

## **Decontamination of TRU Heterogeneous Waste by the Sonatol Process (\*)**

**Robert Kaiser (Entropic Systems, Inc.) and  
Arthur E. Desrosiers (Bartlett Services, Inc.)**

The Sonatol process uses agitation in fluorinated surfactant solutions to detach small particles, including radioactive ones, from surfaces of objects. About fifteen years ago, Entropic Systems, Inc. demonstrated that contacting particle contaminated surfaces with a dilute solution of a high molecular weight fluorinated surfactant in an inert perfluorocarbon liquid under high shear conditions resulted in very effective removal of micron or submicron sized particles from solid surfaces, without otherwise affecting these objects. The detached particles are then removed from these solutions by filtration.

Based on experience from various programs utilizing the Sonatol approach, we believe that heterogeneous TRU waste at various DOE sites) will be successfully decontaminated by contacting it with the Sonatol perfluorinated surfactant solution in a cleaning chamber that allows for mechanical agitation of the items being processed in the chamber, as well as spraying or ultrasonic agitation. The TRU contaminated material is transferred from the storage drum to a transfer basket in a hot side glove box. The basket is transferred to the cleaning chamber, where it, and its contents, are sequentially exposed to circulating fluorinated surfactant solution, fluorinated rinse and then dried. The cleaned (i.e. decontaminated) basket is then off-loaded into a clean glove box, where it and its contents are surveyed for residual contamination. Materials that meet the decontamination criteria are then repackaged and removed from the system. Materials that do not meet the criteria are reprocessed. Other than the removal of particulate contamination, the processed materials are unchanged.

The liquids leaving the are recirculated through a bank of stainless steel and ceramic filters, with a pore size as small as 0.2 microns, to remove the suspended particles, including the TRU particles of primary concern. The fluorinated surfactant solution is recovered primarily by filtration, while the rinse is recovered by filtration and distillation. The TRU contamination is captured primarily on the finer filters in the filtration train as solid waste free of hydrogenated organics that can be safely shipped to WIPP in TRUPACT II containers.

The major advantage of the process over incineration or other oxidation processes is that it operates in closed loop under near ambient conditions, thus minimizing the potential for fugitive TRU emissions. This has very significant safety and cost impacts.

(\*) For presentation at Industry Partnerships for Environmental Science and Technology Conference, Morgantown, W VA, October 30, 2001.

---

# **Decontamination of TRU Heterogeneous Waste by the Sonatolâ Process**

**Robert Kaiser<sup>1</sup> and Arthur E. Desrosiers<sup>2</sup>**

<sup>1</sup> **Entropic Systems, Inc., Woburn, MA**

<sup>2</sup> **Bartlett Services, Inc., Plymouth, MA**

**October 30, 2001**

**Industry Partnerships for Environmental Science and  
Technology Conference, Morgantown, W VA**

# OBJECTIVE

- Clean-up of Pu-238 contaminated heterogeneous waste
  - Eliminate/reduce hydrogen generation due to radiolysis of organic materials

# TECHNOLOGIES

## CURRENT

- Destroy organic bonds
  - WAP
  - DCO
- Convert hydrogen gas
  - Venting
  - Hydrogen getters

## ALTERNATE

- Decontamination of the waste to below 100 nCi/g by the Sonatol® process.
- Process Approach
- Inherent Advantages

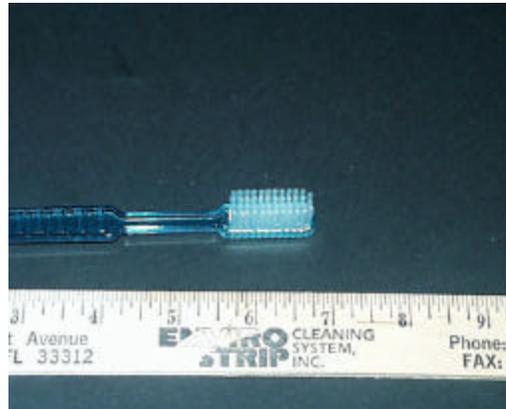
<b>Comparative Properties of Sonatol Liquid and Water</b>		
	<b>Sonatol 70</b>	<b>Water</b>
Formula	C7F16	H2O
Ave. Molecular Weight	388	18
Boiling Point, °C	80	100
Pour Point, °C	-95	0
Vapor Pressure @ 20°C, torr	79	24
Density, g/ml	1.73	1.00
Surface tension, dyne/cm	13	72
Viscosity, cs	0.56	0.9
Specific Heat, cal/g-°C	0.25	1.00
Heat of Vaporization @ BP, cal/g	19	540
Hildebrand Solubility Parameter, (MPa <sup>-0.5</sup> )	12.3	47.9
Hydrogen Bonding Capability	Very Low	Very High
Flammability	None	None
Flash Point, °C	None	None
Flammability Limits, vol-% in air	None	None
Volatile Organic Compound (VOC) Limits	NA	NA
Ozone Depletion Factor (CFC11 = 1.0)	0	0
Total Worker Exposure Limits per 8 hr day	None	None

# Sonatol Decontamination of Simulated Pu-238 Heterogeneous Waste-Toothbrush Contaminated With Sylvania 2213 Phosphor

As Received



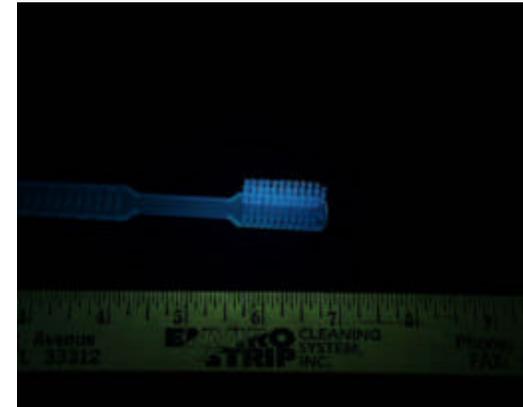
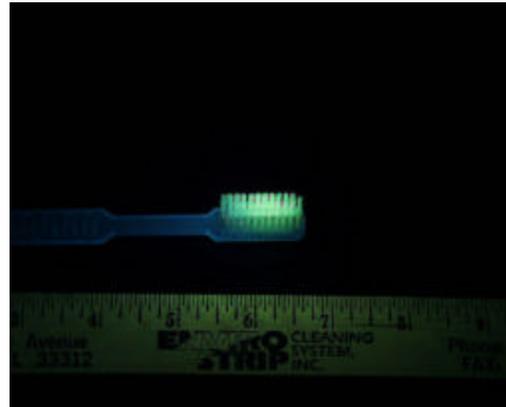
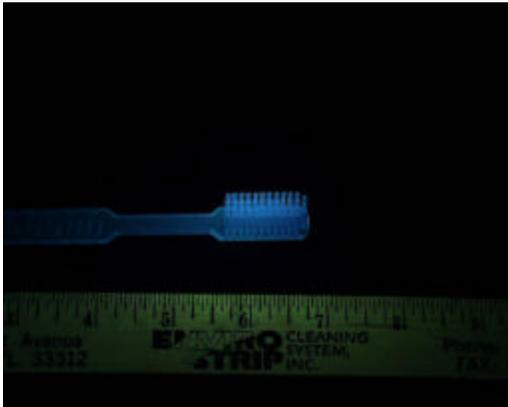
Contaminated with 2213 Phosphor



After Sonatol Decontamination



Under Normal Illumination



Under UV Illumination

# Filtration Removes Suspended Contaminant from Sonatol Liquid

Contaminated Liquid

Before Filtration

After Filtration



With Normal Illumination

Contaminated Liquid

Before Filtration

After Filtration



With UV Illumination

# **HISTORICAL DEVELOPMENT OF THE SONATOLâ PROCESS**

- Precision Cleaning Studies for the USAF
- Decontamination Studies for the USNRC
- Operational Experience
  - Filter cleaning at SRS
  - Decontamination of heterogeneous TRU waste at Battelle

Sonatul® Filter Decontamination  
System at SRS



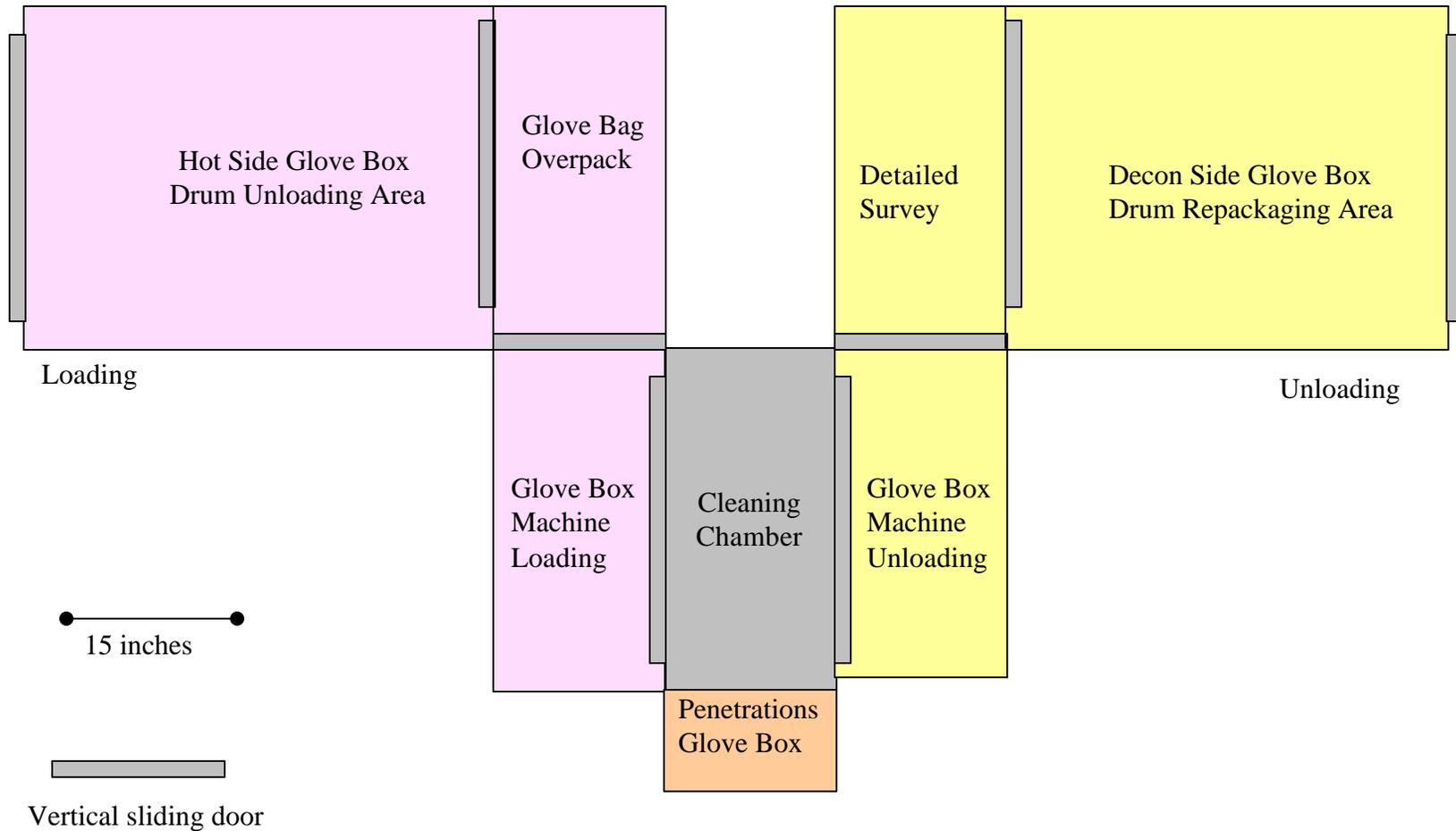
TRU Mophead Decontamination  
System at BCLDP



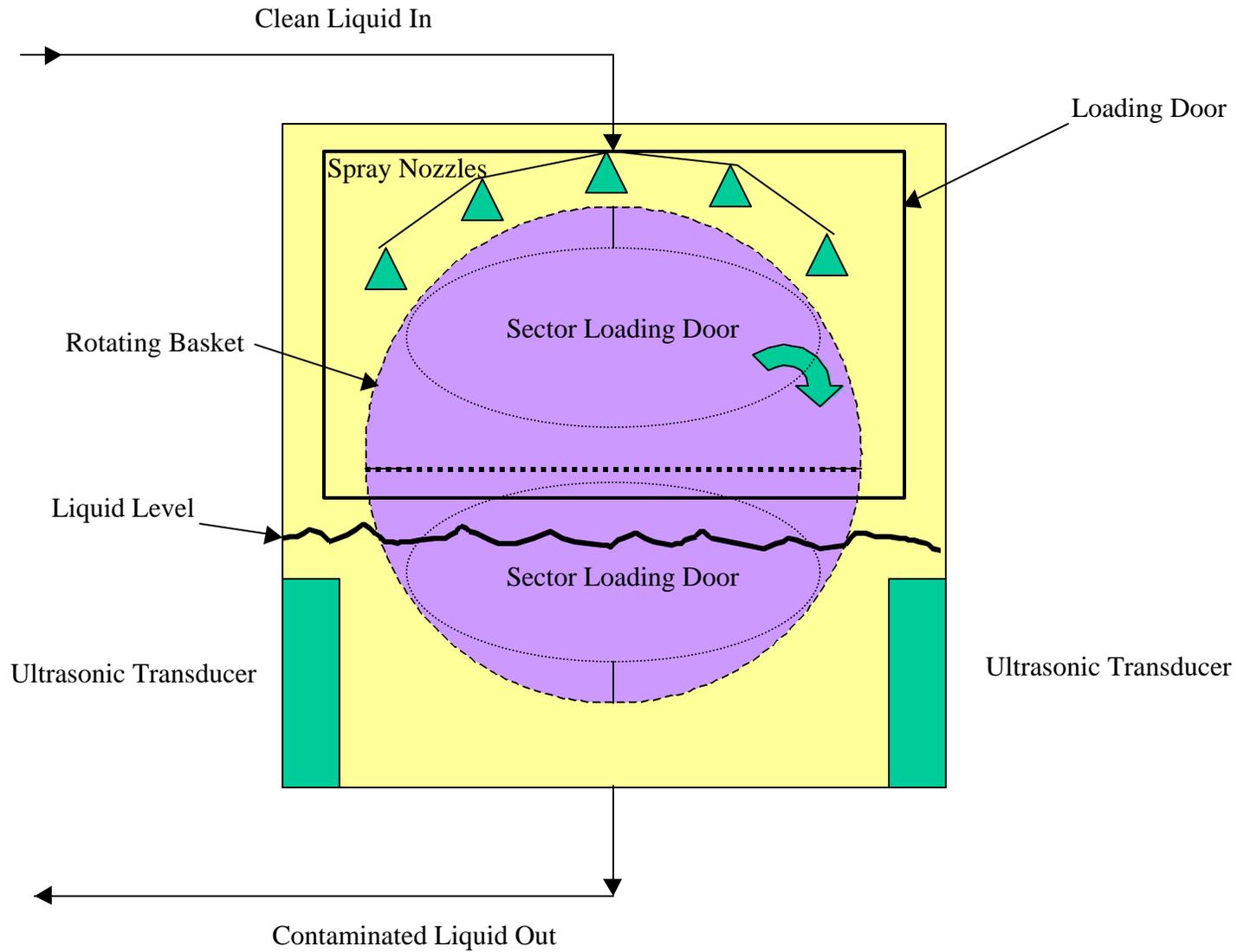
# **DECONTAMINATION OF PU-238 CONTAMINATED HETEROGENEOUS WASTE BY THE SONATOL® PROCESS**

- Process Description
- Provisions for Contamination Control
- Capital and Operational Costs
- Benefits of the SONATOL® Process

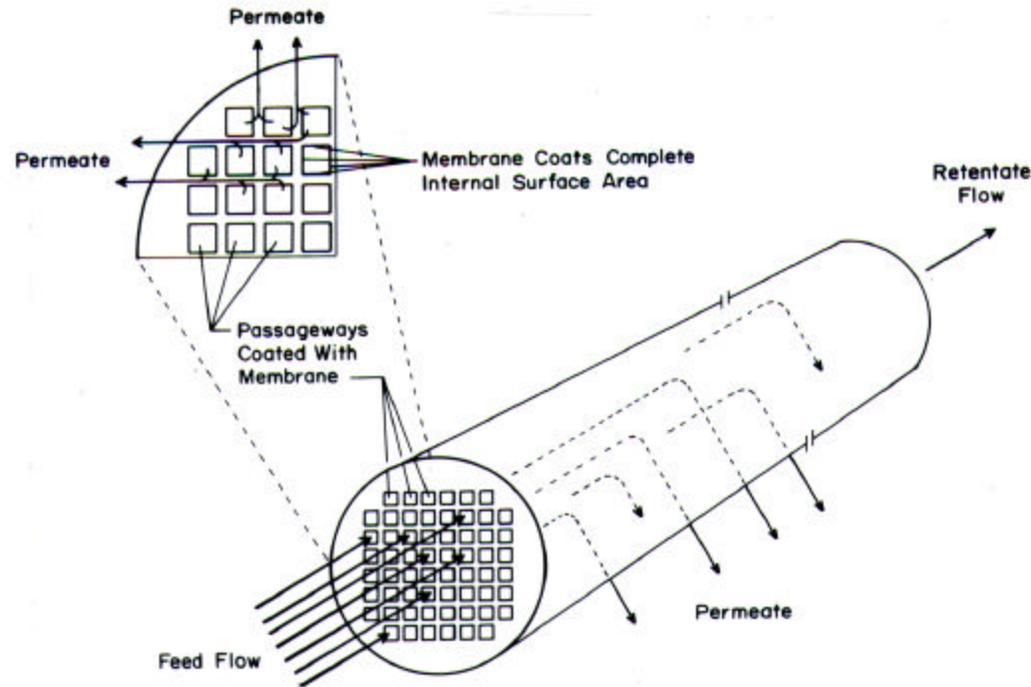
# Plan View of Pu-238 Decontamination System



# Schematic Representation of Interior of Cleaning Chamber

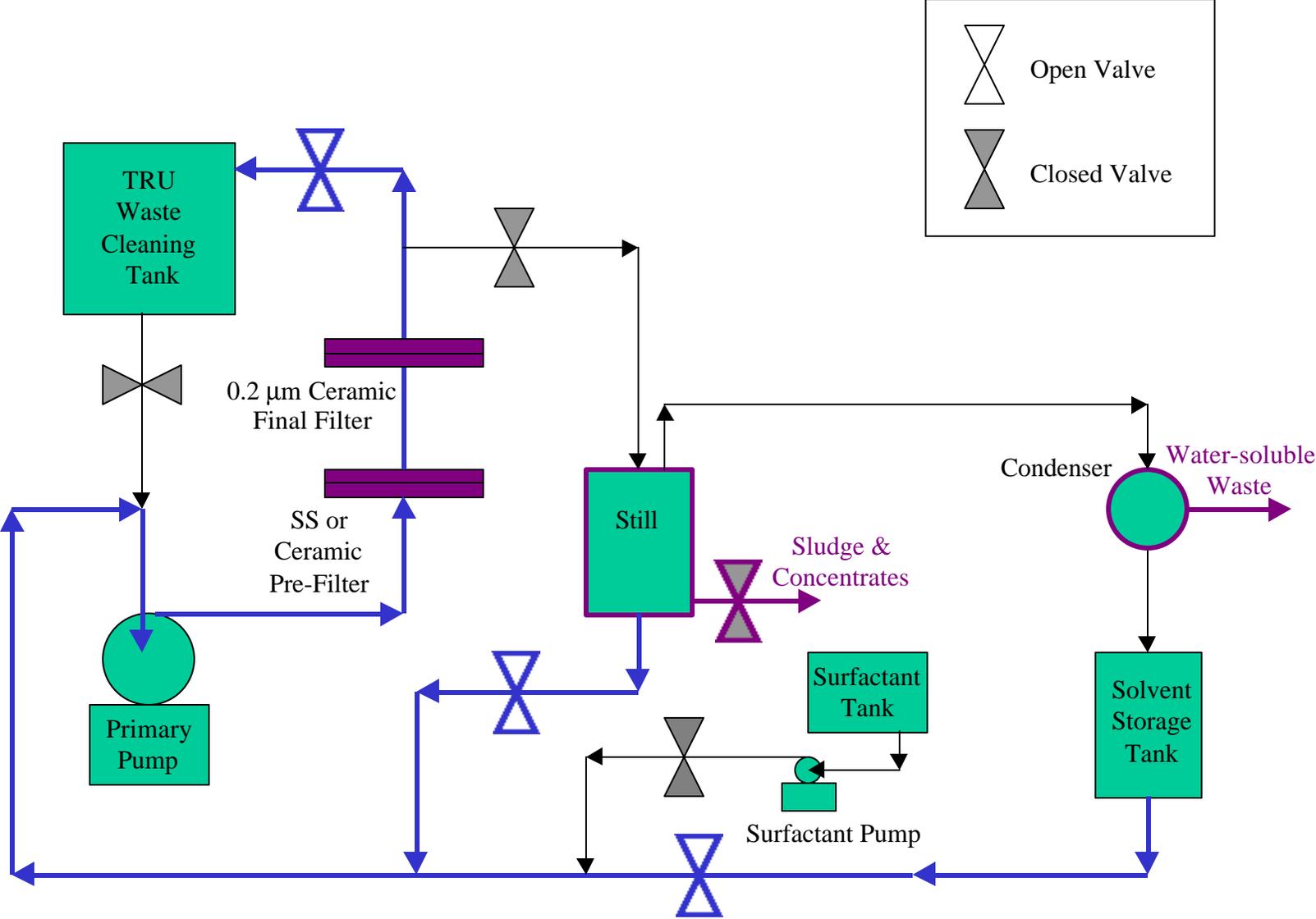


# Schematic Presentation of Ceramic Membrane Monolith



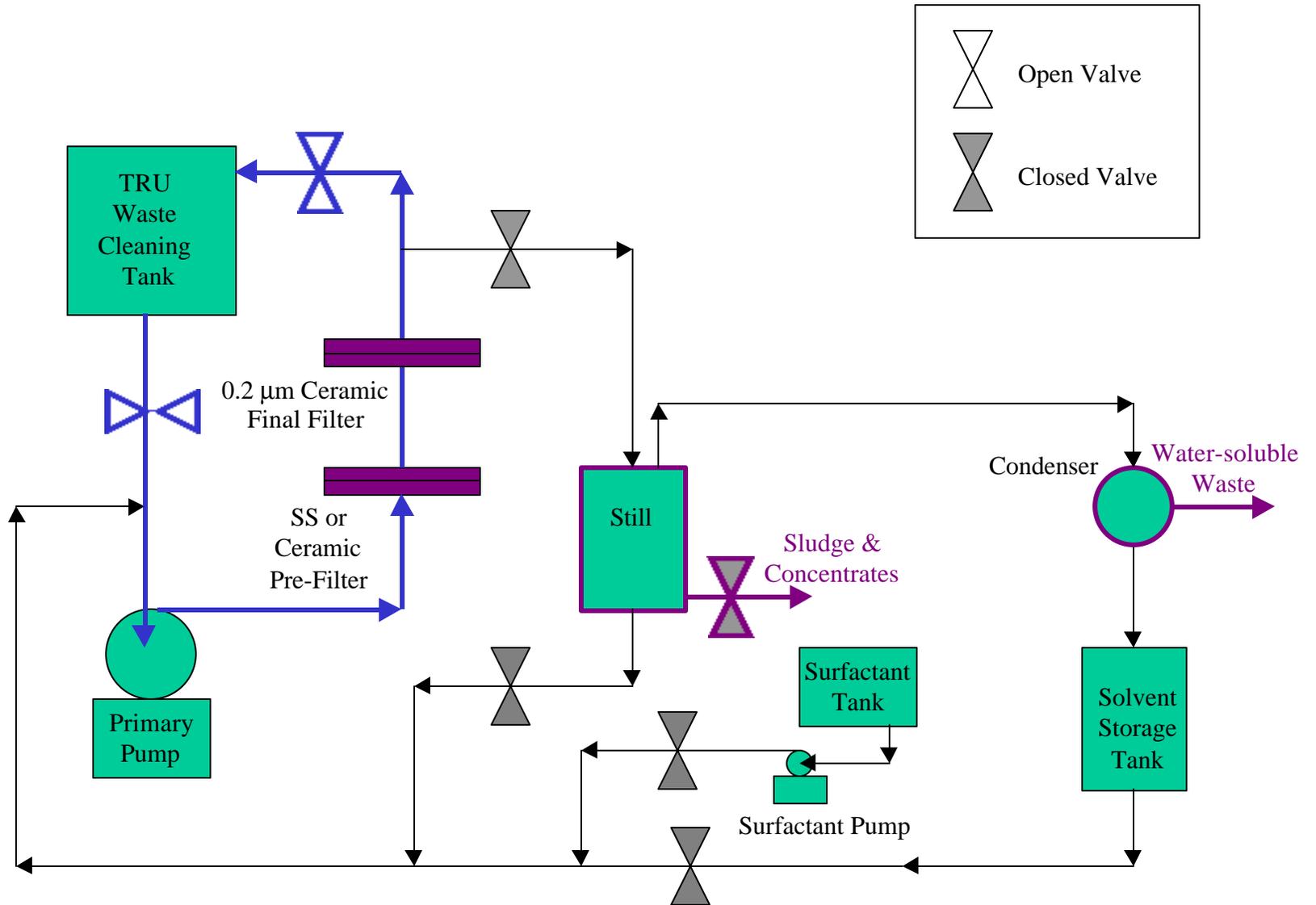
# Sonatot Process Flow Diagram

Step 1: Fill Cleaning Tank with Sonatot Fluid (Option)



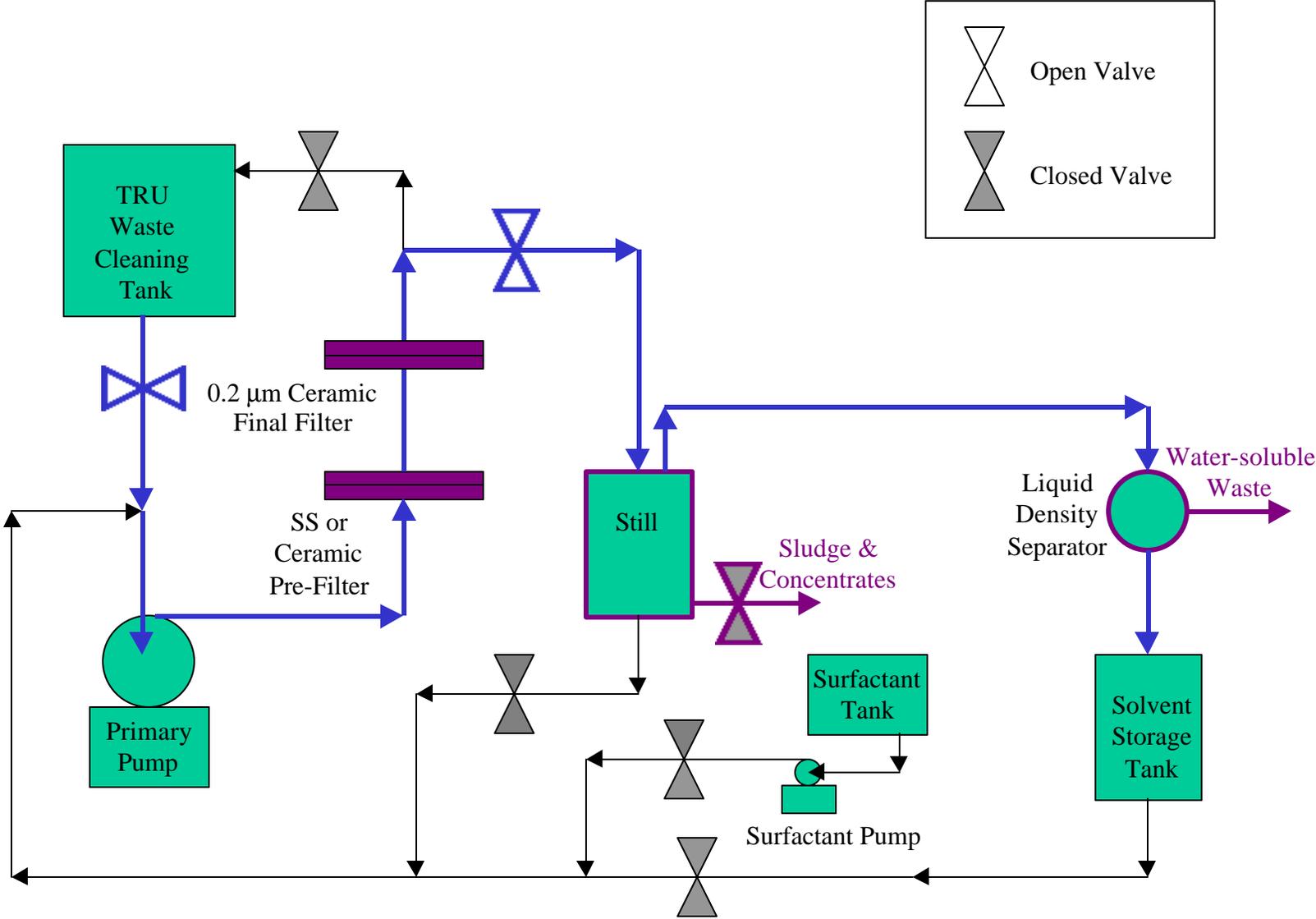
# Sonatul Process Flow Diagram

Step 2 or Step 5: Circulate Sonatul Solution



# Sonatul Process Flow Diagram

Step 3 or Step 6: Drain Sonatul Fluid to Still & Recycle Solvent



# Benefits of the Sonatol® Process

- Demonstrated ability to remove sub-micron TRU particulate contaminants from solid substrates
- DFs > 1000 have been achieved in tests
- Treats heterogeneous waste streams, including debris, job control waste, clothing, etc.
- Compatible with acids, bases, chlorinated solvents, and flammable liquids
- Wastes can be processed repeatedly, if needed

# Simple, Safe, Automated Process

- Organic content converted to LLMW; no need to destroy C-H bonds
- Operates at ambient conditions
- Maintains near absolute containment
- Uses inert, nonflammable cleaning liquids- no corrosive or oxidizing chemicals
- Pu-238 recovered in stainless steel and ceramic filters -filter canister certified for disposal at WIPP

# Contamination Control

- Glove boxes accept 55-gallon drums
- System can be put in additional permacon-style containments
- Legacy wastes can be opened in nitrogen atmosphere
- No potential for accidental emissions through gaseous vent
- Self-cleaning process

# System Economics

- Process materials are commercially available
- Related filter cleaning application successfully demonstrated at SRS at 1 drum/day level
- Heterogeneous TRU waste decontamination, including mop heads, demonstrated at Battelle
- Projected 1 drum/day system cost: <\$1 million