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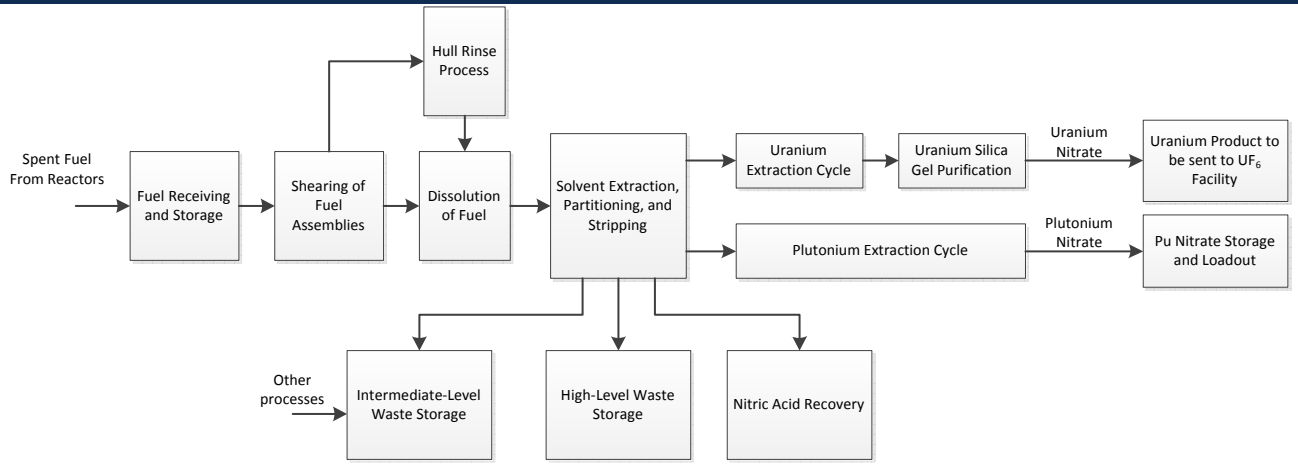

Source Term Evaluation for a Spent Fuel Reprocessing Facility

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NNSA

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Background and Motivation

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- Two aqueous reprocessing plants for commercial fuel have been licensed in the US
  - Nuclear Fuel Services reprocessing facility at West Valley in 1966 (operated for a few years)
  - Barnwell Nuclear Fuel Plant Separation Facility in 1970 (never operated)
- Both were licensed under 10 CFR Part 50 by the AEC
- 40+ years later interest in reprocessing has been rejuvenated
- NRC is preparing to reestablish licensing capabilities
  - The major gap is in evaluating potential source terms

Source Terms

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- Source terms are releases from a confinement building into the environment
- Atmospheric releases generally have the greatest and most immediate consequences
- Characterizing source terms is essential for licensing
- Source terms from an aqueous reprocessing facility can be created by a range of accident types

Typical Source Term

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- Initial release is into a room or compartment of the confinement building
  - Energy insertion
  - Mass insertion
  - Physical form, vapors or aerosols
  - Aerosol size distribution
- Vapors and aerosols are transported through confinement to atmosphere
  - Through doors or holes in walls
  - Through ventilation system
  - Through filters

Most Significant Accident Types

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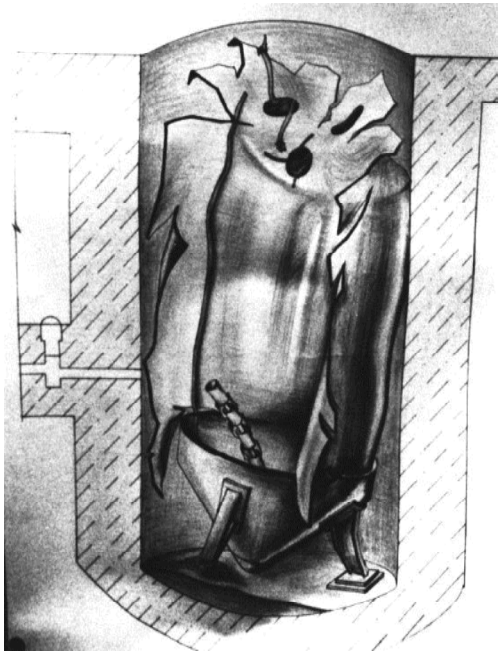
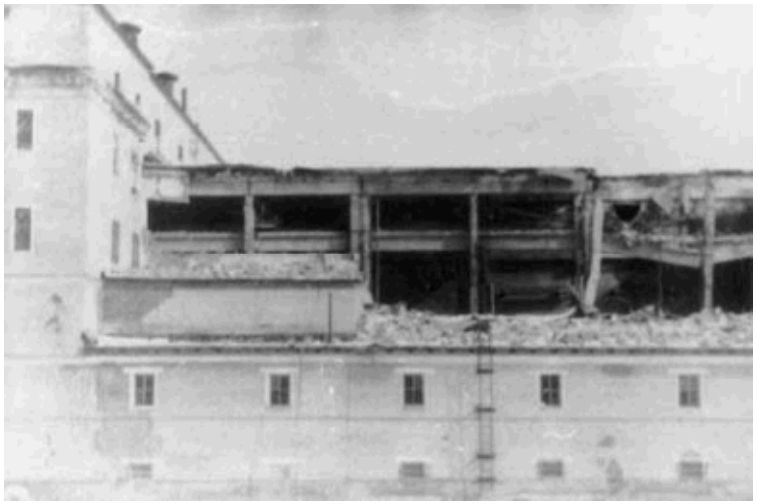
- Chemical explosion
  - Process controls fail to maintain temperature or concentration limits of aqueous or organic solutions
  - Released energy can exceed 1 GJ (over milliseconds)
- Fires
- Reactivity excursion
  - Process controls fail to maintain concentration limits on fissile isotopes (U-235 and Pu-238)
  - Released energy can exceed 20 MJ per excursion (over seconds), with a total of 1 GJ (over tens of minutes)
- Pipe or vessel leaks

Chemical Explosions

- Initiating event
- Rapid release of energy within a closed vessel
- Generation of pressures that can burst vessel
- Ejection of liquids and vapors from vessel
- Creation of aerosols by shear-induced breakup of ejected globules
- Change of phase
- Aerosol agglomeration, evaporation/ condensation, and deposition
- Damage to walls, doors, and ventilation system





Fires

- Initiating event or result of explosion or leak
- Significant release of energy but over longer time than explosion
- Insertion of mass (soot and radioactive solutes) and energy
- Aerosol agglomeration, evaporation/condensation, and deposition
- Induction of chemical explosions

Reactivity Excursion

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- Fissile materials and neutron moderators are present
- Initiating event
- Volumetric energy insertion
- Generation of pressures that can burst vessel
- Ejection of liquids and vapors
- Creation of aerosols by shear-induced breakup of ejected globules
- Change of phase
- Aerosol agglomeration, evaporation/condensation, and deposition

Pipe or Vessel Leaks (Spills)

- Initiating event or result of explosion
- Creation of aerosols by shear-induced breakup and fracturing of ejected globules
- Change of phase

- Aerosol agglomeration, evaporation/condensation, and deposition
- Fires can result

Estimating a Release

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- Previously, correlations in DOE-Handbook-3010-94 have been used to estimate released mass and size distribution
  - Many assumptions are highly conservative
  - Some correlations are based on bench-scale experiments
  - Experiments often do not capture important phenomena
- Alternative approach is to use a basic-principles model to estimate the creation of aerosols
- Initial focus is on chemical explosions
  - Most energetic and likely to damage confinement
  - Produce largest source terms

Estimating a Source Term

- First estimate releases into compartments in the confinement
  - Use DOE Handbook when appropriate or release is inconsequential
  - Use basic-principles models to evaluate release when more realism is needed
- Evaluate damage state caused by accident sequence
- Estimate transport of vapors and aerosols through compartments and into atmosphere (leak path factor)
  - Treat mass and energy insertion using a safety systems code
  - MELCOR has traditionally been used by DOE as the SSC

Summary

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- There is a growing interest for licensing a spent fuel reprocessing plant in the US
- As a result, the NRC is gearing up to evaluate the safety of such plants
- Current focus is on proven technology, i.e., aqueous reprocessing
- Sandia is developing a capability to evaluate accident source terms to support NRC licensing
- Current plan is to replace DOE Handbook correlations for important source terms with basic-principles modeling.
  - We expect a significant reduction in conservatism.