Why do we cement wells

- Principle Functions of primary cementing
  - Restrict fluid movement between formations
  - Bond and support the casing

- Additional uses of cement
  - Protect the casing from corrosion
  - Prevent blowouts
  - Protect the casing from shock loads in drilling operations
  - Sealing off loss circulation or thief zones
Oil well cementing highlights

1883 – Hardison/Stewart - Pico, CA
1903 – Steel casing cemented - Lompoc Field, CA
1910 – 2-plug cementing method – A.A. Perkins
1919 – Erle P. Halliburton – Burkburnett, TX
1921 – Erle P. Halliburton patents Jet Mixer
1940 – Halliburton introduces bulk cement
Circulating to condition mud
Pumping Lead Cement & drop bottom plug
Cementing Equipment Evolution - 1920
Cementing Equipment Evolution - 1950
Well Schematic
Mississippi Canyon 252 #1-01

Rig Floor = 75'

Water Depth 5,067'

36" @ 5,321'
28" @ 6,217'
22" @ 7,937'
18" @ 8,969'
16" @ 11,585'
13 5/8" @ 13,145'
11 7/8" @ 15,103'
9 7/8" @ 17,168'
7" x 9 7/8" @ 18,360'
Cement Additives

Specific Materials for Optimum Cement Performance

Accelerators
Light Weight
Fluid Loss
Gas Migration
Defoamers
Loss Circulation
Retarders
Expansion
Heavy Weight
Dispersants
Retarders

- Sodium and calcium lignosulfonates
- Oligosaccharides
- Tartaric acid
- AMPS copolymers
- Aminotri(methylphosphonic acid)
Fluid-Loss Control Additives

- Prevent leak-off of water into rock
- Maintain key characteristics of cement slurries (thickening time, rheology, and strength development)
- Avoid build-up of cement filter cake

- Cellulose derivatives
- Synthetic polymers
- Latex

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Weighting Agents

Maintain well control with increased hydrostatic pressure
(up to 21 lb/gal, occasionally higher)

- Hematite ($\text{Fe}_2\text{O}_3$)
  - Up to 100 lb/sk
- Hausmannite ($\text{Mn}_3\text{O}_4$)
  - Up to 100 lb/sk
- Ilmenite (iron-titanium oxide)
- Barite ($\text{BaSO}_4$)
  - Up to 135 lb/sk
- Sand
  - Often used in conjunction with other weighting agents
Supplementary Cementing Materials in the Oilfield

- Fly ash (50:50 fly ash:cement typical)
- Silica fume (15% bwoc typical, 28% max)
  - Low density slurry (>11 lb/gal) with little free water
- Silica flour (35-40% bwoc typical, 70%+ max)
  - Prevent strength retrogression >230 °F
- Pumice (up to 150% bwoc)
- Cement kiln dust
- Blast furnace slag
- Zeolite
- Metakaolin
Lab Testing

- Compressive Strength, Fluid Loss, Thickening Time, Gel Strength
  - Up to 600 °F and 40,000 psi
Conventional Cement

- Cement is brittle
- Radial cracks formed
- Longitudinal communication occurred
- Cement bond failed creating a microannulus
Foam Cement

- No radial cracks
- Only slight debonding
- Foamed cement deformed and absorbed the expansive energy without failure due to its elastic nature
Historical facts regarding EOR well cementing

• More than 35 years of EOR experiences

• More than 15,000 CO₂ EOR well in USA (9000 producing + 6000 injectors)

• Portland based formulations have been used in all the above wells

• Various 3rd party studies of CO₂-EOR operation in the USA have not detected any evidence of CO₂ leak in the drinking water
HALF “GREEN” CEMENTING UNIT
Equipment

- **1919**: First jobs
- **1921**: Jet Mixer
- **1932**: Float/Guide Equipment
- **1947**: Marine Department
- **1957**: HT-400™ Pump
- **1971**: Recirculating Mixer
- **1991**: Automatic Density Control

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Large Scale Stress Testing

Conventional Cement

- 5 1/2" pipe cemented inside 7 5/8” casing
- Inner pipe pressured in stages until cement failure was indicated at 4500 psi
Cementing Equipment Evolution

1930

1940

1978

2000

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