Advanced Head-End Processing of Spent Fuel

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INTRODUCTION

- **The DOE Advanced Fuel Cycle Initiative (AFCI) is pursuing the development of a spent fuel processing scheme that would greatly improve the capacity of Yucca Mountain**
  - **Development efforts toward an advanced dry head end for the processing of U.S. spent fuel are underway and include previous experiences and lab scale experiments.**

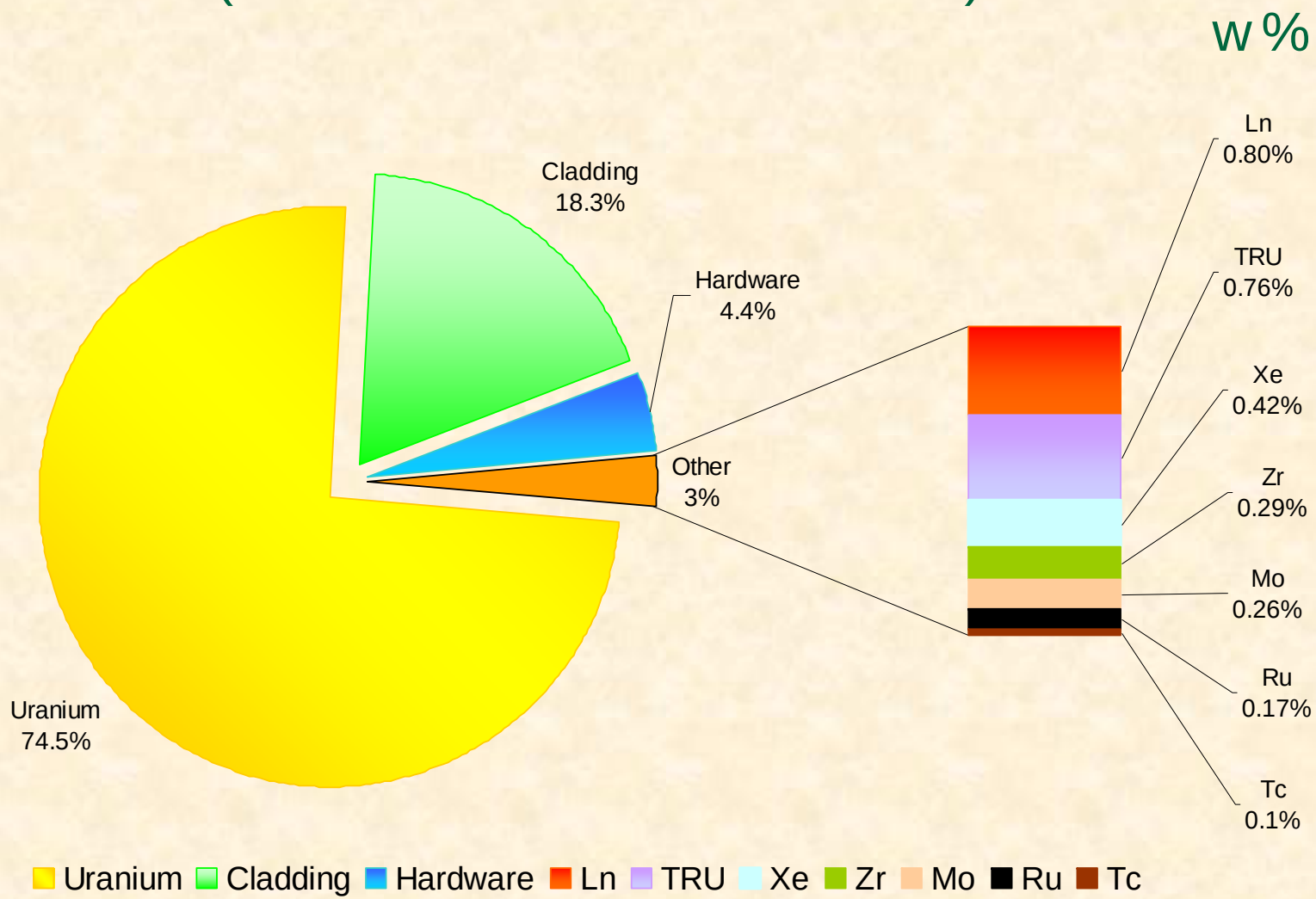
Overall objective:

Replace the traditional chop-and-leach approach by a more efficient and cost effective alternative with significantly lower emissions and lower TRU losses.

- In the French plant (La Hague), the chopped fuel is fed into a very large wheel-dissolver. The hulls and insoluble residues are supercompacted producing 0.15 m^3 of metal waste per tonne of fuel. A 2000 MT/yr plant would generate 300 m^3/yr of HLW.

- In the BNFL case, the chopped fuel is fed into a basket-type dissolver. The washed hulls are stored in very large buildings (larger than the reprocessing plant).

Composition of Spent Nuclear Fuel
(PWR 33000 MWd/MTIHM)



Overall scheme

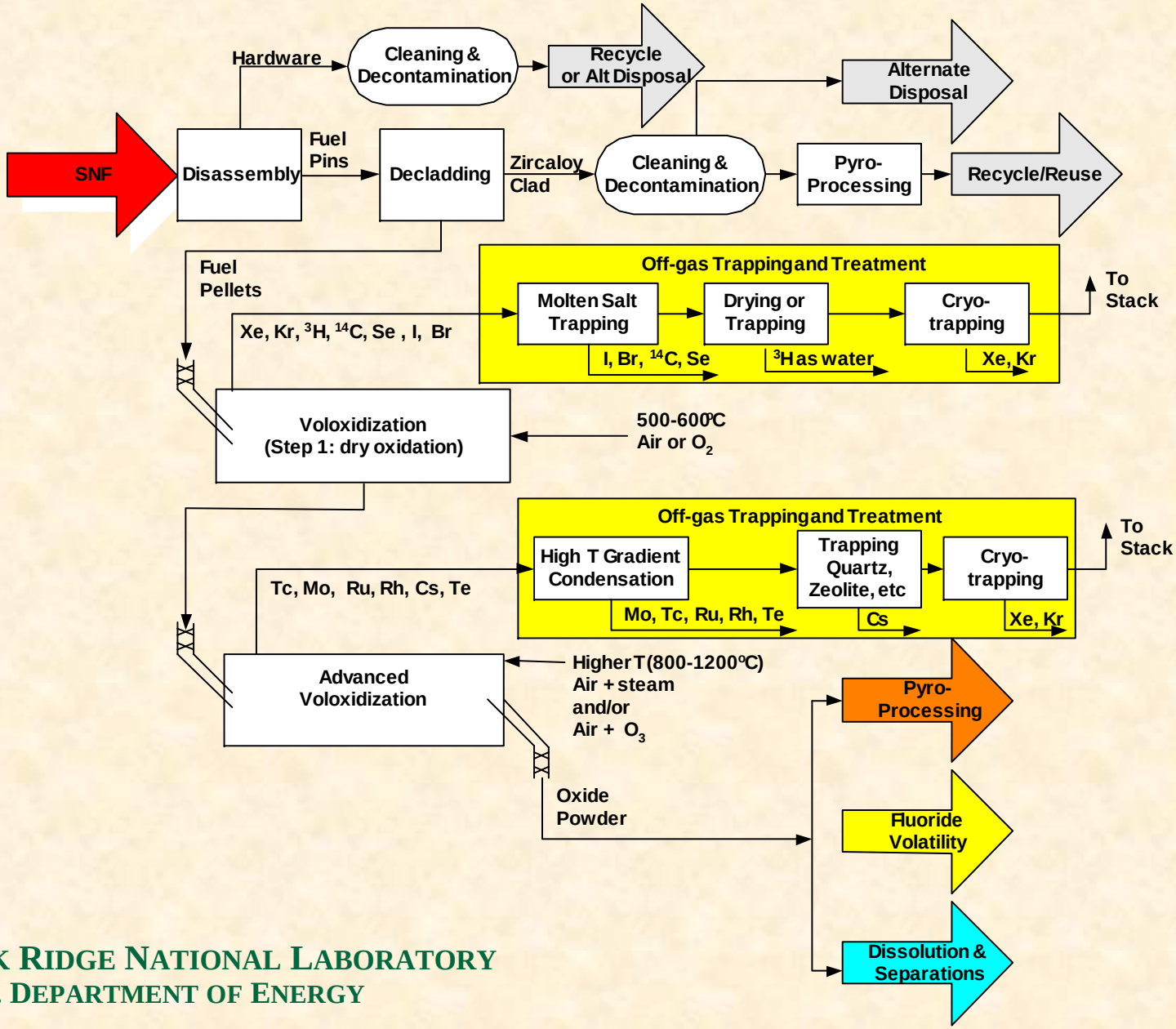
- **The envisioned advanced head-end processing has the following steps:**
  - **Disassembly of the spent fuel elements by cutting the end rods and retrieving the fuel pins.**
  - **Decladding of the fuel pins to cleanly recover the fuel for further processing.**
    - Three main options: mechanical separation, oxidative decladding and cladding volatilization by chlorination
  - **Cleaning and decontamination of cladding and hardware for potential reuse or lower cost disposal.**
  - **Treatment of the fuel to remove some key species and producing a powder that can be fed into a much smaller and simpler continuous dissolver.**

Goals

- Simplify separations and reduce costs
  - Up-front removal of several key fission products
    - Tc, I, Mo, Cs
  - Minimize emissions (^{3}H, ^{85}Kr, ^{14}C) and TRU losses
  - Reduce insoluble solids and colloids in the dissolver by:
    - removing noble metals (Tc, Ru, Rh, Mo)
    - No cladding fines by eliminating chopping

- Separate the hardware and cladding with the minimum degree of retained contamination

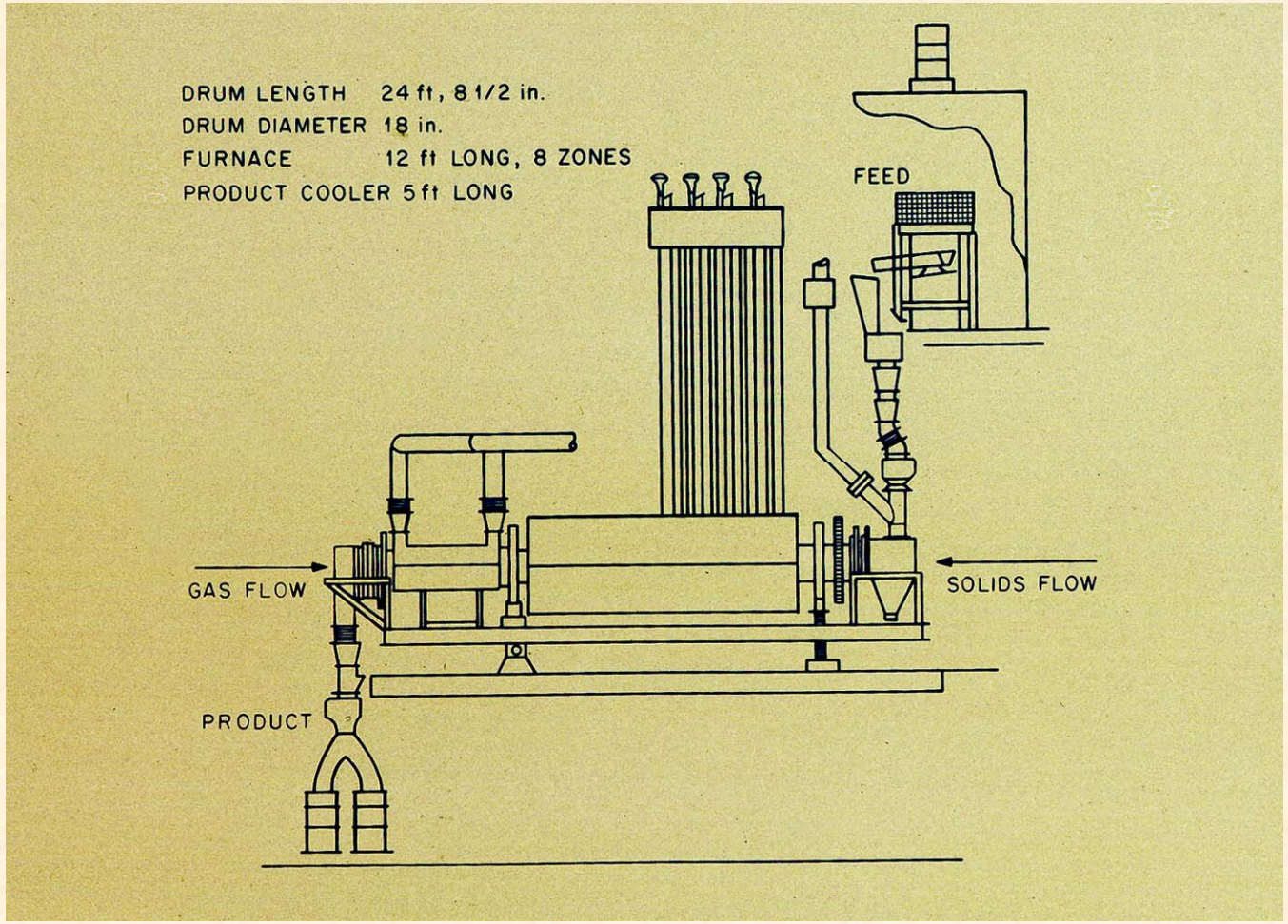
Overall Scheme



Potential Advantages

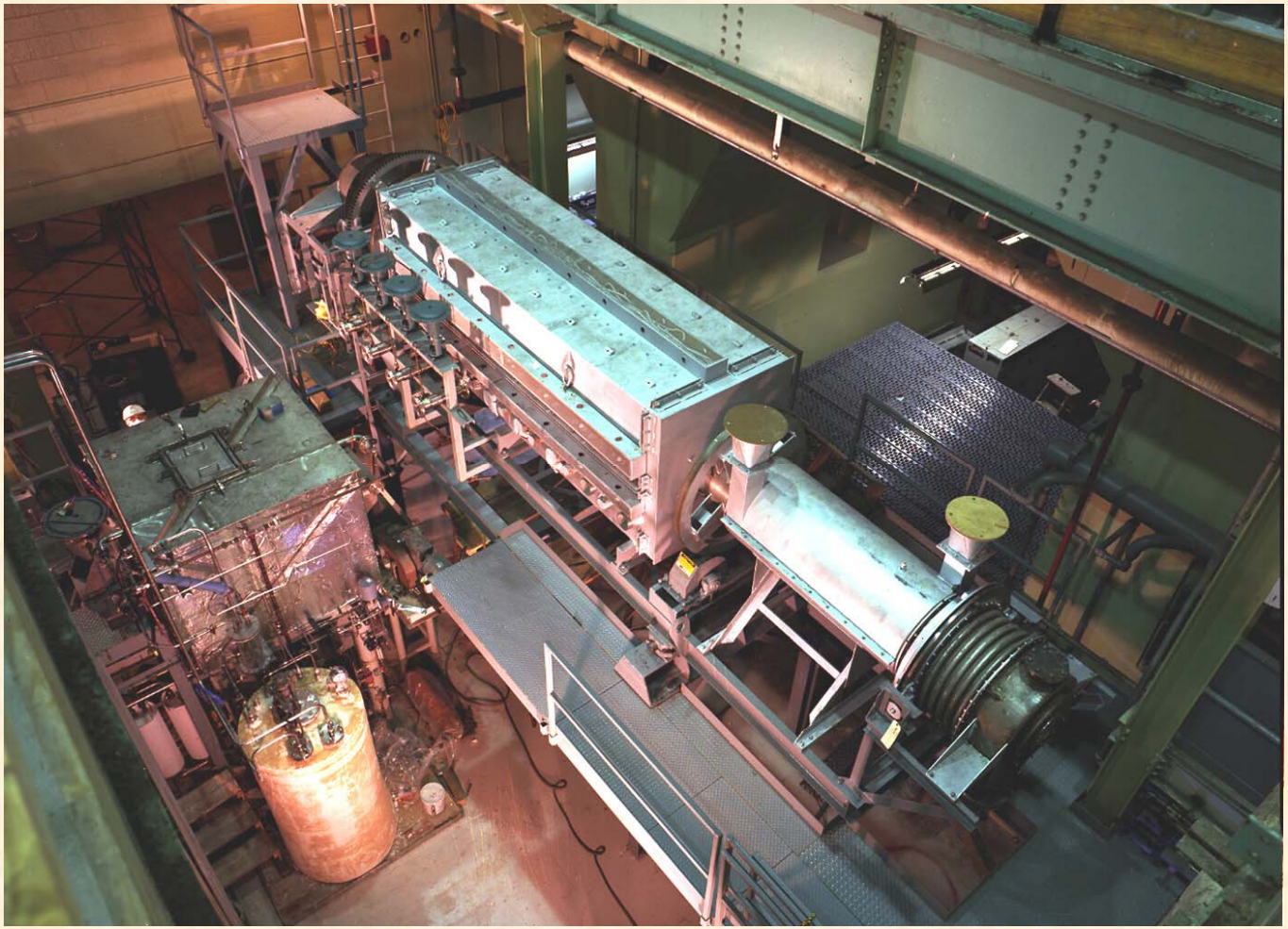
- **One AFCI goal is the separation of long-lived FP's such as Tc. Unless removed upfront some Tc follows the dissolver insolubles making it very difficult to isolate.**
- **Mo interferes with downstream separation processes.**
- **There is no practical way to isolate ^{3}H during the aqueous processing; so, it needs to be removed upfront.**
- **Iodine is a source of corrosion and complicates the treatment of dissolver off-gas.**
- **Cs: Up-front removal reduces need for shielding and limits radiolytic degradation of solvents.**

Concept of a Pilot-Scale Voloxidizer — 0.5 MT/day —

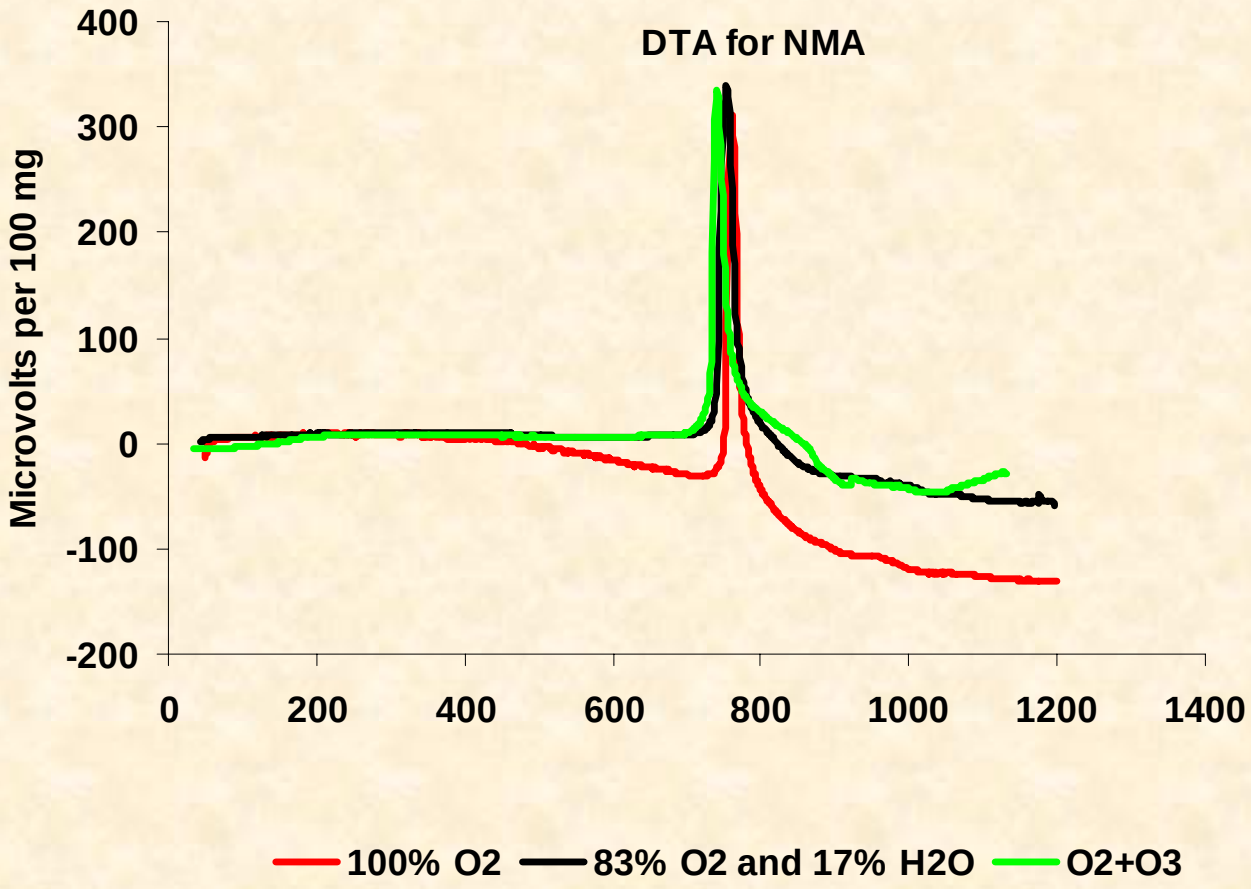


View During Installation

(Equipment development done during late 70's and early 80's, system not longer exists)



DTA of Noble Metals Alloy (Mo, Ru, Pd, Re and Rh)

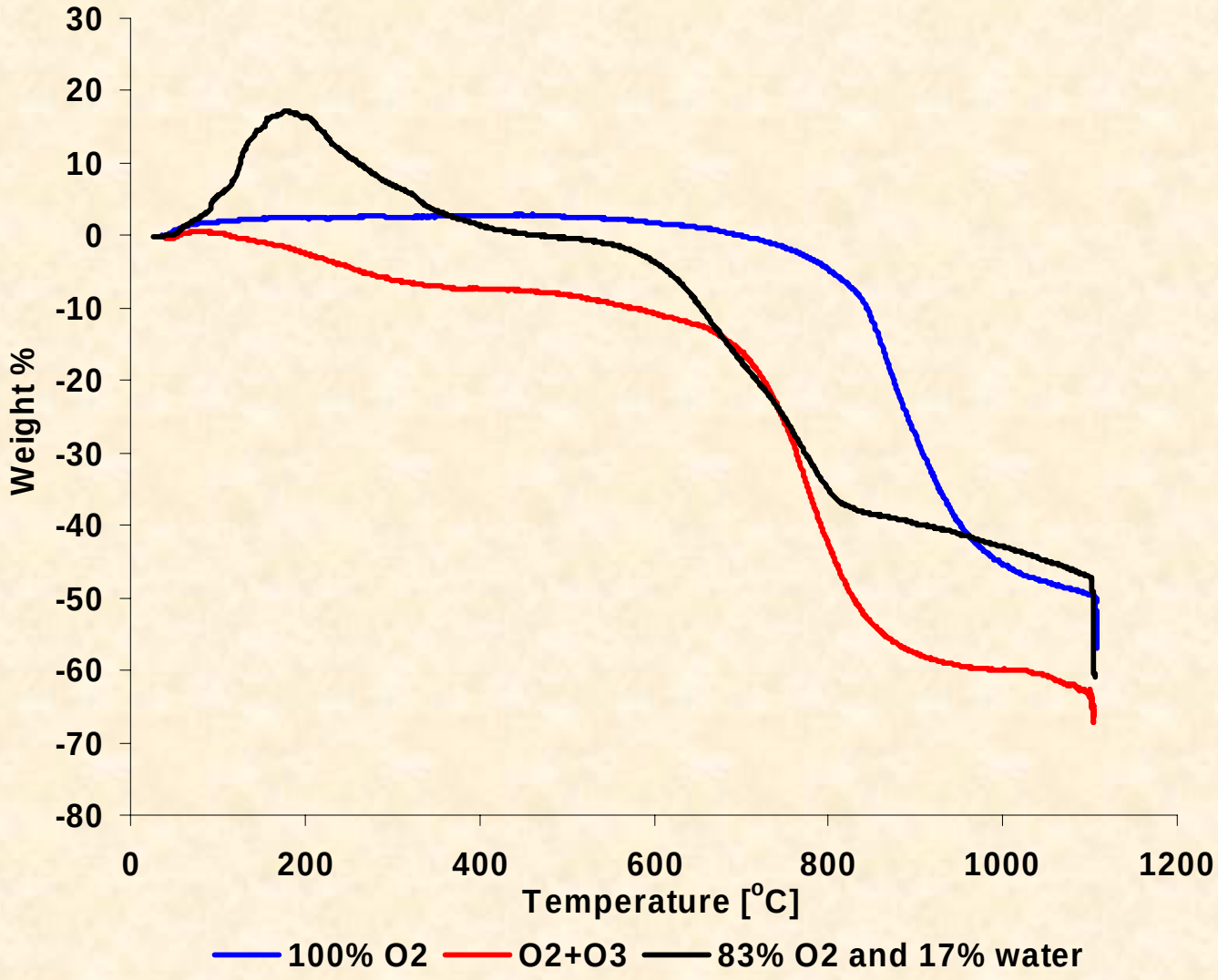


Condensed crystals from “noble metal alloy”

TGA of Noble Metals Alloy (Mo, Ru, Pd, Re and Rh)

- **Deposits of white needle-like crystals precluded the determination of relevant gravimetric data; however, the weight loss was significantly different for the ozone treatment**
  - **Pure O_2 : 44% weight loss**
  - **O_2 / H_2O: 45% weight loss**
  - **O_2+O_3 : 96% weight loss**

TGA of cesium oxide



Conclusions

The R&D efforts are underway.

The information collected from spent fuel processing, from the analysis of potential releases during severe reactor accidents, and from previous developments in disassembly and decladding seems to indicate that the overall process appears to be reasonable

Preliminary hot and cold tests seem to indicate that all of the goals can be achieved