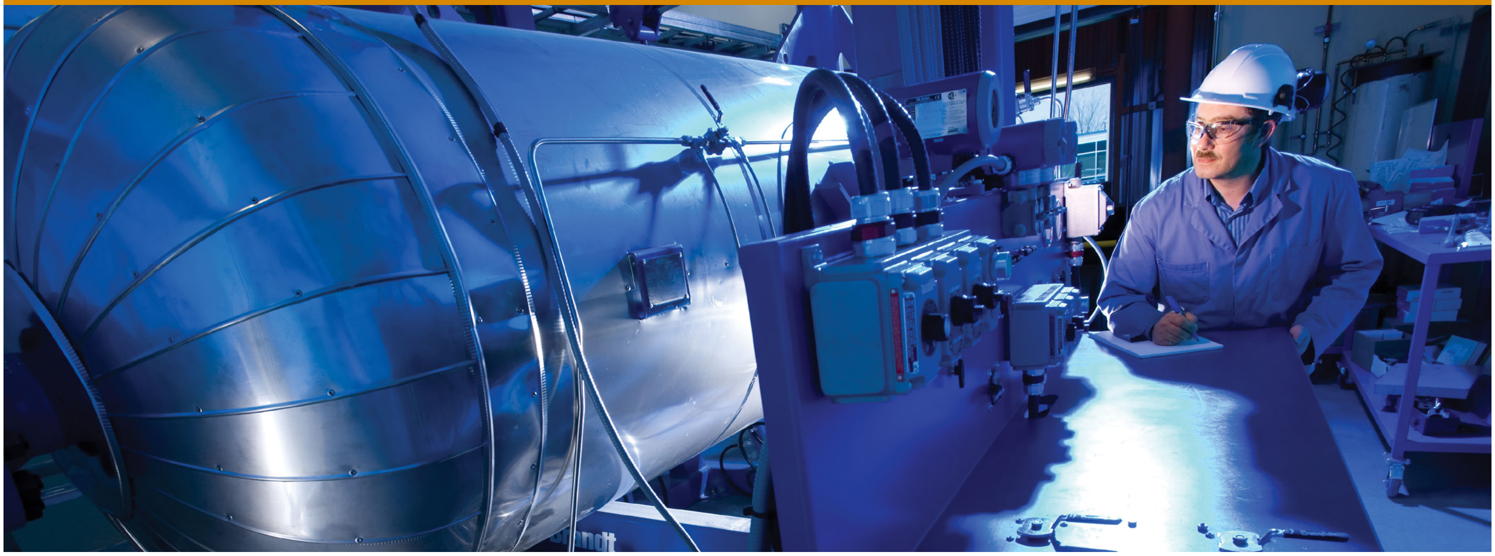
SRC SASKATCHEWAN RESEARCH COUNCIL



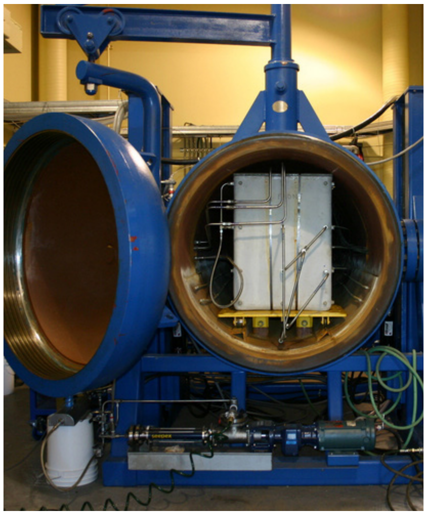
SVX at SRC: 3-D Physical and Numerical Modelling of Solvent Vapour Extraction

Using the largest known solvent vapour extraction (SVX) scaled physical modelling apparatus in the world, researchers at the Saskatchewan Research Council (SRC) work to advance SVX processes for enhancing recovery of *heavy oil*. They complement realistic laboratory results with rigorous approaches to numerical simulation to improve performance predictions of this low-energy, low-greenhouse-gas emissions alternative to thermal extraction methods. Particularly for thin, partially depleted reservoirs, SVX may be the only viable option.

A new hybrid physical model that can operate at higher temperatures was also commissioned and is described on a separate fact sheet. SRC uses this physical model to evaluate *thermal* solvent vapour extraction (TSVX) methods of enhanced oil recovery (EOR) for heavy oils and *bitumen*.

SVX Model Facts and Features

- In operation since 2004
- Comprises overburden pressure vessel (OBPV) system and 3-D physical model system
- At 10 to ~60°C, OBPV rated up to 10.5 MPa (1500 psi) working pressure; 3-D system to 10 MPa
- Certified OBPV system measures 2.5 m long × 1.06 m ID
- Can evaluate various wellbore geometries and be rotated 90° for a 2.5 m vertical section, of the same order of magnitude as a typical thin heavy oil reservoir



3-D physical model in pressure vessel. SRC's sealed, explosion-proof SVX laboratory is certified as Class 1, Zone 2 by the Canadian Standards Association.

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EOR Processes That Can Be Studied at SRC's SVX Lab

- SVX after primary production(pressure depletion)
- SVX after secondary production (waterflood)
- SVX after CHOPS
- SVX with multilateral wells
- SVX with T-wells
- Waterflooding

Numerical Simulation of SVX

To scale up SVX processes and predict both laboratory and field performance, SRC history-matches 3-D physical model run results. We offer advanced techniques and algorithms custom developed to tune numerical models to:

- Properly handle the non-equilibrium solvent solubility that occurs during SVX processes.
- Correct for effects of changing gridblock sizes while maintaining an acceptable history-match.

These techniques require two or more 3-D physical model runs conducted with similar solvent–oil systems and run conditions, but with different well placement geometries. Through history matching and/or adjustment of various run parameters, the simulator is tuned to accurately predict the oil, gas and water production rates and recoveries, and injection/production pressures from the geometrically different experiments. The tuned simulator can then be used to estimate field scale performance for various well types and patterns.

Semi-Analytical Flow Model of SVX Processes

SRC applies its semi-analytical flow model of SVX processes to provide reasonable estimates of field performance, including oil and solvent production rates and recoveries during continuous solvent injection processes.

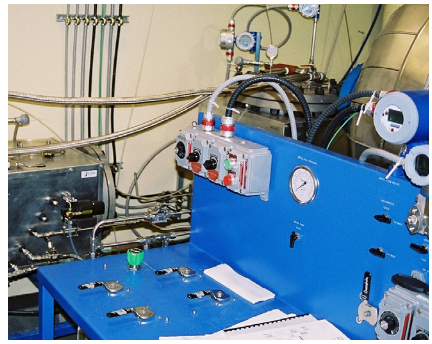
Additional Analytical Tests and Property Determinations

SRC offers further expertise needed to analyze and model 3-D physical model experiments:

- Equation of state determinations to generate solvent vapour quality diagrams
- Phase behaviour (PVT) analysis and fluid characterization of oil viscosity, density and vapour-liquid equilibrium (VLE) as a function of solvent concentration, pressure and temperature
- Pseudorelative permeability determinations
- Asphaltene precipitation modelling and capillary pressure determination

Bitumen-Capable PVT System

A special bitumen-capable PVT system, commissioned at SRC's Regina laboratories, is used to determine oil density, viscosity and VLE relationships as a function of solvent concentration, pressure and temperature. Analysis is conducted at various pressure and temperature conditions from 200 to 23,000 kPaa and 5 to 250°C (density to only ~200°C).



Production vessels and control cart

Live oil mixing system facilitates pressure depletion studies.