Criticality Safety Control Strategy at the MOX Fuel Fabrication Facility

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Overview

- What is the MOX Process?
- French Reference Facilities
- General Criticality Safety Strategy
- Criticality Safety Strategy of AP (Aqueous Polishing) “Wet” Unit
- MOX Facility Process Equipment
- Criticality Safety Strategy of MP (MOX Process) “Dry” Unit

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What is the MOX Project?

- **Mission**
  - Convert 34 metric tons of surplus weapons-grade plutonium to mixed oxide (MOX) fuel for use in U.S. commercial power reactors
  - Once irradiated, plutonium will meet the spent fuel standard – making it inaccessible and unattractive for use in weapons

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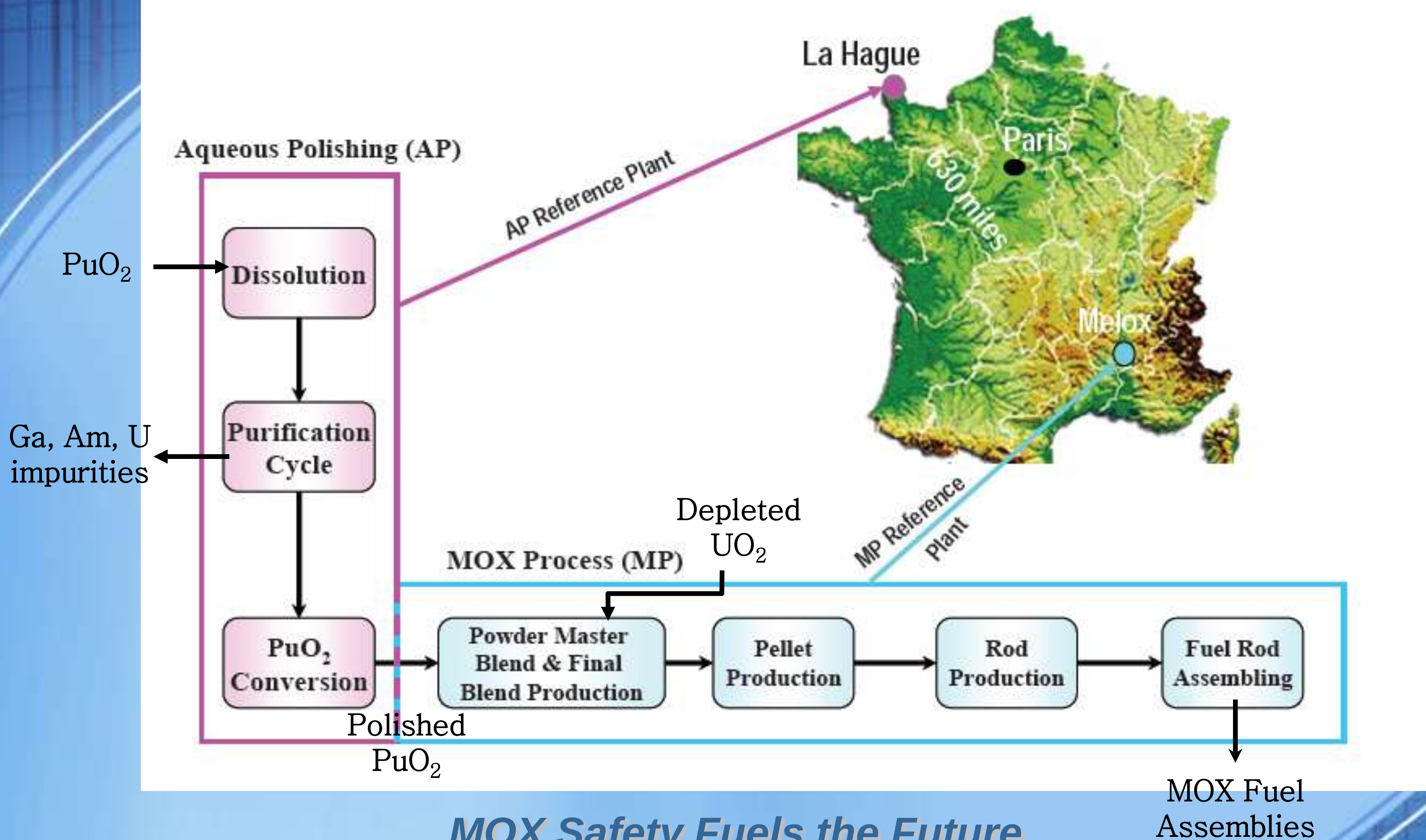
What is the MOX Project?

- **Impact**
  - Total lifetime cost $4.8 billion plus $200-300 million/year to operate
  - Removes about 10,000 warheads from the nuclear arsenal
  - Eliminates $500 million/year in security costs
  - Provides clean, carbon free energy that offsets over $21 billion in imported oil costs at $48/barrel (or $60 billion at $140/barrel)



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MOX General Criticality Safety Strategy

- Nuclear Criticality Safety Evaluations (NCSEs) have been performed to document that the criticality safety requirements of 10CFR70 are satisfied.

- This requires demonstration that the design appropriately satisfies the double contingency criticality safety criterion of ANSI/ANS-8.1, and the "highly unlikely" requirements of 10CFR70.

MOX General Criticality Safety Strategy

- NCSE-Ds evaluate the final design for potential accident event scenarios that are identified in Process Hazards Analysis for MFFF process units and support systems handling fissile materials.
- The Process Hazards Analysis represents a major component of the Integrated Safety Analysis developed to satisfy the applicable requirements of 10CFR70.
- The Process Hazards Analysis provides a systematic and comprehensive evaluation of the MFFF design that identifies events that can potentially result in safety consequences, including criticality accident events.

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MOX Criticality Safety Strategy

Aqueous Polishing (AP) **WET** Units

- **Safe Geometry**
- **Spacing Requirements**

MOX Process (MP) **DRY** Units

- **Safe Mass**
- **Moderation Control**

Criticality Safety in AP Units

- Safe Geometry
  - **Annular Tanks**
  - **Slab Tanks**
- Spacing Requirements
  - **One Foot Minimum Spacing**
  - **Annular, Slab Tanks & Concrete Walls**

Criticality Safety in AP Units

- Physiochemical Control
  - **Dual independent sampling of nitric acid concentration**
  - **Active engineered flow controllers for HAN addition**

- Example:
  - **NCSE-D of the Purification Unit (KPA)**

NCSE-D of KPA Purification Unit

- The purpose of unit KPA is to separate Pu from impurities contained in the flux coming out of the Dissolution units KDB and KDD.

- Plutonium oxide to be processed is weapons grade plutonium from the PDCF (Pit Disassembly and Conversion Facility) and from AFS (Alternate Feed Stock).

- This NCSE-D demonstrates that the MFFF KPA unit is critically safe under all normal and credible abnormal conditions. A single credible event or failure or human error will not result in a criticality accident.

NCSE-D of KPA Purification Unit

- The criticality control parameters applicable to the Purification unit KPA are geometry control, associated with neutron absorbers control, interaction control, and reflection control and physicochemical control, concentration control, isotopic control and process variables controls.

- The double contingency principle was applied. The MFFF KPA unit design incorporates sufficient factors of safety that would require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible.

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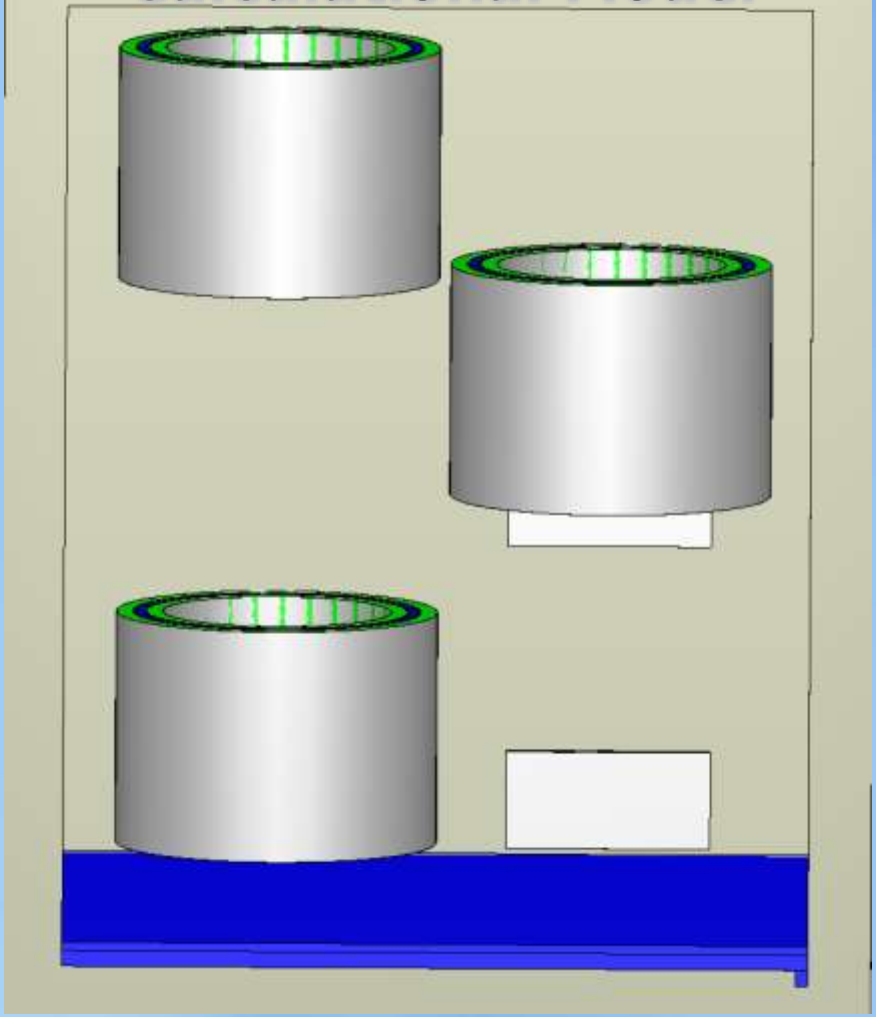
Calculational Model



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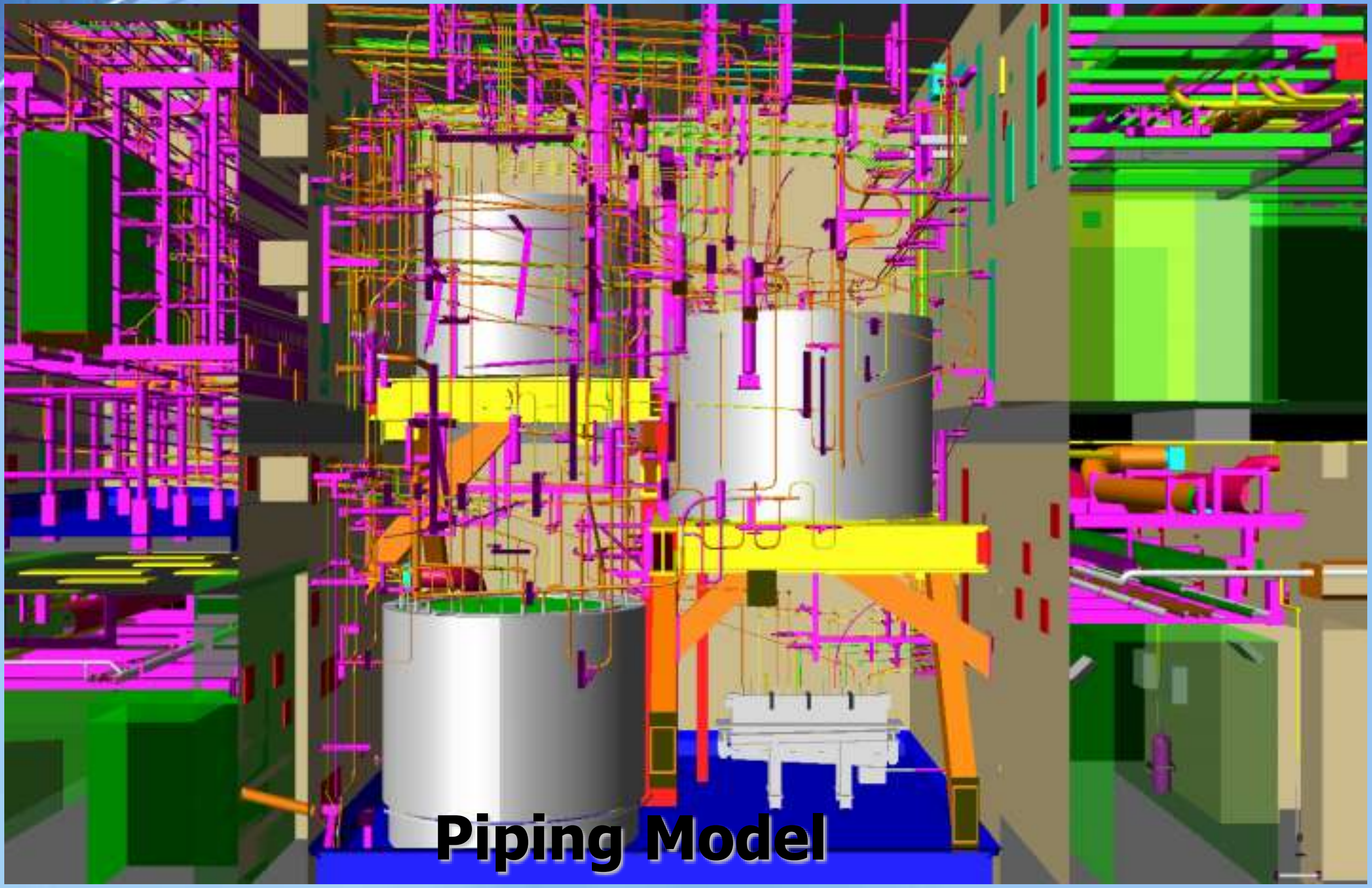

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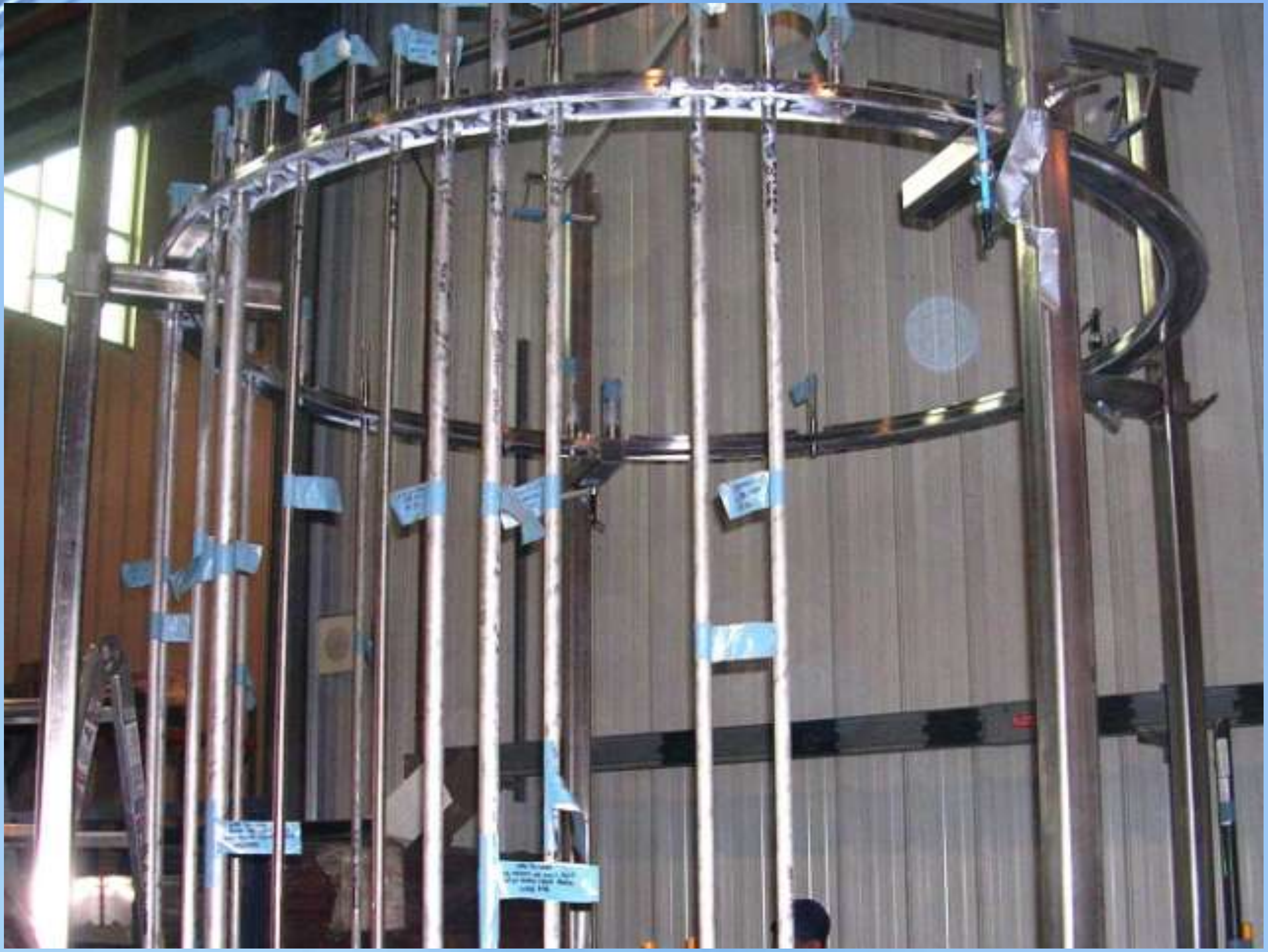
Annular Tank Fabrication



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Annular Tank Specifics

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Slab Tanks

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Criticality Safety in MP Units

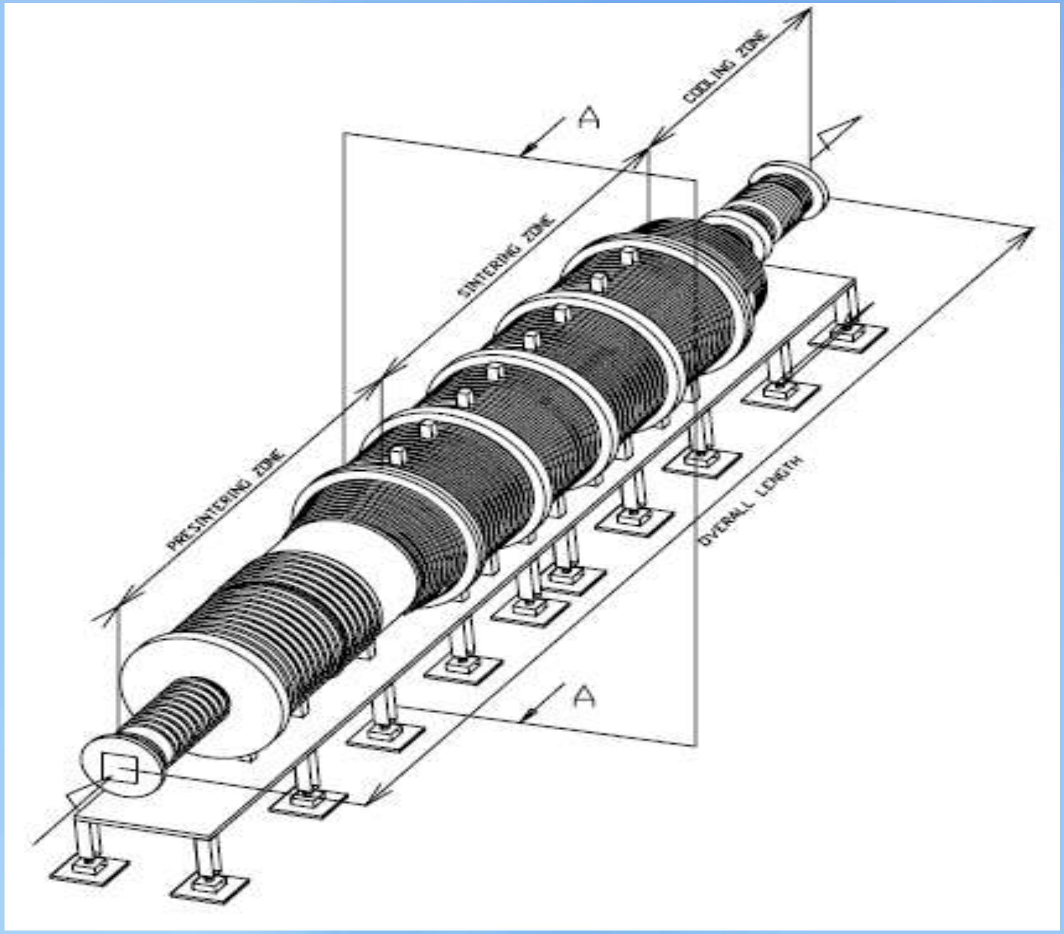
- Safe Mass
  - **Mass Limited Processes**
  - **Mass Limited Gloveboxes**
- Moderation Control
  - **Moderation Controlled Areas**
  - **Moderation Limited Gloveboxes**
- Example:
  - **NCSE-D of the Sintering Furnaces**

NCSE-D of Sintering Furnace

- The main purpose of the unit is to sinter green pellets or green scraps. In addition, the unit can be used to recycle or re-sinter pellets not reaching proper design specifications.

- This evaluation demonstrates compliance to the **Double Contingency Principle** (DCP) **and** provides detailed characteristics of process, engineering features, and administrative controls that are relied upon to ensure all postulated criticality accident scenarios are **highly unlikely**.

Sintering Furnace Overview



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Criticality Safety of Furnace

Mass Control

- Configuration Control of the Sintering Furnace design limits the number of boats (pellet containers) that can physically be present in the furnace.

- Mass is controlled per boat and the number of boats in the furnace is limited providing overall mass control.

Criticality Safety of Furnace

Moderation Control

- Safety functions limit water equivalent moderation inside the furnace to only a humid gas mixture (argon-hydrogen).
- Passive design features and engineered controls labeled as Items Relied Upon For Safety (IROFS) are present to prevent the introduction of water equivalent moderation beyond humidity saturated process gas.
- The supporting criticality calculations use a bounding moisture value of 5 wt % water inside the pellets.

Conclusion

MOX Criticality Control Strategy

- Double Contingency Criticality Safety Criterion of ANSI/ANS-8.1, and the "highly unlikely" requirements of 10CFR70 are applied as well as all applicable ANSI Standards.
- Control Hierarchy: Preferred Passive Design, then Active-Engineered Controls, and finally as necessary Administrative Controls are applied.
- NCSE-Ds in accord with Integrated Safety Analysis developed to satisfy the applicable requirements of 10CFR70.

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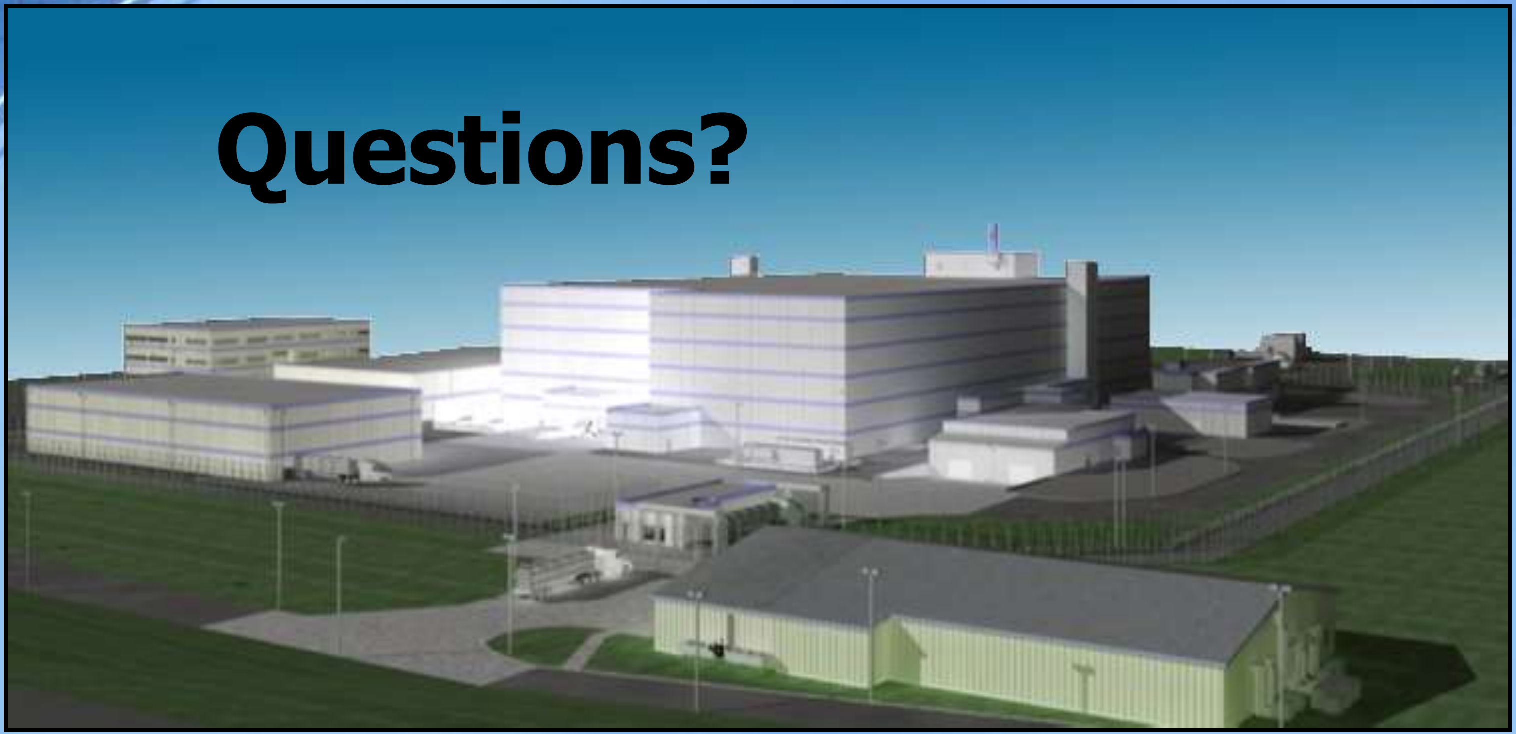

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