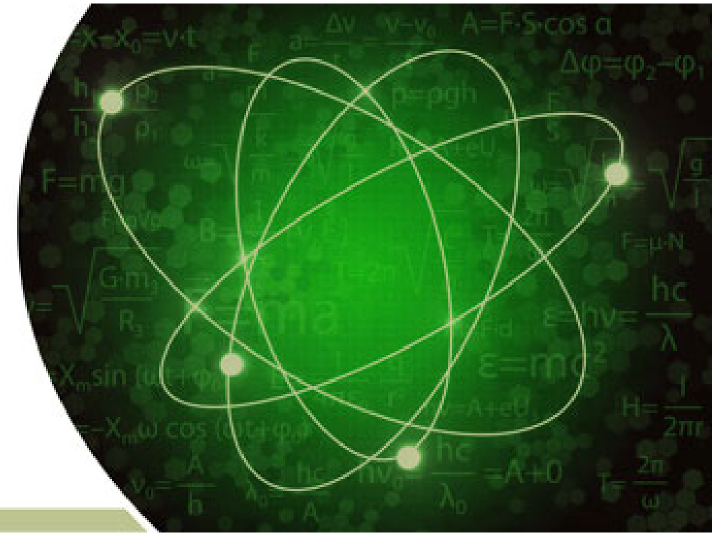
ANS Annual Meeting

2019 THE VALUE OF NUCLEAR



MISSION CHANGE FROM ENRICHMENT TO DEACTIVATION IMPACT ON NUCLEAR CRITICALITY SAFETY

Tom Hines
Portsmouth/Paducah Project Office Nuclear Safety Oversight Lead

Matthew Wilson
Senior NCS Consultant, Paschal Solutions Inc.

Brandon J. Little
Nuclear Safety Engineer, Four Rivers Nuclear Partnership, LLC

John B. Justice
Nuclear Safety Lead/Senior NCS Engineer, Four Rivers Nuclear Partnership, LLC

Portsmouth/Paducah Project Office

<u>MISSION STATEMENT:</u>

The Mission of the Portsmouth/Paducah Project Office (PPPO) is to conduct the safe, secure, compliant, and cost effective environmental legacy cleanup of the Portsmouth and Paducah Uranium Enrichment Sites on behalf of the local communities and the American taxpayer.

<u>VISION STATEMENT:</u>

Safely Working for a Shared Vision of a Cleaner Tomorrow.

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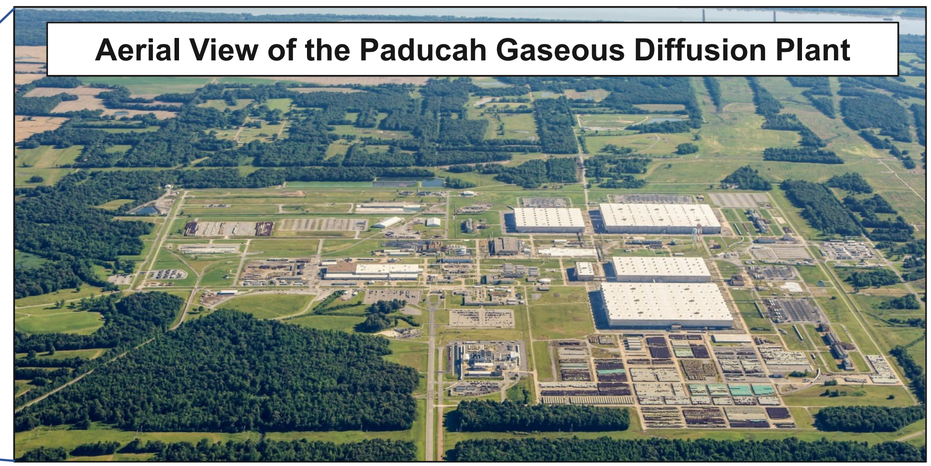
Purpose

- The paper presents the following:

1. How the mission change from uranium enrichment to deactivation affected <u>personnel</u> who worked at the GDPs.
2. What <u>changes in process conditions have occurred</u> as a result of the mission change.
3. The NCS Program <u>transitional challenges</u> from enrichment to deactivation.
4. <u>Lessons learned</u>.


Aerial View of the Portsmouth Gaseous Diffusion Plant


Aerial View of the Paducah Gaseous Diffusion Plant

Mission Change Impact on Personnel

- "*Nothing is so painful to the human mind as a great and sudden change.*"
  - Mary Wollstonecraft Shelly

- Changed Condition – Maintaining a flow of UF_6 to…….**shutdown and deactivation.**

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Mission Change Impact on Personnel (cont.)

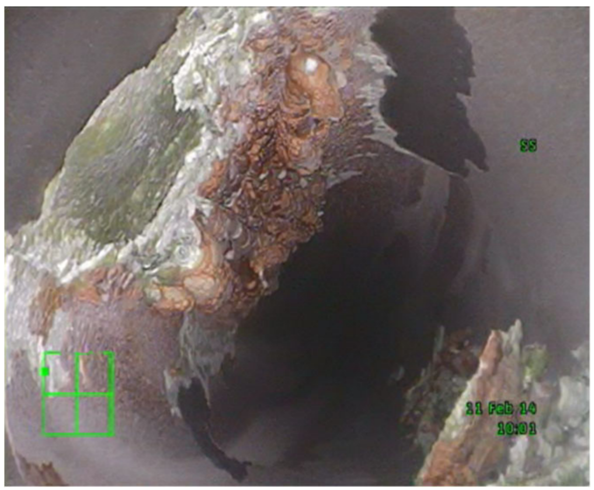
- **Mission Change Summary**:
  - ❑The enrichment process had a defined and understood mission!
    - To make enriched uranium product safely and efficiently by feeding UF_6 into the process, flowing it through the cascade to achieve isotopic separation, and then withdrawing the product into cylinders.
  - ❑The deactivation mission is to eliminate hazards and return the site to a green field state.
    - Sequence, method of accomplishment, and timing needed to be established and communicated to the workforce.
      - What equipment is needed to keep functional for deactivation?
      - How to deactivate (e.g., clean out, tear out, leave as-is, other)?
      - What building or process to do first?

Mission Change Impact on Personnel (cont.)

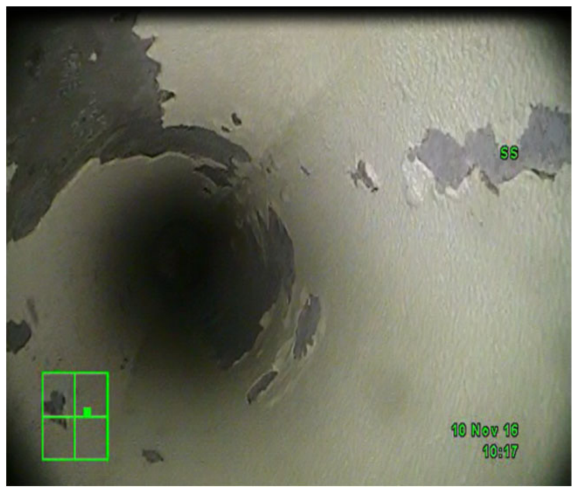
- **The mindset that the shutdown plant does not need a criticality safety program.**
  - It is true that UF_6 was removed from most of the process; however, fissile material remains in the processing equipment due to reactions of UF_6 with water, oil, and plate-out.
  - Many of the criticality accidents resulted from changing the fissile material process and not recognizing that the change affects criticality safety (LA-13638, A Review of Criticality Accidents).
  - The gaseous diffusion plants and equipment are large and interconnected. Even "small" amounts of fissile material in individual components cannot be ignored due to the accumulation potential.
  - Characterization (e.g., enrichment and mass) and evaluation of the remaining fissile material and the changed process conditions is required to provide an adequate safety envelope.

Mission Change Impact on Personnel (cont.)

- **Residual uranyl fluoride in Pipes**



~ 45-kg deposit in 12-inch pipe



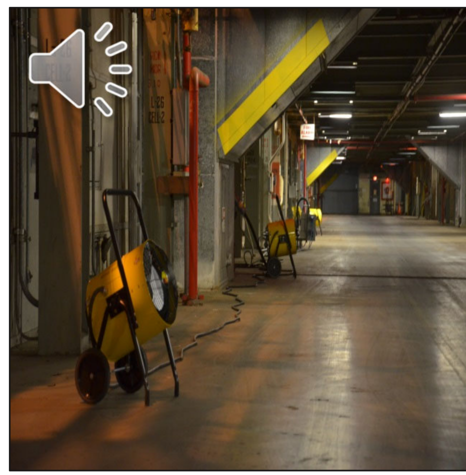
Thin non-uniform deposit film in 4-inch pipe

Deposit caked on pipe wall

Mission Change Impact on Personnel (cont.)

- **Psychological Implications:**
  - The GDPs operated for several decades enriching UF_6; shutdown led to removal of UF_6 from cascade and a change in the day-to-day activities of personnel.
  - The mechanical “hum” of compressors was replaced with an “eerie silence” at the plants.
  - Personnel often claim that, “***its difficult not hearing the cascade running***”.
  - Loss of purpose of personnel – making enriched product to ???



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Mission Change Impact on Personnel (cont.)

"The secret of change is to focus all your energy, not on fighting the old, but on building the new."
- Socrates

- **Disruption of the Knowledge Pool and Organizational Changes:**
  - Retirements,
  - Personnel assigned to different work groups,
  - New management,
  - New personnel,
  - New procedures, and
  - Major revisions to operations and maintenance procedures.

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Mission Change Impact on Personnel (cont.)

"The art of progress is to preserve order amid change and to preserve change amid order." - Alfred North Whitehead

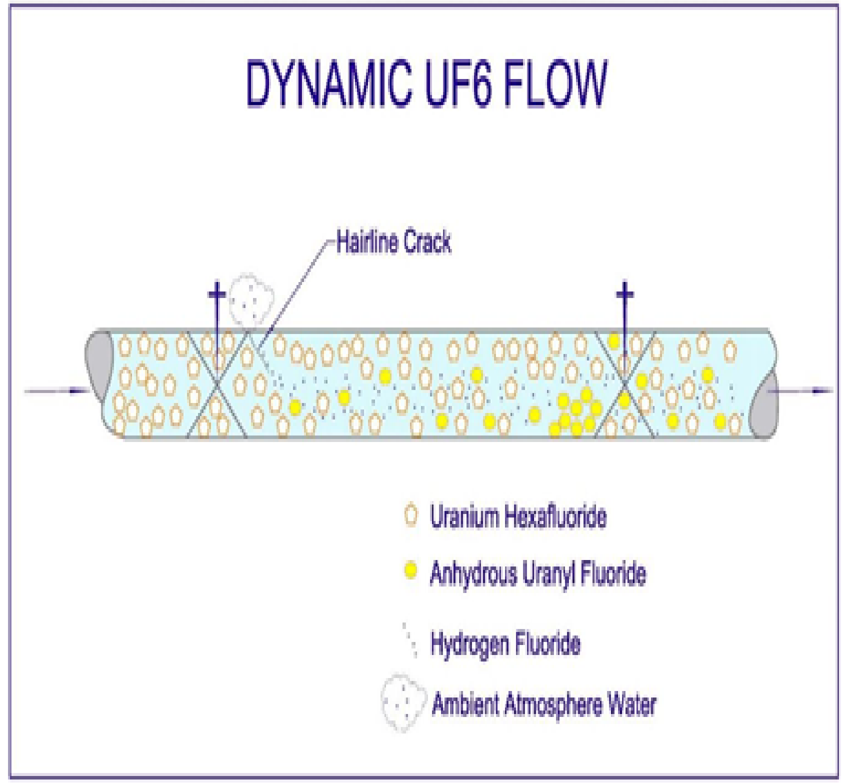
- **New Regulatory Structure:**

- The regulatory structure had changed before (i.e., DOE to NRC) but mission (enrichment) was the same. This latest regulatory change also involved a mission change (enrichment to deactivation).

Process Condition Changes

- **Chemistry (1 of 2) – Historical Operational Conditions for Uranium Enrichment:**

  - The enrichment operation had an ample and readily available source of fluorinating gas as UF_6.
  - UF_6 is a powerful fluorinating agent. Fluorinating agents react with and consume water creating hydrogen fluoride gas and anhydrous uranyl fluoride (UO_2F_2) compounds.
  - The presence of ample UF_6 in the systems during enrichment operation naturally prevented hydration (moderation) of uranium compounds. This nature of process was credited in many Nuclear Criticality Safety (NCS) Evaluations (NCSEs).
  - Operations personnel continuously monitored the cascade for both efficiency and productivity, and quickly reacted to leaks.
  - Most of the system was operated at less than atmospheric pressure resulting in personnel protection (e.g., atmosphere went into the process rather pressurized release of hazardous gases).



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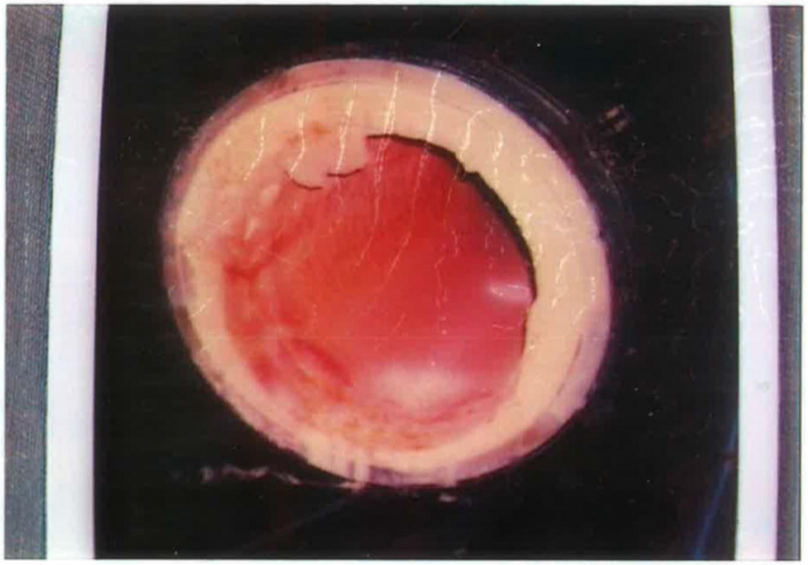
Process Condition Changes (cont.)

- **Chemistry (2 of 2) – Shutdown and Deactivation Conditions:**

  - No UF_6 (i.e., nature of process to prevent hydration no longer present)
  - Equipment **NOT** continuously monitored.
  - For shutdown and deactivation conditions, the lack of an ongoing fluorinating environment, static process, and characterization activities have to be addressed.
  - New controls have been established to address moisture in-leakage and characterization efforts to quantify fissile material deposition (e.g., dry air buffer and NDA method development).

Annular Deposit of UO_2F_2 in 42-inch Diameter Pipe



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Process Condition Changes (cont.)

- **Static and Stagnant:**
  - Many fissile material operations are sitting awaiting characterization or disposal.
  - Many of the NCS controls needed during the enrichment mission are no longer needed (e.g. process gas leak detection eng. control, cylinder heating and filling admin. controls, etc.)
  - Systems are no longer continuously manned and monitored (PGDP examples below).
  - Deterioration of equipment/containment has to be addressed.
  - NCS controls were added to address the static condition as needed (e.g., inspect for water leaks and repair).

Process Condition Changes (cont.)

- **Characterization Activities (1 of 2) – An Overview:**
  - **Characterization -** The process used to determine and document the type and quantity of radionuclides in an item of interest.
  - Chacterization is a key part of "right sizing" the NCS controls for shutdown systems and demonstrating criticality incredible.
    - Empty systems have to be confirmed.
    - Once fissile material deposits have been identified, they can be removed/remediated as appropriate to further "right size" the controls (e.g., iterative process).
    - Used to support Waste Acceptance Criteria for final disposition.
  - Methods include:
    - Visual Inspection……………………………………
    - Intrusive Sampling/Couponing……………………..
    - Nondestructive assay (NDA)………………………
    - Process Knowledge………………………………
  - Useful for Identifying:
    - Presence of deposits
    - U isotope percentages, Tc, TRU
    - Mass of Deposit
    - Where to characterize
  - Documentation and verification of obtained data is essential for evaluating the process conditions and ultimately demonstrating the remaining residual fissile material is not a criticality hazard!

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Process Condition Changes (cont.)

- **Characterization Activities (2 of 2) – A Visualization:**
  - Left Image: Visual inspection shows the inside of a 12-inch G-17 valve coated with UO_2F_2.
  - Middle Image: Converter Measurement System (NDA).
  - Right Image: Intrusive sampling – may warrant use of PPE.

Examples of Process Condition Changes (cont.)

- **Equipment Removal (1 of 3) – Heated Cell Housing Deconstruction:**
  - X-326 Process Building at PORTS - More than 400,000 components and more than 200 miles of piping characterized by Fluor-BWXT.
  - Approximately 6,800 shipped for disposal (**NEVER TO RETURN**).

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Examples of Process Condition Changes (Continued)

Interior of X-326 Cell Floor for Scale: ~ 58 Acres (**HUGE!**)

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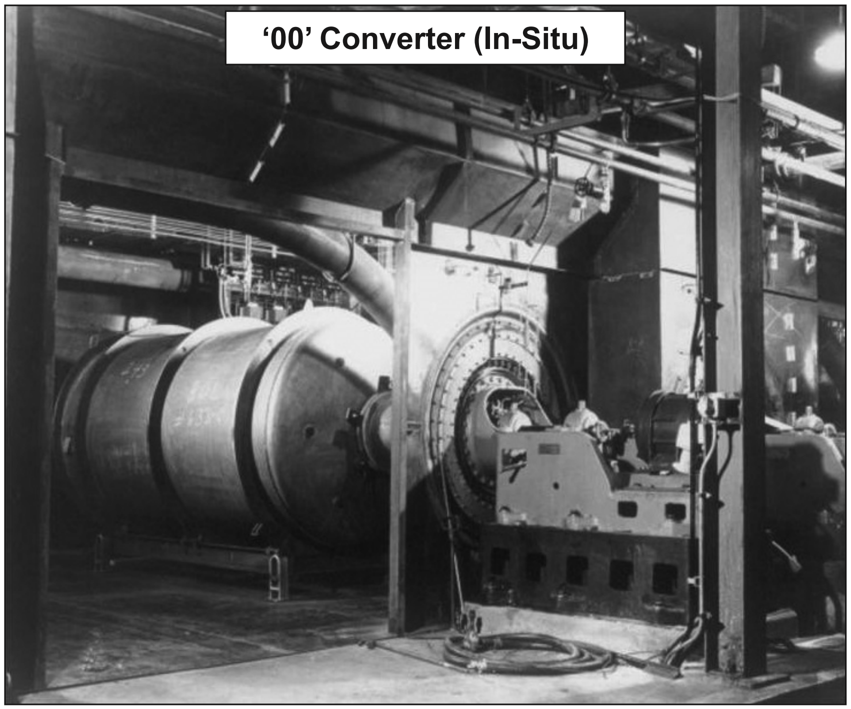
Examples of Process Condition Changes (cont.)

- **Equipment Removal (2 of 3) – Converter Removal at PORTS:**

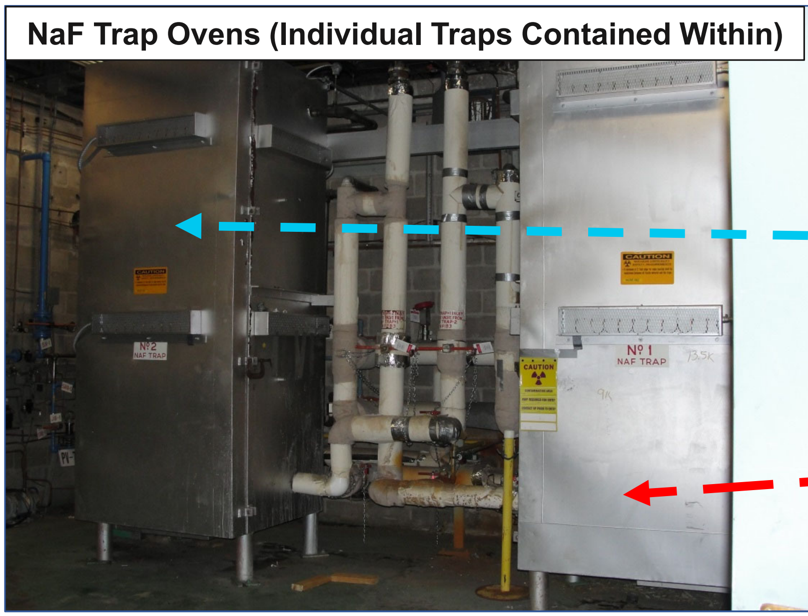


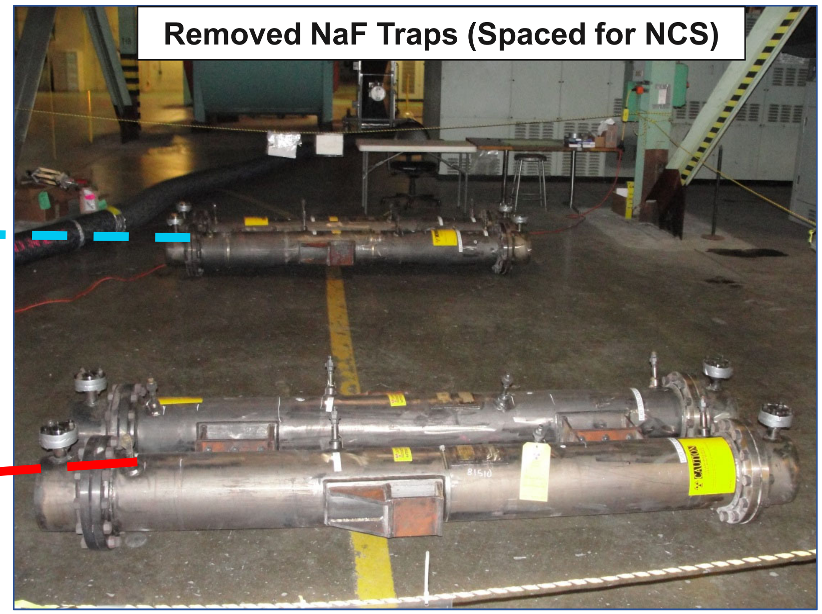
‘00’ Converter (In-Situ)

Converter Removal

Examples of Process Condition Changes (cont.)

- **Equipment Removal (3 of 3) – Sodium Fluoride (NaF) Trap Removal at PGDP:**

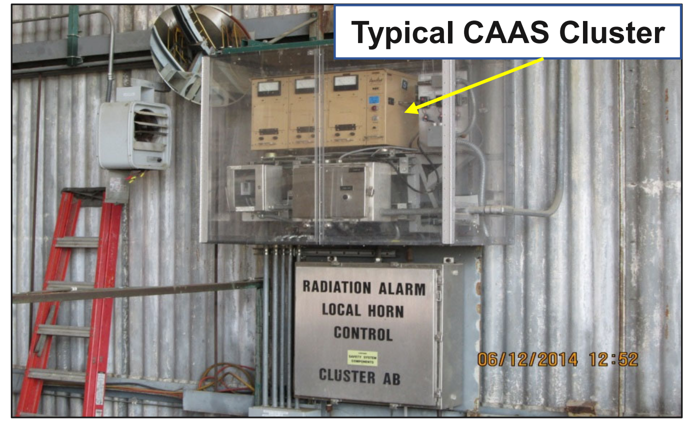




NCS Program Transitional Challenges

- **NCSP Historically Under Enrichment Mission:**
  - GDPs met the process analysis requirements of ANSI/ANS-8.1 with few exceptions (i.e., single contingent operations).
  - Application of double contingency (DC) was met using an integrated hierarchy of both engineering and administrative controls.
  - The enrichment mission control scheme focused on moderation control for many operations. Shortly after transition, the Paducah GDP incurred a significant issue (ORPS Level 1 event) when the administrative controls for moderation were not followed for some piping sections.

Typical CAAS Cluster



Fissile Waste Stored in NCS-Approved 5-gallon containers

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NCSP Transitional Challenges (cont.)

- **NCSP Under Deactivation Mission:**
  - Goal of deactivation is to ensure removal of the chemical and radiological (includes fissile) materials to the extent required to ensure safety and minimal surveillance and maintenance during final stages of facility lifecycle. Also to achieve demolition ready status.
  - Traditional suite of engineering and administrative controls for DC are not appropriate for criticality incredible (CI) when adhering to the nature of process requirement for facility hazard categorization.
  - **Regardless of transition from DC to CI, ANSI/ANS-8.1 still requires process analysis!**
  - This analysis shall establish both the normal case and all credible upset conditions for the remaining facility lifecycle.
    - DOE STD-3007-2017 defines credible as, "*the attribute of being believable on the basis of commonly accepted engineering judgement*."
  - A benefit of characterization and evaluation is an appropriate control selection (e.g., engineered, administrative, CAAS, nature of process).

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NCSP Transitional Challenges (cont.)

- **NCSP Under Deactivation Mission - A Roadmap Forward:**
  - As part of process analysis, NCS will need to show that material in the facilities is CI by “nature of process” when required by the contract.
  - Data from characterization is the key.
    - From DOE STD-1027-2018, precluding criticality by nature of process is achieved by taking credit for:
      - Fundamental chemistry.
      - Physics.
      - Distribution of material.
      - **NOT** relying on engineered or administrative controls!
  - CI is achieved when analysis shows remaining residual fissile material cannot achieve a critical configuration by nature of process.

PGDP – Characterization and Staging of Fissile Components (C-400)

PGDP – Removal of Fissile Components (C-400)

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Lessons Learned

- The human impact of change cannot be ignored...
  - Psychological impacts cause stress on personnel. Takes time for adjustment.
  - The change is also an impact on the owner (DOE) to write the contract and set a path forward (e.g., leave as-is, cut out and remove, etc.).

- Changes in equipment status, support systems, and chemistry due to shift from enrichment to deactivation requires evaluation of process condition changes.

Lessons Learned (cont.)

- NCSP transition from DC to CI comes with challenges:
  - ANSI/ANS-8.1 requires process analysis.
  - NCS controls used during the operational mission should not be used for deactivation, demolition, and disposition.
  - Characterization data is required to be thorough and verified to be correct in order to support NCS analysis.

- Moving forward, PPPO has put a definition for CI in the contracts of both PORTS and PGDP.

- Contracts require development and PPPO approval of the plan(s) for characterization and the process to achieve criticality incredible.

- The process for which NCS analysis shows CI by nature of process should be documented in the D&R Contractor's NCSPDD.
  - NCSPDD approved by DOE per DOE O 420.1C Chg 1.

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Questions/Open Forum