

Pilot Scale Fluidized Bed Steam Reforming Overview for Tank 48



SRNLTM
SAVANNAH RIVER NATIONAL LABORATORY

We Put Science To Work

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Talk Outline

- **Steam Reforming and THOR® Introduction**
- **Steam Reforming Applications**
- **THOR® Steam Reforming Process Description**
- **THOR® Steam Reforming Testing for DOE**
- **Hazen Pilot Fluidized Bed Steam Reforming Facility Discussion**
- **Summary**
- **Questions & Answers**

Introduction of THOR® Treatment Technologies LLC

- **Joint venture formed by Studsvik, Inc. and Washington Group International**
- **Business focuses on thermal treatment of DOE and DOD waste**
- **More information on THOR® is available at the website www.thortt.com**

Steam Reforming Process Background

- Steam Reforming uses high temperature (700°C-1100°C) steam, with catalysts and/or additives, to break down organic and inorganic materials and produce desired end products, i.e. “reforming the feed”
- Has been used as a chemical process for over 100 years



Steam Reforming Applications

- Commercial chemical applications
 - Biomass gasification, syngas and hydrogen production, metal reduction, chemical processes, petroleum refinery applications, and black liquor destruction/energy recovery in the pulp and paper industry
- Commercial radioactive application
 - THOR® facility in Erwin, TN treats radioactive waste from commercial nuclear power plants
- DOE radioactive application
 - THOR® facility is being installed as part of the Idaho Cleanup Project (ICP) to treat radioactive Sodium Bearing Waste (SBW)

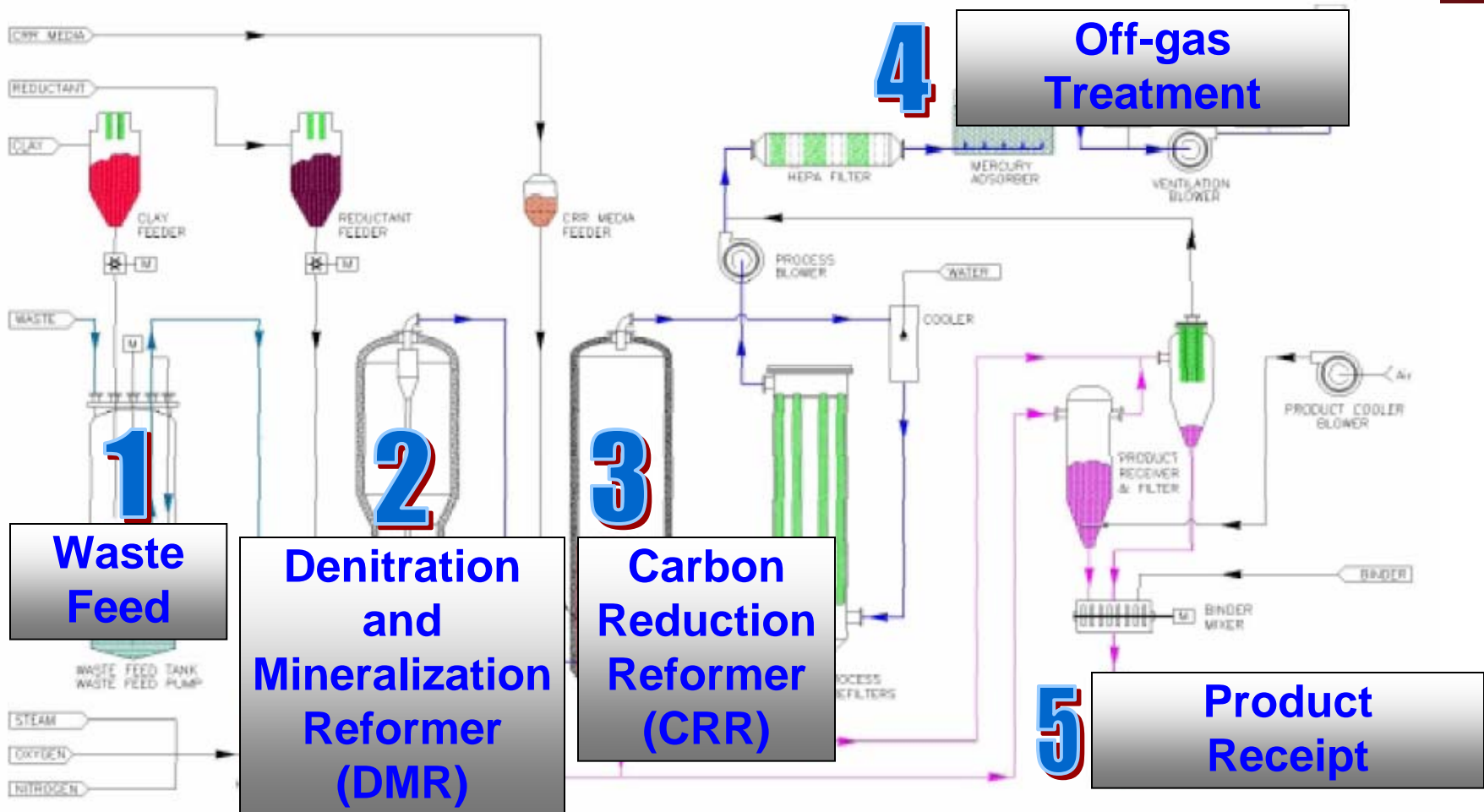
THOR® Process Chemistry

- Converts nitrates and nitrites to nitrogen gas
 - **$\text{NO}_3 / \text{NO}_2 + \text{CO} / \text{H}_2 \rightarrow \text{N}_2 + \text{CO}_2 + \text{H}_2\text{O}$**
- Destroys organics
 - **$\text{C}_x\text{H}_y + \text{H}_2\text{O} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$**
- Has no liquid effluent and off-gas is generally safe
 - **NO_x is typically less than 300 ppm in off-gas**
 - **S, Cl, F is typically less than 10 ppm in off-gas**
 - **There are no secondary process wastes**
- Can treat most kinds of DOE wastes
 - **Accepts solid, liquid, slurry or gaseous feeds**
 - **Accepts high water, organic and sulfur content, high or low pH materials (no neutralization)**
 - **Has high throughput in small footprint**

THOR® Process Attributes and Operations

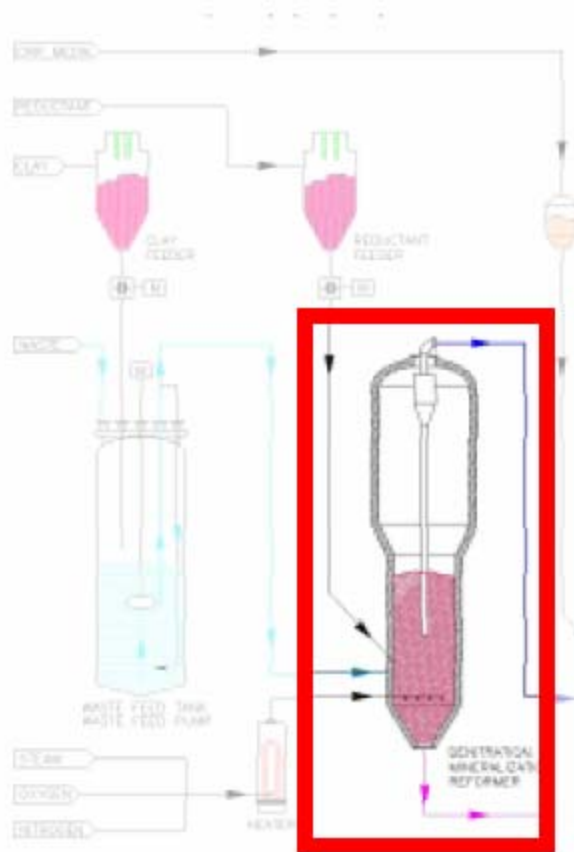
- Passivity of the process and its operation
- Online product sampling and analysis
- Robust process with wide operating parameters
- Simplicity in system hardware and operations
- Zero liquid discharge
- Continuous operation vs. batch

THOR® Steam Reforming Process Overview



Legend: CEMS—Continuous Emissions Monitor, Rad Non—Radioactive Emissions Monitor

THOR® Steam Reforming Process-Denitration and Mineralization Reformer (DMR)

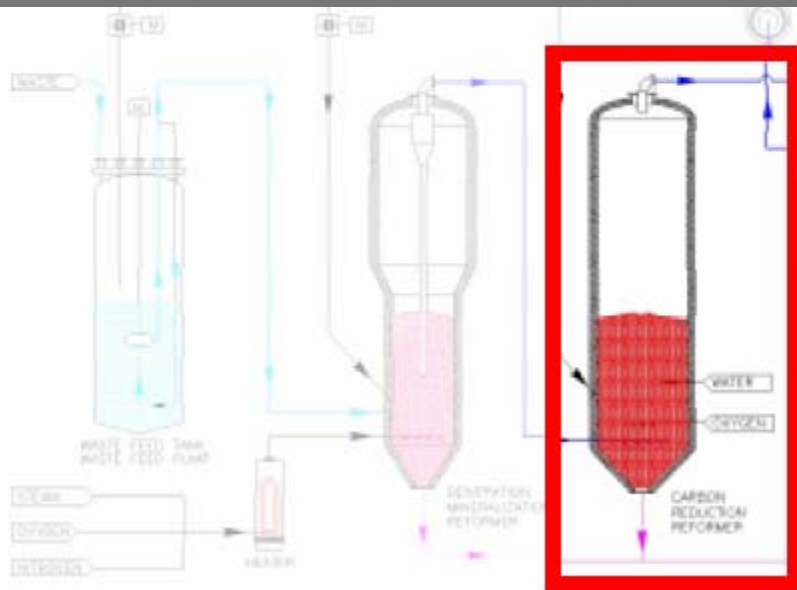


- DMR: Operates in a strongly reducing environment
- Reductants are used to convert nitric acid, nitrates, and nitrites directly to nitrogen gas
- Other reactants like clay may be added to convert radionuclides, alkali metals, sulfate, chloride, fluoride, phosphates, and non-volatile heavy metals into a solid mineral product

Liquid: CEM-Continuous Effluent Monitor, Red Box-Reductive Effluent Monitor

THOR® Steam Reforming Process- Carbon Reduction Reformer (CRR)

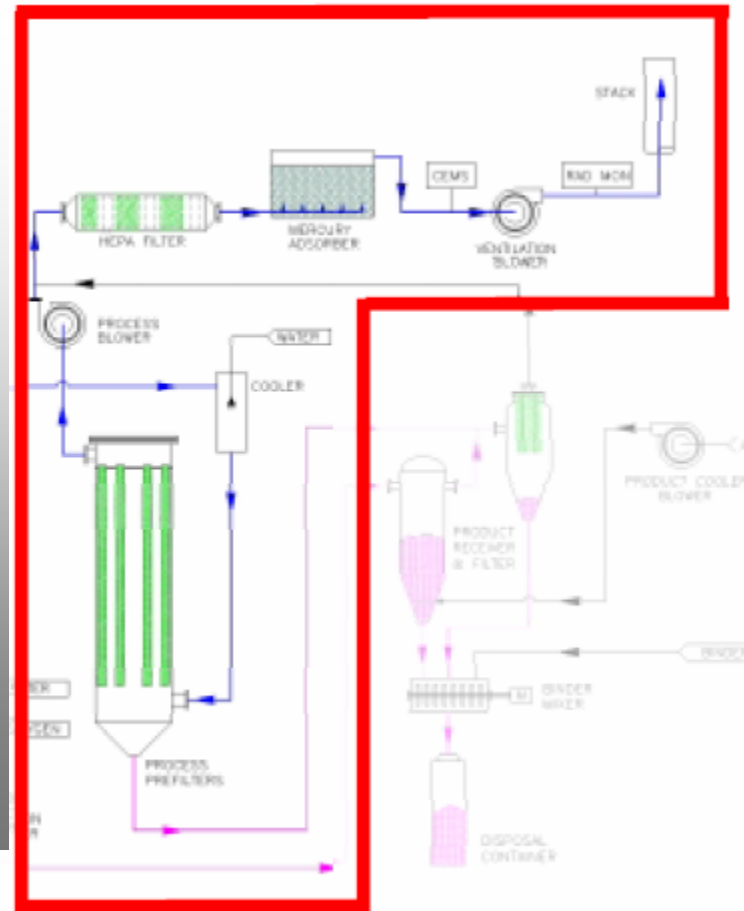
- CRR: Operates in both reducing and oxidizing modes
- Receives process gas and entrained fines from DMR



- Converts residual NO_x to nitrogen gas in lower reducing sections
- Converts carbon fines and residual organic gases to carbon dioxide and water vapor in upper oxidizing section

THOR® Steam Reforming Process- Off-gas System

- Offgas from the CRR (mostly nitrogen, water vapor, and carbon dioxide) is cooled, filtered, and monitored prior to being released to atmosphere
- No wet scrubber required to be MACT-compliant



THOR® Steam Reforming Testing for DOE

- Nine demonstrations using SBW and LAW surrogates have been conducted since August 2000
- THOR® successfully produced desired sodium carbonate product for SBW surrogates
- THOR® successfully produced desired product for LAW surrogates, a mineralized alkali-aluminosilicate
- Pilot plant testing of the THOR system for ICP was completed in February
 - 2000 gals of surrogate processed
 - All system parameters are within projected limits
 - NO_x <200 ppm
 - SO_x <50 ppm
 - CO <50 ppm
 - THC ~0

Hazen Pilot Fluidized Bed Steam Reforming Facility

- **Located in Golden, CO**
- **Performed IWTU pilot tests**
- **Performed WSRC Tank 48 Tests**
- **Will perform INEEL SBW Tests**

Hazen Pilot Test Facility

- **Successfully completed 4 weeks of testing with Tank 48 Simulant on October 13**
- **Initial findings show that off-gas is clean:**
 - **CO ~ 5 ppm**
 - **THC ~ 1 ppm**
 - **NO_x ~100 ppm**
 - **SO₂ ~20 ppm**
- **Initial Benzene in DMR 942 ppm but 0 ppm after CRR**

Hazen Pilot Test Facility Summary

- **Initial results show that Tank 48 simulant can be processed by steam reforming**
- **Carbon was best reductant in DMR out of sugar, Propylene Glycol, and Polyethylene beads**
- **Plan to perform experiments to examine impact of carbon on downstream processing in DWPF**
- **Final Hazen Report to be issued early 2007**