DIAL

Salt Well Pumping Flow Loop

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Background

Previous experience at Hanford has indicated occasional plugging of transfer lines under certain temperature and concentration conditions. Blocked pipelines represent a significant challenge to the remediation of high and low-level nuclear waste as typical methods employed to unplug the line cannot be used due to safety (shielding) requirements. In addition, the loss of a transfer line amounts to an increase in operational costs owing to schedule delays and reprioritization. A laboratory-scale facility, the Salt Well Pumping Flow Loop (SPFL), shown in Figure 1, has been designed, constructed, and tested at DIAL for the evaluation of the laminar transfer of typical process streams, including those from evaporators, interstitial liquid recovery, and dissolved salts.

In a typical experiment the high ionic strength salt solution is prepared and held at an elevated temperature representing conditions in the waste tank. The fluid is allowed to continuously circulate until temperature equilibrium is achieved; thereafter, one or more heat exchangers are activated resulting in chemical and

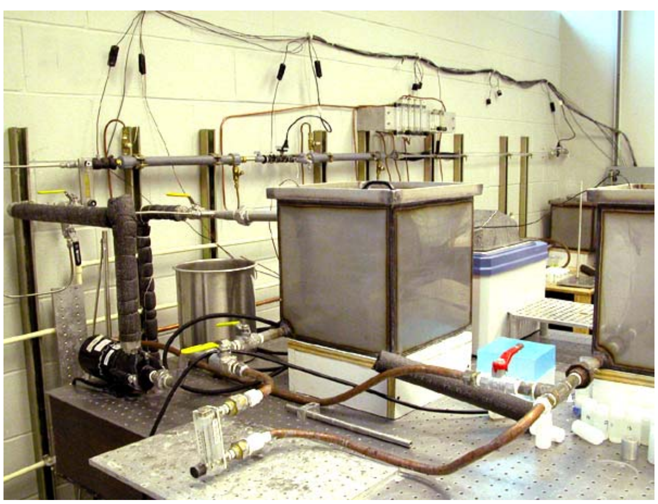


Figure 1. The SPFL contains tanks that store the brine composition and the diluent, pumps, valves, the channel, and a receipt tank. Temperature control is achieved using counter-current, tube-in-shell exchangers. Pressures and temperatures are measured at specific locations and collected with a control system. Portions of the line can be replaced with an acrylic channel permitting image recording of crystal growth, agglomeration, plug formation, and plug remediation. The system is scaled based on infrastructure at the site.

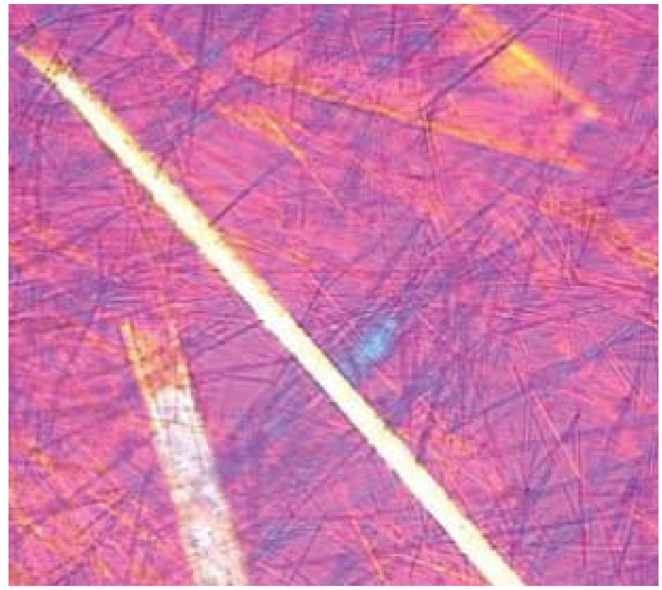


Figure 2. Polarized light microscope image of sodium phosphate dodecahydrate crystals.

physical changes within the brine solution. A decrease in local temperature corresponds to an increase in viscosity and to regions of different crystal formation. Certain crystals, notably phosphates, carbonates, sulfates, and double salts, will exist in various hydrated forms. One key to avoiding plug formation is to control the chemistry of the process stream - either through temperature and/or dilution.

Application

The SPFL has been used to obtain additional information on the crystallization of sodium phosphate dodecahydrate ($Na_3PO_4 \cdot 12H_2O \cdot 0.25NaOH$). Previous plugs at Hanford for transfers from Tanks 241-SX-104 and 241-U-103 were believed to arise from the formation of this crystal, Figure 2.

Experiments were performed on the SPFL to establish the phosphate concentration and temperatures where plug formation will occur. The growth of the crystals was followed using imaging, shown in Figure 3.

Initially single particles were obtained that later grew to critical sizes where deposition occurred. Agglomerates formed and deposited. Eventually an increase in viscosity coupled with the large particle sizes resulted in drastically reduced velocities and further crystallization resulted in plug formation.

Product

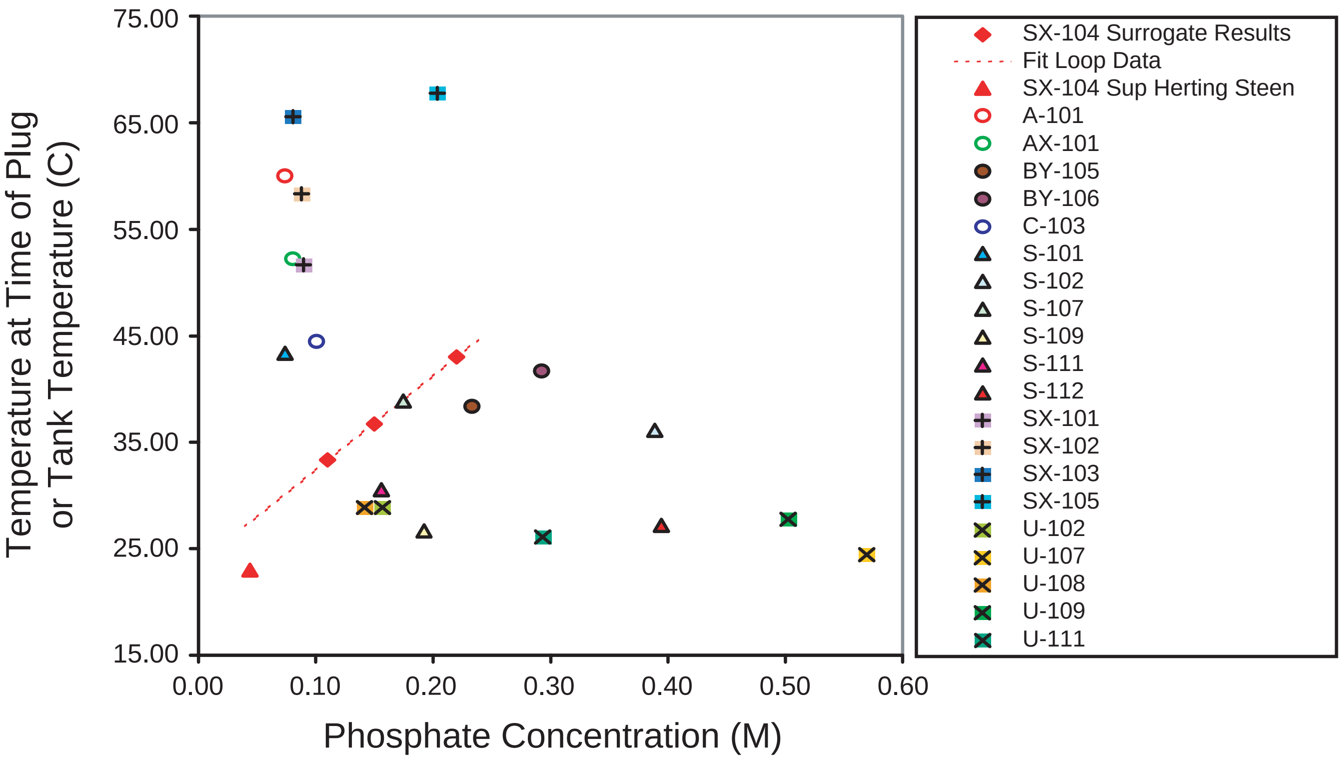
By performing experiments at different phosphate concentrations it became possible to establish a relationship between concentration, time to plug, and temperature. This data was then used to develop an operational envelope, Figure 4, describing all of the single-shell tanks at Hanford. The individual tank phosphate concentrations were taken from available inventories and the temperatures represent the waste storage conditions.

Availability and Future Studies

The salt well pumping flow loop is currently available for evaluating solution conditions and particle behavior during waste or product transfers. Modeling in combination with advanced diagnostic tools and standard instrumentation can be employed to evaluate specific operating conditions necessary for improving process efficiency and trouble-shooting.

Figure 3. Sequential images of phosphate crystal growth showing entrained particles and deposited aggregates. Scale shown is in inches.

Figure 4. The dilution strategies necessary for the safe transfer of phosphate bearing wastes in Hanford tanks can be established using this operating envelope.



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