

## **Criticality Safety Design Challenges at the MOX Fuel Fabrication Facility**

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# Overview

- **What is the MOX Project?**
- **French Reference Plants**
- **NCS Challenges in Design Phase**
- **NQA-1 Suppliers for IROFS Components**
- **Maintaining Independence**
- **Qualified NCS Staff**
- **Conclusion**

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# What is the MOX Project?

- **Primary Mission:**  
**Nuclear Non-Proliferation**
  - 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
- **Regulated by the United States Nuclear Regulatory Commission (NRC), owned by the Department of Energy (DOE)**

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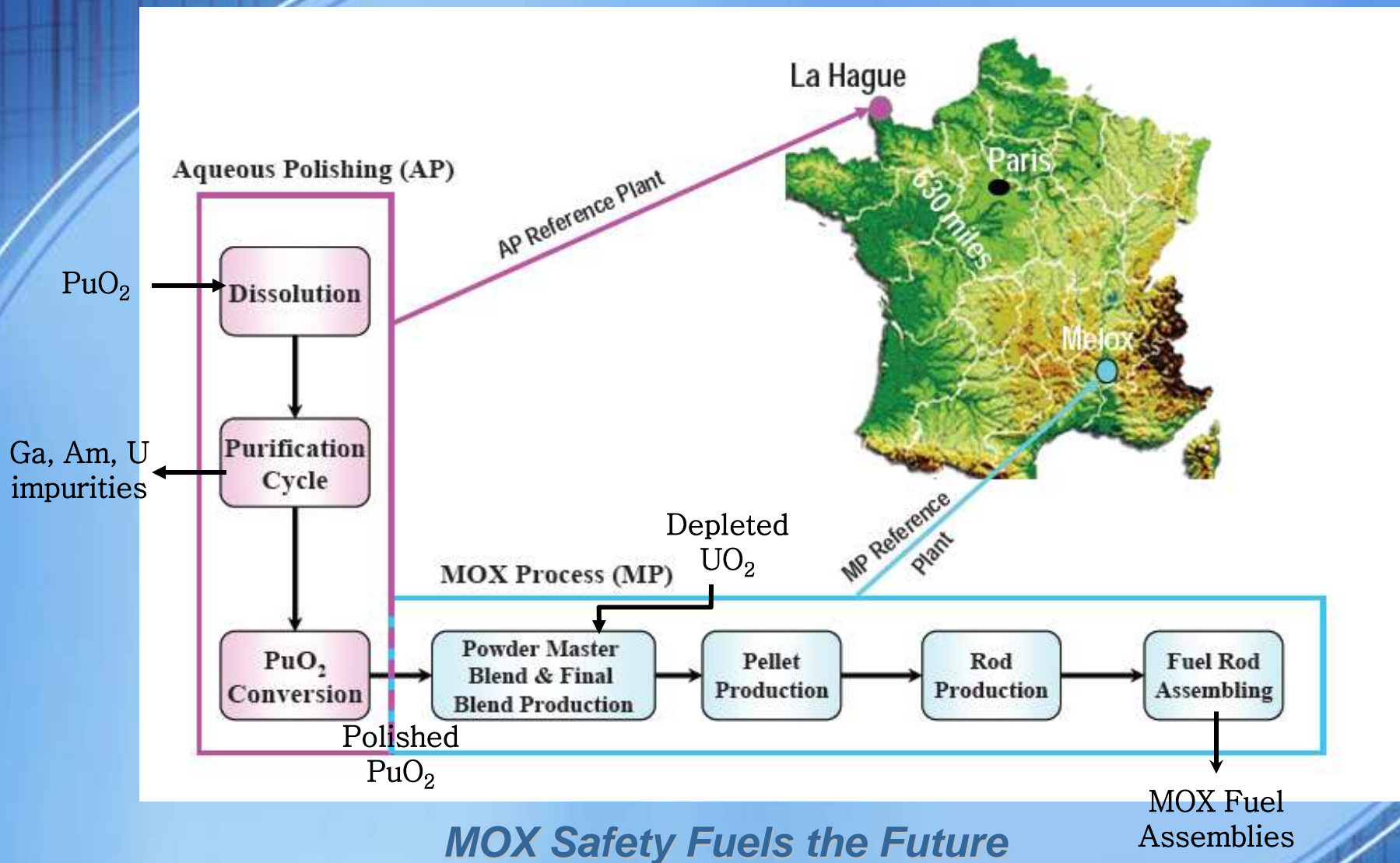
# What is the MOX Project?

- **Impact**

- Total lifetime cost \$4.8 billion plus \$200-300 million/year to operate
- Removes multiple 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

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# NCS Challenges Design Phase

- French NCS Control Philosophy  
Melox (**MP/Dry**) & La Hague (**AP/Wet**)
- Americanization of French **NCSEs**
- Construction Authorization Report (**CAR**)
- License Application (**LA**)
- Integrated Safety Analysis Summary (**ISAS**)

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# NCS Challenges Design Phase

- **NRC** Regulatory Environment
- **IROFS** (Items Relied On For Safety)
- Computer Logic/Code Validation  
Normal vs. Safety PLCs (**NPLC/SPLC**)

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# NCS Challenges Design Phase

- Mechanical Design Group (**MDG**)
  - Design Based Documentation
- Procurement Design Group (**PDG**)
  - **IROFS** or **Commercial Grade Dedication**
- Software Design Group (**SDG**)
  - Logic Design vs. Human Interface
- Laboratory Design Group (**LDG**)
  - Sampling (**NON-IROFS** Equipment)

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# NQA-1 Suppliers IROFS Components

- Limited **IROFS** Component Suppliers
- Commercial Grade Dedication (**CGD**)
- Vendor **NCRs** (Non-Conformance Reports)
- **Handling** of Critical Components
- Verifying Vendor **Quality Assurance**
- **Quality Control** Requirements

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## Items Relied On For Safety

Postulated credible high consequence events (e.g., **criticality**) are made highly unlikely based on the application of IROFS features:

- Application of the **single failure criteria** or **double contingency**
- Application of 10 CFR 50 Appendix B and **NQA-1** quality assurance requirements
- Application of **Industry Codes and Standards**
- **Management Measures**, including surveillance of **IROFS** (i.e., failure detection and repair, or process shutdown capability)

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# Safe Geometry Annular Tank



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# Annular Tank Spacing



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# Annular Tank Top View



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# Safe Geometry Slab Tank



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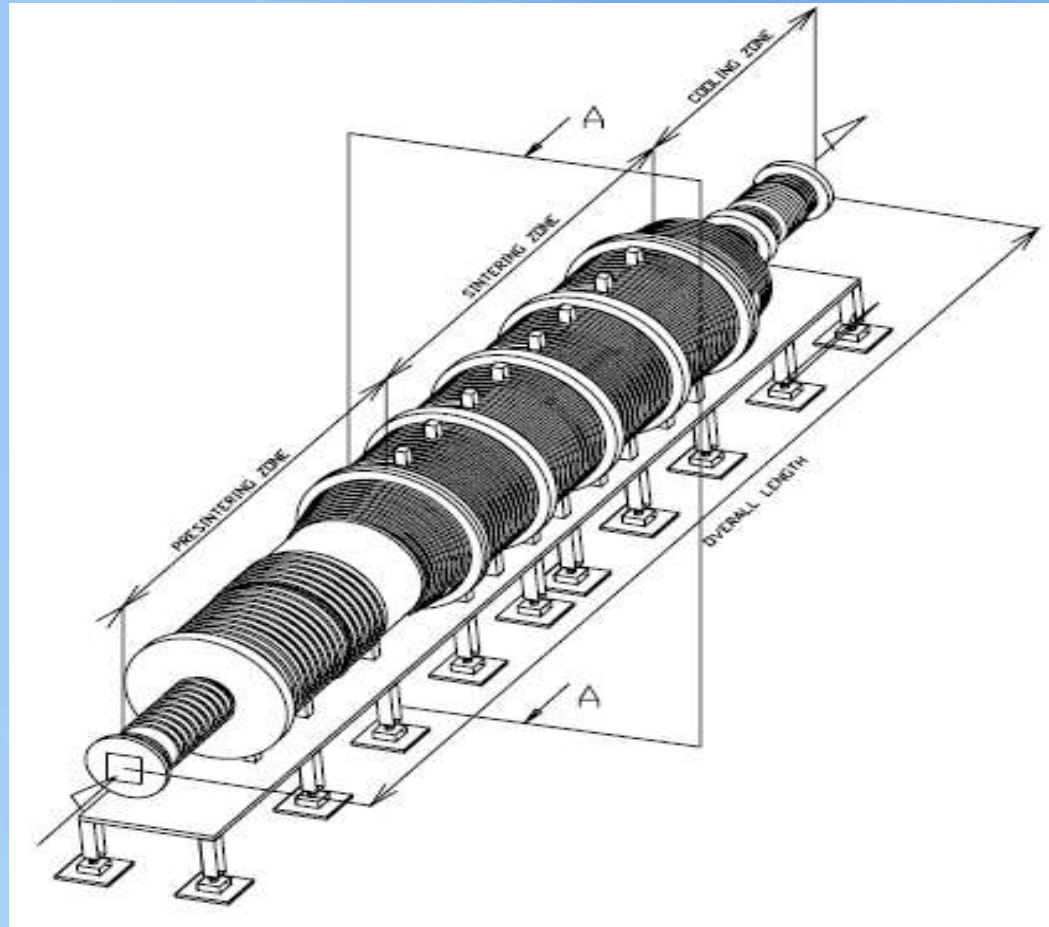


# Slab Tank Top View



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# Sintering Furnace



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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.

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# 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.

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# Maintaining Independence

- Design Change Process
  - Engineering Change Requests (**ECRs**)
- Procedural Development
  - **NCS** Procedure Review
- Limited Conditions of Operations (**LCO**)
  - Operating Limits Manual
- Programmatic Procedures
  - **Moderation** Control Program
- Training
  - **NCS Review** of Lesson Plans

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# Attracting Qualified NCS Staff

- French & United States **Contractual** Support
- Qualified Nuclear Criticality Safety Engineers
  - **NRC** Regulator Experience
  - **Fuel Fabrication** Experience
  - Special Nuclear Materials, e.g., **Plutonium**
- State of the Art Training Facility (w/ Gym)
- **NCS** Technicians
- Operational Support
- **Gateway Outreach Programs**

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## Conclusion

- **MOX Services Continues to Meet the Challenge**
  - Managing Design Change Process
  - Procurement of IROFS Equipment
  - Attracting Qualified NCS Personnel
- **Approaching Cold Start-Up**
  - Operational Limits Manual
  - Procedural Development
- **Preparing for the Nuclear Renaissance**
  - Non-Proliferation & Energy Independence

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# Questions?



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