# Testing of Wellbore Isolating Cements with $CO_2$

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## Objectives

- Design and construct apparatus to simulate environments in $CO_2$ sequestration wells.
- Apparatus designed for testing cements, rocks or any other materials that may encounter $CO_2$ (wet, dry or $H_2O$ rich phase).
- Perform $CO_2$ exposure experiments and analyze the effects.

## Specifications

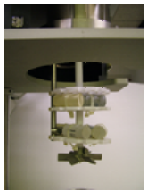
- Two 1-gal 316SS reactors with Alloy C-276 lining
- Maximum Pressure: 2900 psi, Maximum Temperature: 350° C
- Magnetically coupled stirrer (0- 600 RPM)
- Programmable depressurization system
- Reactors operate independently.
- 1 Lt supercritical CO2 reservoir
- Two 260-mL reciprocating syringe pumps (0- 10,000 psi)
- Pump jackets cooled by ethylene glycol.
- System protected by uninterruptible power supply (UPS).
- Fully automated system

## Test Procedure

- Place samples in reactors.
  (Samples are isolated according to chemistry.)
- Close reactor and pull vacuum to remove air.
- Fill reactor with deaerated 15% NaCl solution.
- Heat system to test temperature.
- Pressurize with $CO_2$ to test pressure.

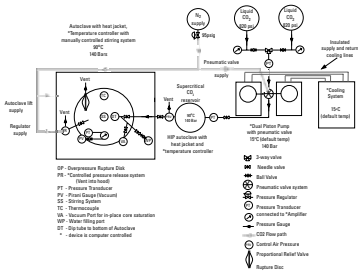
- Monitor and maintain conditions throughout test duration.

- Reduce temperature to ambient.
- Reduce pressure at controlled rate to ambient.
- Sample withdrawal and characterization



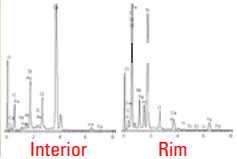
Reactors

Supercritical $CO_2$ System

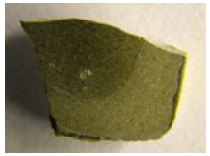


Schematic Diagram

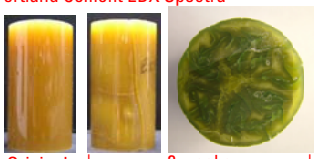
Portland Cement - 2 weeks



Interior Rim
Portland Cement EDX Spectra



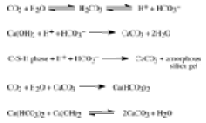
Portland Cement - 4 weeks



Original | --------- 2 weeks --------- |
Epoxy Resin Cement

## Cement Chemistries

- Portland Cement
  principal hydration products: $Ca(OH)_2$ + CSH phase
  both products thermodynamically unstable to wet $CO_2$



- Epoxy Resin
  bisphenol-A resin with amine hardener
  silica flour filler

## Test Conditions

- 90°C, 2000 psi (supercritical $CO_2$) in brine
- Exposure Time: 1 week to 4 weeks
- Depressurization Time: 1 hour to 5 hours

## Summary and Future Work

- Testing so far has mainly been performed to verify proper equipment operation.
- Thorough sample characterization - chemistry, mineralogy and texture changes
  - compressive strength
  - permeability and porosity
  - SEM/EDX
  - petrography, Raman microspectroscopy
  - XRD
  - CT-scan
  - dimensional changes
  - fluid chemistry