryer and yellowcake packaging operators, and the results are being reviewed by the radiation safety officer.
- Corrective actions specified in the license or in the licensee's implementing procedures are being taken for bioassay results that exceed the action levels.
- General and breathing zone samples are collected as specified in the license or the licensee's implementing procedures.
- Occupational air sample results are analyzed, and internal doses assigned per site procedures based on NRC-approved solubility classification, use of respirators, and airborne sample results.
- Respiratory protection program has been established and implemented for workers who work in airborne radioactivity areas.
- Protective clothing is provided to workers, and showers or changes of clothing are available to workers.
- The dryer and packaging operations areas are posted as airborne radioactivity areas during operations, as required by regulations and site procedures.
- Doors and other access points are posted as radiation areas or airborne radioactivity areas as necessary.
- The radiation safety officer or designee performs surveys of the dryer room after completion of a packaging campaign before downgrading radiological postings.
- Spills of yellowcake are promptly cleaned up or areas washed down.
- Non-routine work or maintenance on the dryer are conducted using radiation work permits.
- The dryer area is included in daily visual inspections including locating yellowcake contamination on surfaces for each day the dryer is used.

#### 03.04 Transportation Activities

Ensure drums of yellowcake slurry or yellowcake are prepared for shipment in accordance with U.S. Department of Transportation (DOT) requirements and site procedures. This includes:

- surveys of external surfaces including the bottom of the drums
- preparation of shipping papers including emergency response instructions
- drums are marked and labeled in accordance with DOT requirements
- trailer has been placarded in accordance with DOT requirements
- truck and trailer have been surveyed prior to transporting drums offsite

- preparation of international shipments including use of Yellow II labels and possession of export license

#### 03.05 Effluent Monitoring for Yellowcake Stack Emission Control Equipment

Dryers which use a yellowcake stack for emissions control are required to adhere to the requirements in 10 CFR 40, Appendix A, Criterion 8. Ensure the following when inspecting the use of yellowcake stacks:

- Stacks are sampled at the required frequency, and results are presented in the semi-annual effluent and environmental monitoring reports that coincide with the sample collection.
- Checks are made and logged hourly of all parameters (e.g., differential pressures and scrubber flow rates) that determine the efficiency of the yellowcake stack emission control equipment operation. Licensee suspends operations if emission control equipment for dryers or packaging areas is not performing within operational specifications.

#### 03.06 Dryer and Packaging Procedures

Licenses specify that written standard operating procedures shall be established for all activities that involve handling, processing, or storing radioactive materials. All such procedures should include consideration of pertinent radiation safety practices. Ensure procedures have been established for all operational activities involving radioactive material including instructions for managing operations during upset conditions. Note that operations involving dryer and drum packaging may be covered by a series of procedures, and the process may not always be continuous, but procedures should be established for all operational activities involving radioactive materials. Procedures must include checks of the operational parameters as specified in the license or application, or these operational parameters are automatically recorded. Ensure non-routine activities including maintenance are controlled using radiation work permits.

Verify the license is aware of over pressurization of yellowcake drums and have standard and emergency procedures in place to address these types of incidents as discussed in IN 1999-03, Revision 1, "Exothermic Reactions Involving Dried Uranium Oxide Powder."

#### 03.07 Changes to Procedures, Programs and Facilities

Some licensees have license conditions that allow it to make changes to existing procedures, programs, and facilities under certain conditions. These changes could include updating site procedures, adding or removing equipment, adding or removing chemicals to the process, and revising the organizational structure. These changes are commonly documented in SERP evaluations, or equivalent, and are summarized in an annual report to the NRC. The inspector should verify that:

- Changes to procedures are reviewed by the pertinent staff and/or the SERP.
- Changes to the design of the dryer or the introduction of new chemicals to the precipitation process have been reviewed by the SERP.

- Changes made by the SERP did not impact the licensing bases and did not require prior approval by the NRC.
- Changes have not eliminated the interlocks, alarms, and controls referenced in the license used to monitor critical parameters and to initiate safety shutdowns.
- Changes made through the SERP process are reported to the NRC as required by the license in an annual report.

The inspector should review the SERP evaluations during the inspection to ensure the licensee's approved changes have been effectively implemented as described in the SERP evaluation. Review of SERPS should be documented in the inspection report and a statement indicating whether the inspector agreed with the SERP's determination that a license amendment was or was not required for the change/update to operations.

#### 89025-04 RESOURCE ESTIMATE

The inspection effort will require 1–2 NRC staff and will take about 1 to 2 days (8–16 hours) to complete, depending on the complexity of the licensee's dryer and yellowcake packaging operational programs. This resource estimate excludes travel, preparation, and documentation time.

#### 89025-05 PROCEDURE COMPLETION

This IP is complete when the inspection staff observe the activities, interview site staff, and review records as needed to satisfy the objectives of this IP. This IP should be completed at least once per year if the site utilizes a dryer and that dryer has been operational since the last inspection. In the event that the inspector confirms the dryer was not used since the last inspection, this IP can be deferred, based on site status and operations, or at other frequencies as established in the Master Inspection Plan.

#### 89025-06 REFERENCES

IMC 2801, "Uranium Recovery and 11e.(2) Byproduct Material Facility Inspection Program"

NRC Information Notice 1999-03, Revision 1, "Exothermic Reactions Involving Dried Uranium Oxide Power (Yellowcake)," March 4, 2014

NUREG-1910, Revision 1, "Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities," May 2009

NUREG-2150, "A Proposed Risk Management Regulatory Framework," April 2012

NUREG-CR/6733, "A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees," September 2001

Regulatory Guide (RG) 8.22, Revision 2, "Bioassay at Uranium Mills," May 2014

RG 8.30, Revision 1, "Health Physics Surveys in Uranium Recovery Facilities," May 2002

RG 8.31, Revision 1, "Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Is Reasonably Achievable," May 2002

END

Attachments:

Attachment 1: Revision History for IP 89025



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Commitment Tracking Number	Accession Number Issue Date Change Notice	Description of Change	Description of Training Required and Completion Date	Comment Resolution and Closed Feedback Form Accession Number (Pre-Decisional, Non-Public Information)
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