

Rheology of Savannah River Site Tank 42 Radioactive Sludges (U)

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RHEOLOGY OF SRS TANK 42 RADIOACTIVE SLUDGES

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Knowledge of the rheology of the radioactive sludge slurries at the Savannah River Site (SRS) is necessary in order to ensure that they can be retrieved from waste tanks and processed for final disposal. At Savannah River Site (SRS), Tank 42 sludge represents one of the first HLW radioactive sludges to be vitrified in the Defense Waste Processing Facility (DWPF). The rheological properties of unwashed Tank 42 sludge slurries at various solids concentrations were measured remotely in the Shielded Cells at the Savannah River Technology Center (SRTC) using a modified Haake Rotovisco viscometer.

Rheological properties of Tank 42 radioactive sludge were measured as a function of weight percent total solids to ensure that the first DWPF radioactive sludge batch can be pumped and processed in the DWPF with the current design bases. The Tank 42 sludge sample, as received, contained 27 wt% total solids. The weight percent total solids were adjusted by dilution with water or by concentration through drying.

The yield stress and consistency of the sludge slurries were determined by assuming a Bingham plastic fluid model. The general shape of the sludge slurry flow curve data supports the Bingham plastic fluid approximation (Figure 1). Yield stress and consistency were determined using the intercept and slope of the flow curves, respectively. Figure 2 shows the apparent viscosities as a function of shear rates for Tank 42 HLW radioactive sludge slurry containing 34 wt% total solids.

The yield stresses were 10, 11, 63, 90 and 381 dynes/cm² at 8, 17, 23, 27 and 34 weight percent total solids, respectively. The apparent viscosities were 10, 20, 35, 45 and 150 centipoises at 300 sec⁻¹ shear rate, respectively. These results agreed with results of non-radioactive sludge simulants. For example, a 15 wt% total solids non-radioactive sludge simulant has a yield stress of 12 dynes/cm², and an apparent viscosity of 12 centipoises at 300 sec⁻¹ shear rate.

Rheological properties of SRS Tank 21 radioactive sludge has been studied previously, as reviewed in reference 1. It was found that below 14 wt% insoluble solids, the yield stress of Tank 21 sludge was less than 40 dynes/cm², and the consistency was less than 10 centipoises.¹ This is consistent with what has been observed with Tank 51 sludge containing less than 18 wt% total solids.¹ Tank 42 sludge containing less than 17 wt% total solids, or 13 wt% insoluble solids, had only a quarter of the yield stress, 10 dynes/cm², but twice the consistency, 20 centipoises.

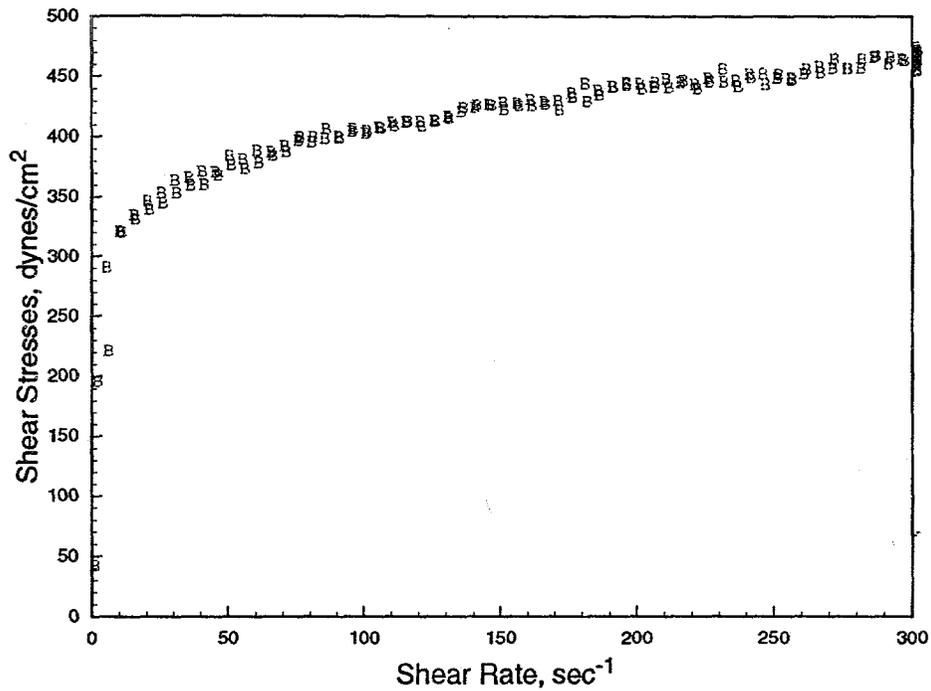


Figure 1. Tank 42 Sludge Containing 34 wt% Total Solids Behaves as a Bingham Plastic Fluid.

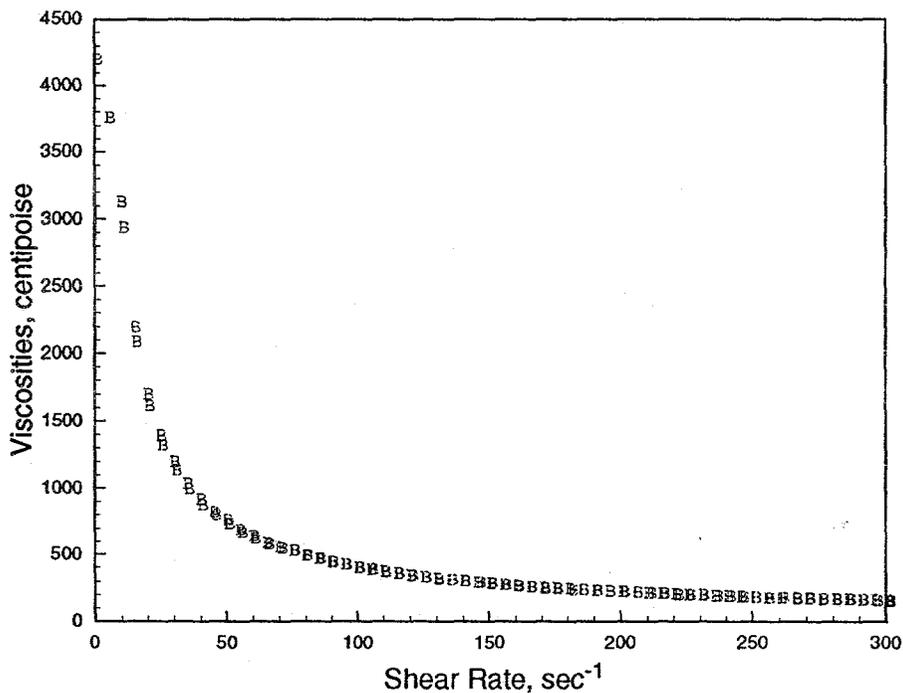


Figure 2. Rheology Behavior of Tank 42 Sludge Containing 34 wt% Total Solids.

It was also also found that, at 44 volume % total solids (or 17 wt% insoluble solids), the yield stress of Tank 21 radioactive sludge was in the range of 80 to 120 dynes/cm², and the consistency was from 15 to 20 cp.¹ The yield stress results compared very well to those of Tank 51 sludge.¹ However, Tank 42

sludge has a higher consistency, but a lower yield stress at a comparable solids concentration. Both, Tank 51 and Tank 21 radioactive sludges have been washed, but Tank 42 sludge was not washed at the time the rheology was measured. The differences in their rheological properties can be attributed to the sludge washing process.

During the Extended Sludge Processing (ESP), the concentrations of sodium, nitrite, and nitrate in the DWPF sludge feed are reduced to the appropriate levels to ensure the processability of the glass and to minimize NO_x emissions and production of ammonium nitrate in the vent system. Hay and Bibler² reported that the settling rate of Tank 42 sludge increased as density of the wash water decreased with each wash cycle. The higher consistency of Tank 42 sludge slurry compared to those of Tank 51 and 21 washed sludges is due to the higher density of the supernate. Viscosity was correlated to a function of the square root of density by Thomas *et. al.*^{3,4} for associated and nonassociated liquids. Although the viscosity model^{3,4} was developed for a liquid mixture rather than a solid-liquid slurry, it indicates that density has an additive effect on the consistency of the unwashed sludge compared to the washed sludge slurries.

Furthermore, the morphology of the wash sludge slurries was also changed during the wash cycles of the ESP process. Lower density and better packing of solid particles in the settled washed sludge slurries increases the settling rate as indicated in Hay and Bibler's paper², and the yield stress as evidenced from the lower yield stress of Tank 42 unwashed sludge compared to washed Tank 51 and Tank 21 sludge slurries.

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