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What is SEMPRASAFE?

- Joint Venture between Energy*Solutions* and Studsvik to process US-generated low-level radioactive resin through Studsvik's THOR® process
- Creates a superior waste form for disposal at Clive
- Based on 10 years of experience safely handling these materials within the existing regulatory environment

Why SEMPRASAFE?

- Addresses resin waste management issues at nuclear power plants
- Offers best practices in processing and disposal to the nuclear power industry
- Addresses issues of NRC Commissioners in Staff Requirements Memo on blending
- Builds on the long-standing business relationship between Energy*Solutions* & Studsvik

NRC Position on Blending

- NRC has recently stated its new position that “large-scale LLRW blending may be conducted when it can be demonstrated to be safe.”
- Commission recognized significance of
  - Homogeneity
  - Intruder Protection

SEMPRASAFE and the THOR Process

Commercial Nuclear Waste Treatment with the THOR Process in Erwin, TN

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THOR Process Overview

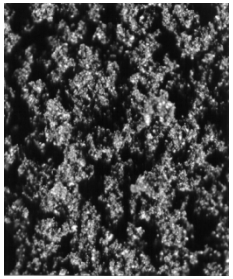
Organic Resin

- Polystyrene Beads
- Organics
- Metals
- Water
- Salts

Heat

Mineral Former

Pyrolyzed Resin



- Fixed Carbon
- Salts
- Metal Oxides, Spinels, and Aluminates

Heat

Oxygen from Superheated Steam

Reformed Resin

- Metal Oxides, Spinels, and Aluminates
- Salts
- Residual Fixed Carbon

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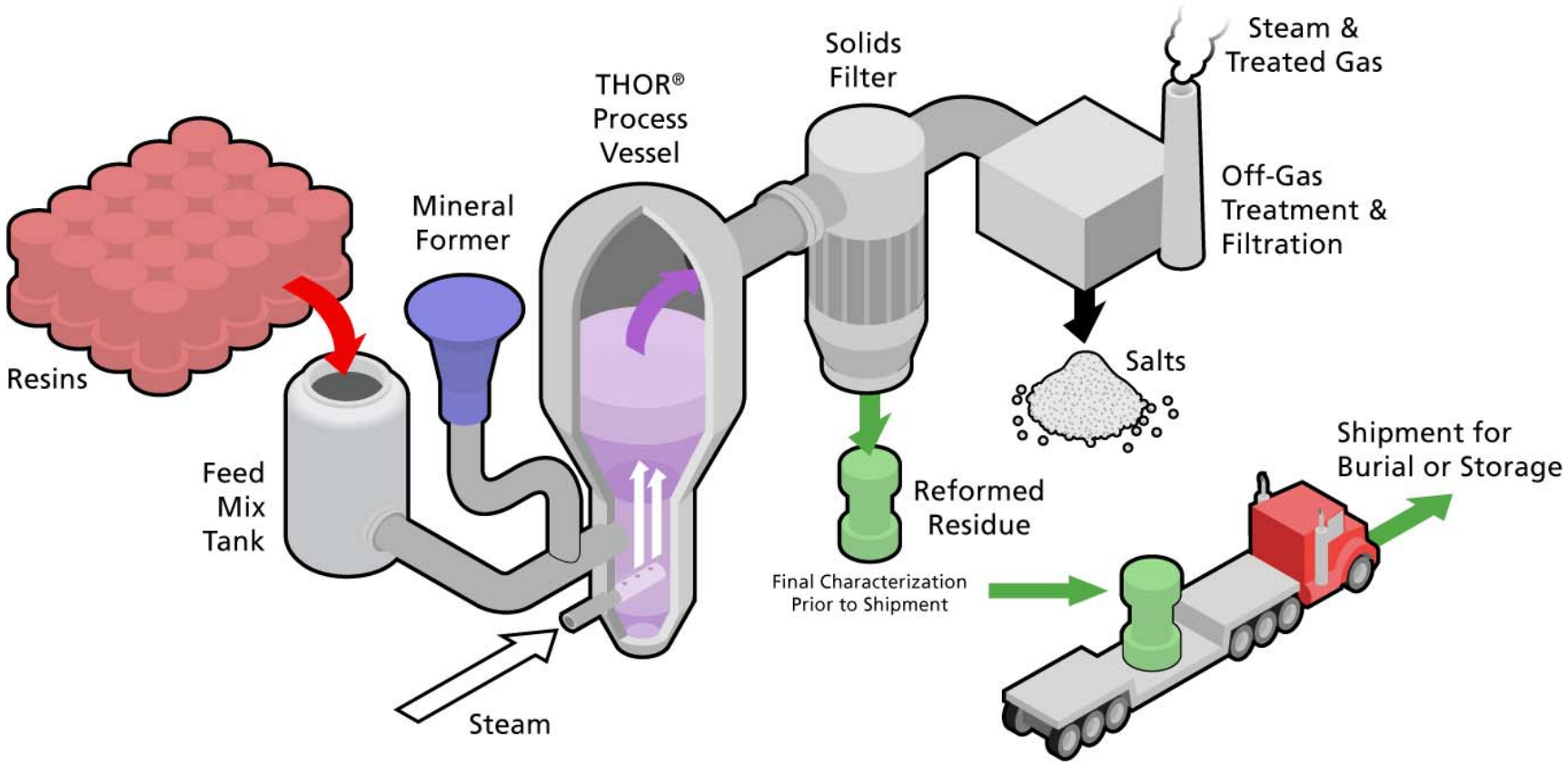
THOR Process Flow Diagram



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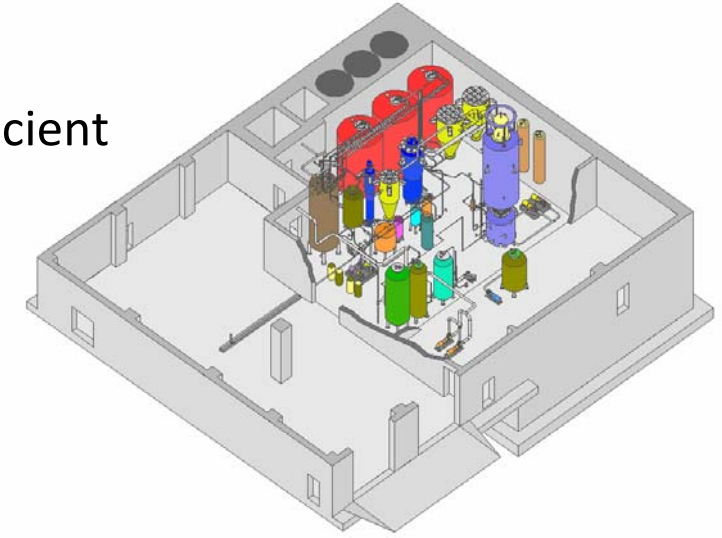
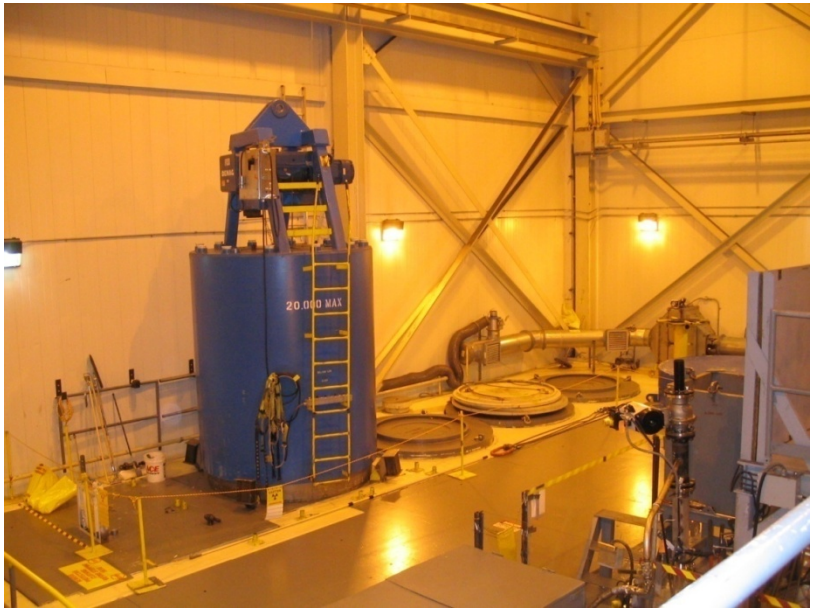
Fluid Bed Process Operational Features

- Uniform reactions and consistent product due to
  - Complete mixing due to fluid-like behavior
  - Better gas-solid contact than other processes
  - Uniform temperature gradients
- Very high heat transfer coefficients so more efficient
- High efficiency due to continuous operation
- Highly predictable
- Highly reliable
- High degree of control



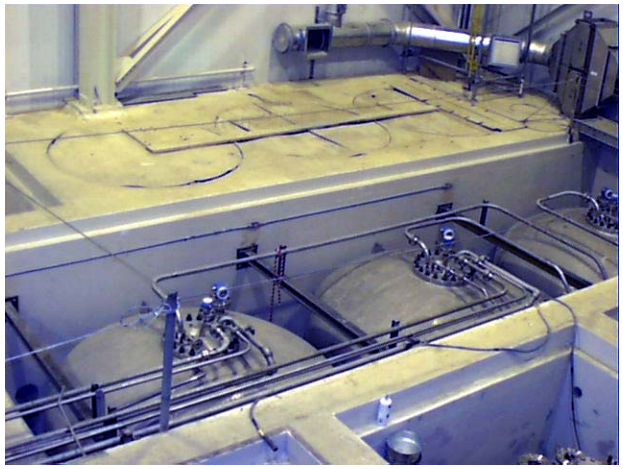
Waste Receipt

- Waste in high integrity containers (HICs) transferred from cask
- Utilize shielded transfer bell
- Material slurry transferred from HICs to process tanks



Processing Equipment

Waste Receipt Tanks, Process Filters, Steam Superheaters



Reactions in a THOR Reformer

Main Reaction Inputs

- Steam
- Coal or Charcoal
- Waste
- Mineral Former

Main Reaction Outputs

- Water Vapor
- Carbon Dioxide
- Nitrogen
- Reformed Residue

- Main gas phase reactions in fluidized bed reformer

• $C_xH_yO_z \leftrightarrow C + CH_4 + CO + H_2$	Decomposition of organics
• $H_2O + C \leftrightarrow H_2 + CO$	Water gas reaction
• $CO + H_2O \leftrightarrow CO_2 + H_2$	Water gas shift reaction
• $2NO_3 + 3C \leftrightarrow N_2 + 3CO_2$	Conversion of nitrates to nitrogen gas
• $2NO_3 + 6H_2 \leftrightarrow N_2 + 6H_2O$	Conversion of nitrates to nitrogen gas
• $C + O_2 \leftrightarrow CO_2$	Oxidation of carbon
• $2CO + O_2 \leftrightarrow 2CO_2$	Oxidation of CO to CO_2
• $2H_2 + O_2 \leftrightarrow 2H_2O$	Oxidation of H_2 to water

THOR Final Waste Forms

Waste Constituent or Characteristic	No Mineral Former (DOE)	Mineral Former (SPFE)	Clay Former (DOE)
Organics	Destroyed	Destroyed	Destroyed
Alkali Metals	Carbonate	Aluminate	Alkali Aluminosilicate mineral (NAS)
Inorganic Metals	Oxides, Spinels	Oxides, Spinels, Aluminates	Spinels and Oxides bound in NAS matrix
Cl, S, F, P, B	Alkali Salt	Alkali Salts, Aluminum Compounds	Bound in NAS matrix
Radionuclides	Oxides or Carbonates	Spinels and Oxides, or Carbonates	Spinels and Oxides bound in NAS matrix
Waste Form	Inorganic and soluble	Inorganic, reduced solubility, non-leachable	Immobilization / non-leachable

Facility and Process Overview

- Shielded facility
- Treats ion exchange resins
- Extremely good radionuclide retention
- >9,900 m^3 (>350,000 ft^3) processed
- >2,900 incoming LLW shipments
- >4.9 x 10^9 MBq (133,000 Ci) processed
- Incoming LLW resin contact dose rates up to 10 Sv (1,000 R/hr)
- Over 10 years of LLRW operation

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THOR Process Applications

- Studsvik Processing Facility
  - Ion Exchange Resins
- DOE-Idaho Integrated Waste Treatment Facility
  - Nitrate Slurry Waste: Remote Handled TRU (Start-up in 2011)
- DOE-Savannah River Site Tank 48H Treatment Facility
  - Nitrate Waste: High Level Waste (Final Design 2011)
- Qualification testing on-going
  - DOE-Hanford
    - Waste Treatment Plant Secondary Waste and Low Activity Waste (LAW)
    - Nitrate Waste: Intermediate Level Waste
  - Foreign Applications
    - Ion Exchange Resins, Pu Contaminated Wastes, Nitrate Waste, Graphite

Waste Disposal and Clive Safety Analyses

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Safety Analysis

- Energy*Solutions* prepared analysis to demonstrate waste can be safely disposed
  - Site suitability
  - Intruder protection
  - Performance Assessment

Site Suitability

- Arid conditions
- Lack of a source of potable water at the site
- Absence of any conditions that would promote the site as a desirable place to live
- Minimal possibility of a residence being constructed at the site

Intruder Protection

- Prior licensing actions for the Clive facility have evaluated intruder scenarios
- Construction intruder, agriculture intruder, and off-site receptor scenarios found not to be reasonable
- Conducted intruder analysis despite absence of credible intruder scenario

Intruder Protection

- Inherent in Clive CWF Disposal Unit Design
- Acknowledged by NRC in SECY-10-0043
- CWF disposal methodology exceeds the requirements of 10 CFR 61 and the Utah Administrative Code
  - Engineered barrier
  - Stability
  - Depth

Groundwater Analysis

- Assumed all waste disposed at Class A limits for all isotopes
- Groundwater assumed to be potable
- Receptor assumed to reside at the facility for 30 years
- The groundwater protection standard was 4 mrem/yr (0.04 mSv/yr), as opposed to the NRC prescribed 25 mrem/yr (0.25 mSv/yr)
- Groundwater standard (4 mrem/yr) not exceeded after 500 years

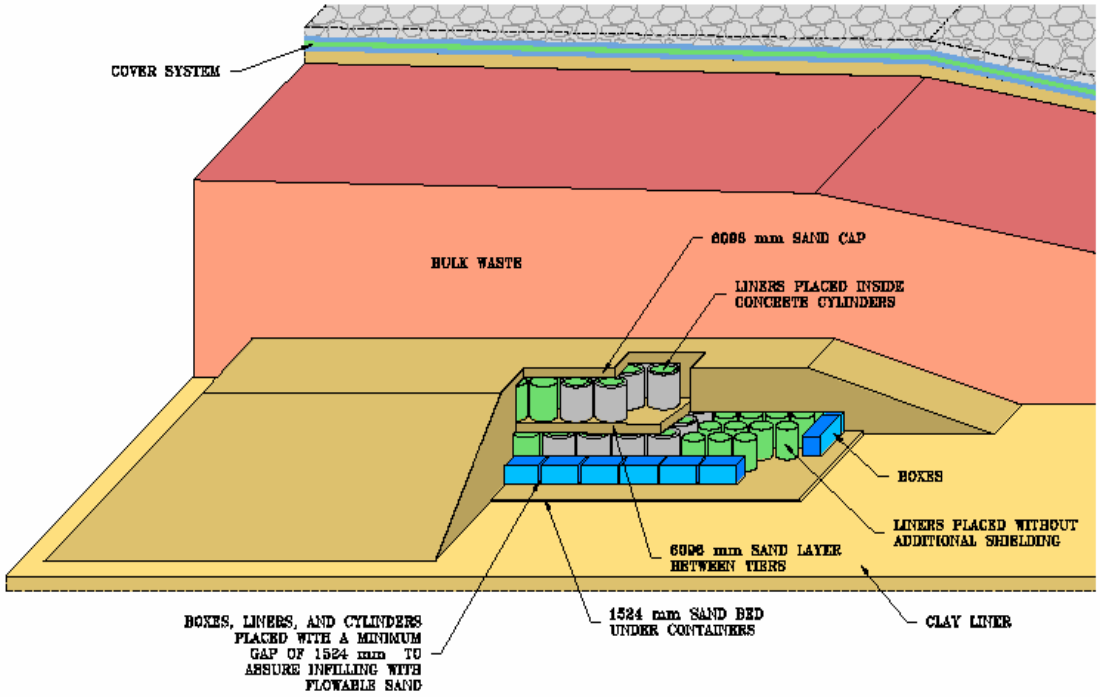
Shipment Arrives

Liner removed from cask

Liner placed in caisson

Caisson backfilled

CWF Disposal Layout



CONTAINERIZED WASTE FACILITY: PLACEMENT CONFIGURATIONS

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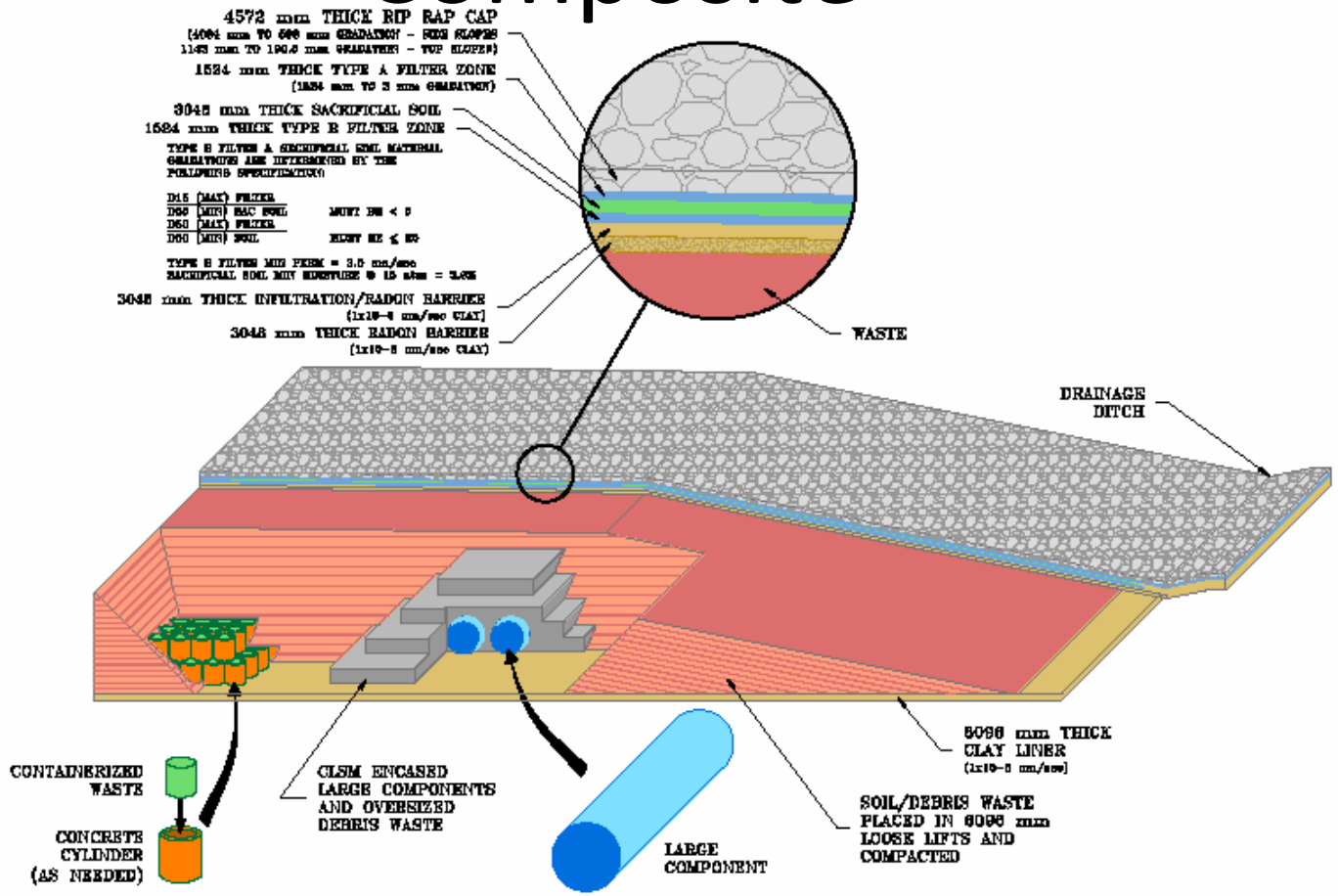
Composite



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Summary of Safety Analysis

- The site is suitably located and licensed for the disposal of Class A waste
- Performance assessment demonstrated acceptability of disposal of large quantities of waste at Class A limits
- CWF provides inherent protection of inadvertent intruder
- Protection of an intruder is provided even though there are no credible intrusion scenarios
- Consumption of the groundwater will not result in a dose that exceeds the standard even though the groundwater is not potable

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ADDITIONAL SLIDES SUBMITTED BY ENERGYSOLUTIONS

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Unique Waste Stream

- Blended waste is not intrinsically unique
- NRC defines blended waste as unique when it meets three criteria
  - Large Quantities
  - At or near Class A Limits
  - Disposed in close proximity

Clive Activity Loading