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The SPE Distinguished Lecturer Program is funded principally through a grant from the **SPE Foundation**.

The society gratefully acknowledges the companies that support this program by allowing their professionals to participate as lecturers.

Special thanks to the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) for its contribution to the program.

Cement and Cementing:
An Old Technique With a Future?

Bernard Piot
Schlumberger

Outline

- Cement
- Cementing: a necessary evil?
- Alternative isolation techniques
- Today's well challenges
  - Cement versatility
- Well architecture tool for the future

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Cement

Material and Regulations

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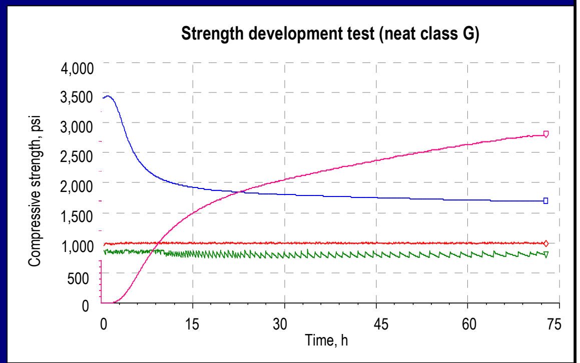
Portland Cement

- Hydraulic binder
- Suspension (paste or slurry) for placement
- Controllable setting
- Solid
  - Strong
  - Impermeable
- Inexpensive
- Available everywhere



History of Oilfield Cement

- Before our era
  - Clay, lime
    $Ca(OH)_2 + CO_2 \rightarrow CaCO_3$
- Roman times
  - Pozzolanic cements
- 1824: Portland cement
  - Selected raw materials
- 1903: Portland cement in oil wells
- 1917: “Oilfield” cements
- API created 20 Mar 1919
- 1940: ASTM Types 1 to 5
- 1948: API Code 32 released
  - Became API RP10B in 52
- 1952: 6 classes of cement
- 1953: API Std 10A
- API Spec 10A in 72
- ISO 10426 since 2000

Cement Types

- Construction cements
  - Common cement
  - API classes A, B, C
- Retarded cements
  - Deeper wells
  - Classes D, E, F
  - Pressurized consistometer
  - Cementing companies
  - Abandoned early 80s
- **Plain Portland cement**
  - Classes G, H
  - Quality control, reproducibility
  - More universal
- Class J cement
  - Replaced by G/H + Silica
- Slag cement
  - ~80s Brine resistance
  - ~90s Mud compatibility
- Others

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Use of Cement

- USA
  - ~ 80% class H and G
  - ~ 10% class A, ~ 10% Class C
- Rest of the world (international service companies)
  - >95% class G (often imported)
  - Class A or C; or local common cement: preferentially Type V (ASTM), or CEM-I 42.5 or 52.5 (EN 197-1)
    - Logistics allowing
    - If good and even quality
    - If adequate quality control

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From API to ISO (since 1998)

- API Committee 10
- ISO TC 67 /SC 3/WG 2
- ISO 10426 – well cements
  - ISO 10426-1 (ANSI/API 10A) - specification
  - ISO 10426-2 (ANSI/API RP 10B-2) - testing
  - ISO 10426-3 (ANSI/API RP 10B-3) – deepwater wells
  - ISO 10426-4 (ANSI/API RP 10B-4) - foam cement
  - ISO 10426-5 (ANSI/API RP 10B-5) – shrinkage/expansion
  - ISO 10426-6 (ANSI/API RP 10B-6) – static gel strength
- Other work groups:
  - Evaluation (logs), High Temperature, Deepwater…

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Cementing: A Necessary Evil?

Evolution of Equipment and Technology,
and an Outline of Their Shortcomings

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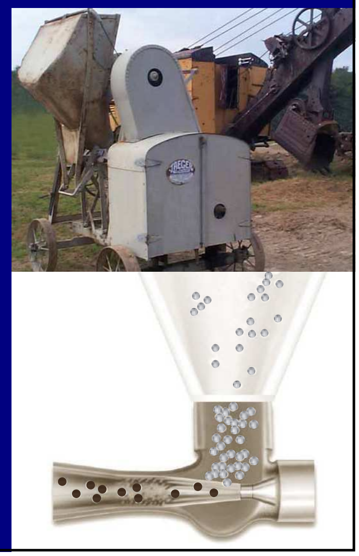
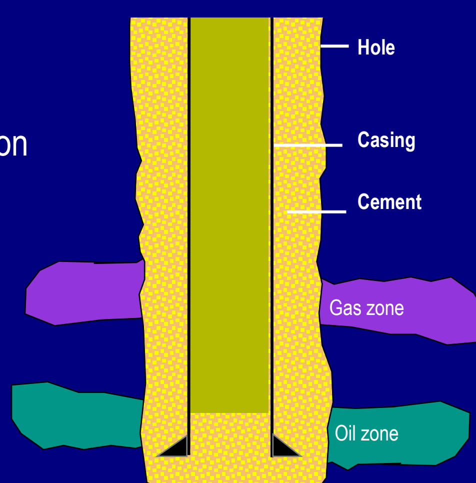
Technology Older Than a Century

- First well cementing ~ 1903
  - Perkins Oil Well Cementing Co., Calif.
  - Shovel/cement mixer
- First use of an eductor
  - Jet mixer invented 1921
  - “High pressure” mixing
  - In use till the 1970s
    - Still used by some
    - Gravity cement feed



Primary Cementing Objectives

- Casing anchor (axial support)
- Protection against corrosion and erosion
- Support of borehole walls
- **Zonal isolation**



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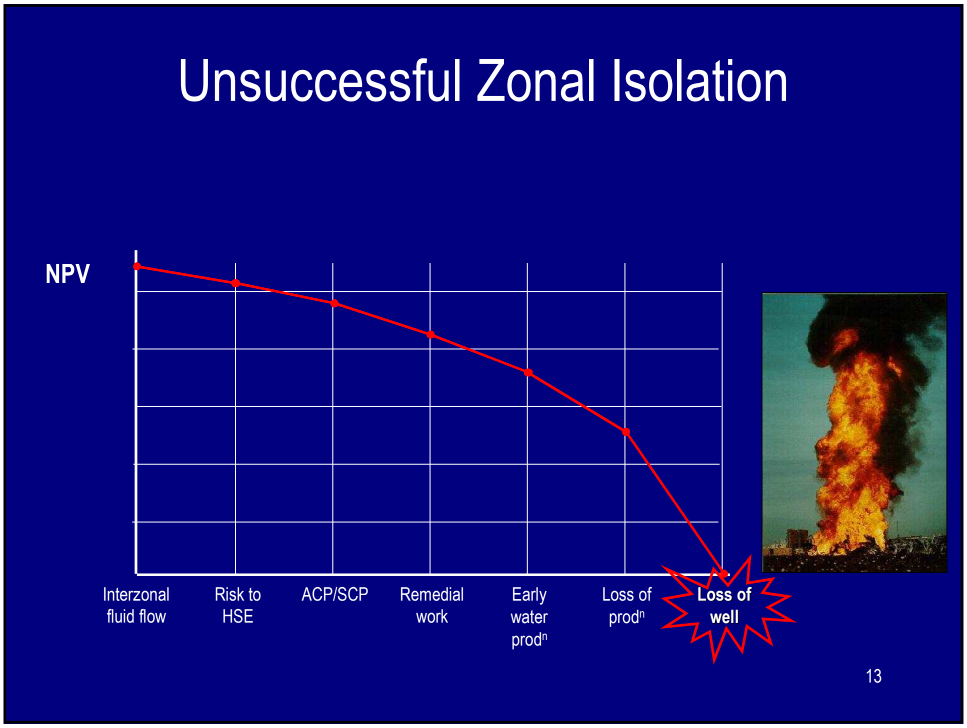

Unsuccessful Zonal Isolation
NPV
Interzonal fluid flow
Risk to HSE
ACP/SCP
Remedial work
Early water prodn
Loss of prodn
Loss of well
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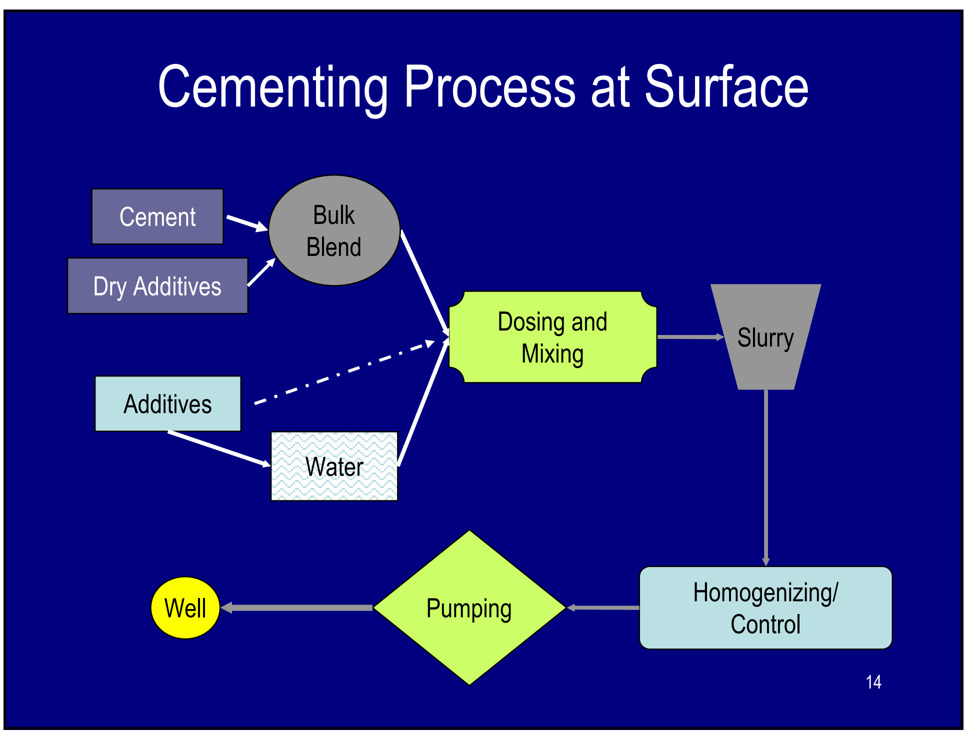

Cementing Process at Surface
Cement
Dry Additives
Bulk Blend
Additives
Water
Dosing and Mixing
Slurry
Homogenizing/ Control
Pumping
Well
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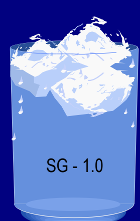
Handling Dry Cement

- From cutting sacks to pneumatic handling
  - Storage
-
-

Control of Mixing



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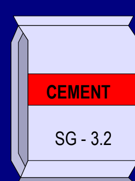

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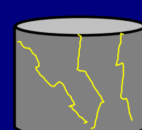

SLURRY SG ~ 1.9

Density Control

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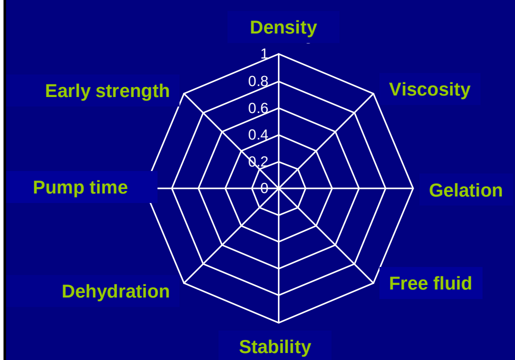
Cement Quality = Slurry Performance



- **W/C ratio**; extender; weighting agent
- Dispersant / viscosifier
- Anti-settling agent
- Fluid loss agent
- Retarder/accelerator

Cementing Additives Key Milestones

- Lignosulphonates and cellulosics
- Sugars and superplasticizing agents (~ 1960s)
- Polyamine/imine (~1970s)
- SB Latex (~ 1980s)
- Co/ter-polymers AMPS (~ 1980s)
  - Temperature stability
- Biopolymers (~ 1990s)
  - Not based on Xanthan gum
- Environmentally friendly additives (end 1990s)
  - OSPAR (OSlo-PARis) convention 1998

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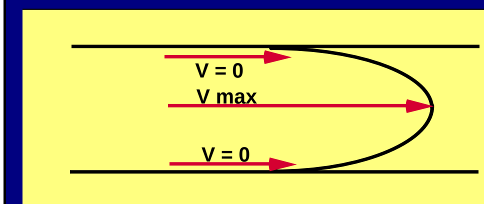
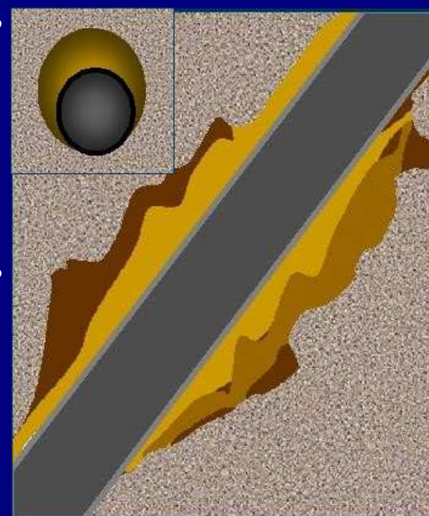
Cementing Process Downhole

- Failures identified 30-40s
- Field practices
  - Turbulent displacement
    - High Reynolds ~50s
    - 10 min contact ~60s
  - SloFlo / Plug Flow ~70s
    - Fluid with yield stress





Mud Removal Modeling

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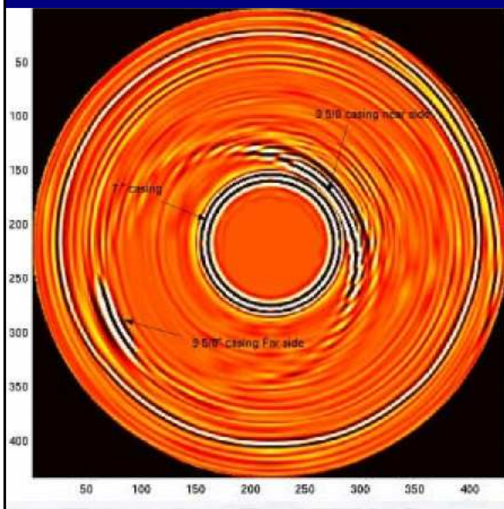
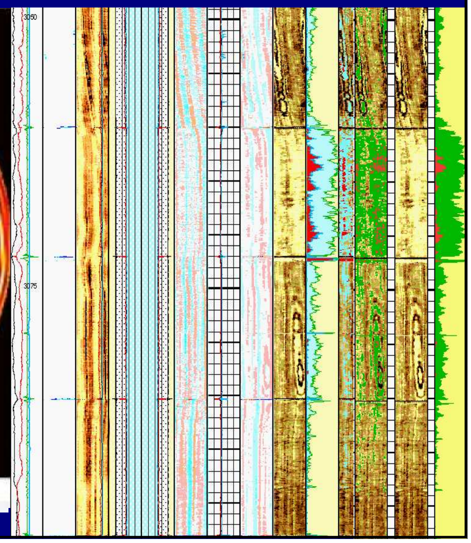
Cement Evaluation Logs





Alternative Isolation Techniques

Other Fluids and Mechanical Means

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Organic Resins

- Very limited applications
  - Cost
  - Shelf-life
  - Sensitivity
  - Health, safety, and environment
  - Compatibility (water, mud…)
  - Placement
  - …

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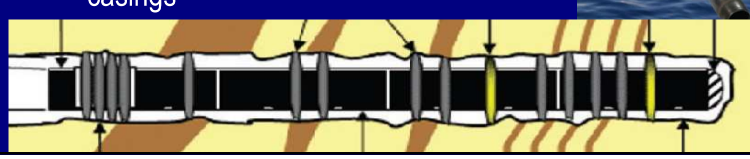
Mechanical Systems

- Complementary to cement
  - Casing drilling, expandable casing (EC)
  - Swellable elastomer layer
- Exclusive of cement
  - EC/Casing with (oil or water) swellable packer
  - Another form of completion
    - May still require cement for most other casings



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Today's Well Challenges and Versatility of Cement

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New Reservoir Isolation Challenges

- Aging and depleting fields
  - Completions at lower pressures
  - Steam injection, stimulation
  - Workovers and repairs
  - Plugging and abandonment
- Exploration and new developments
  - Isolation under higher pressure and temperature
  - Very narrow pore/frac pressures margin
  - In deeper water and at colder temperatures

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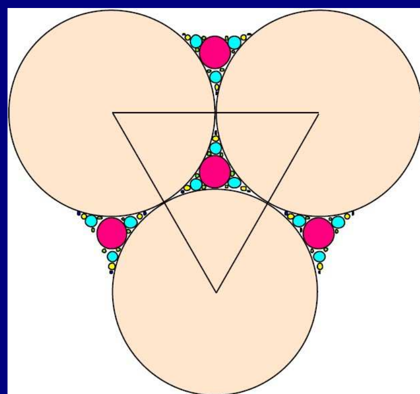
Need for Ultra-Low Density

- Conventional Cement



- High performance/high solid

  fro try

  water/s

  densities

  - 900 to 2800 kg/m

  gy

  low

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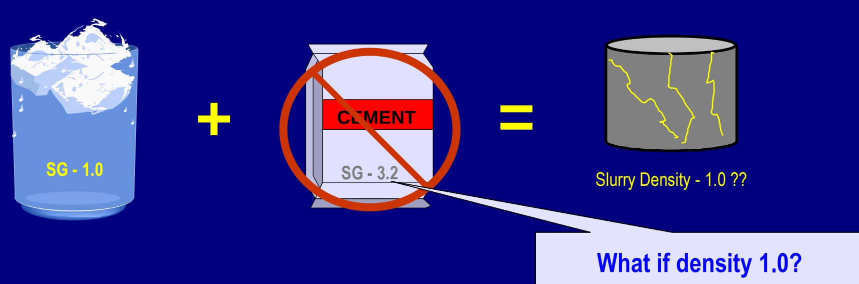
Slurry Quality Control?



Solid Fraction Monitoring

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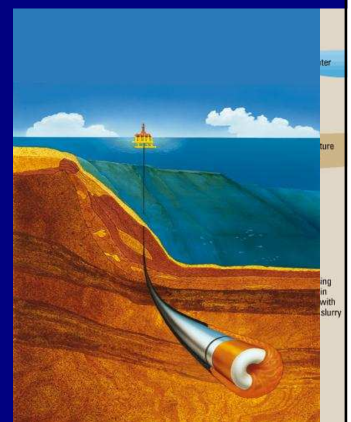
Well Architecture and Logistics

- Lighter isolation-quality cements
  - Depleted reservoirs
  - Single-stage cementing
  - Production liner instead of casing
- Light cements that set faster at low temperatures
  - Deepwater conductors, surface casings…



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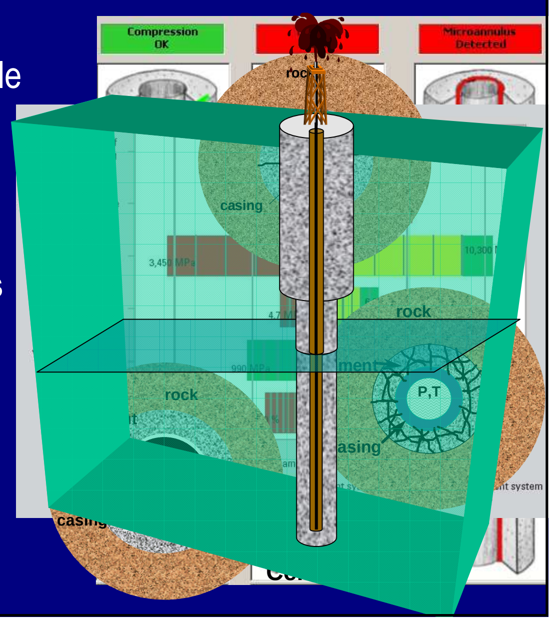
Is Isolation Durable?

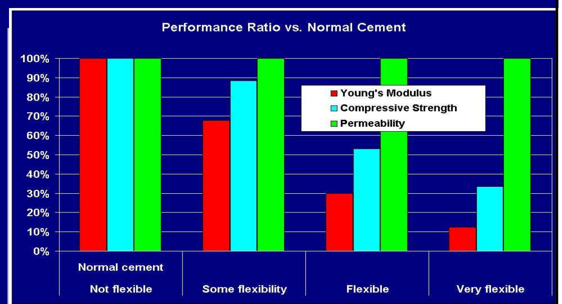
Cement is strong, but fragile

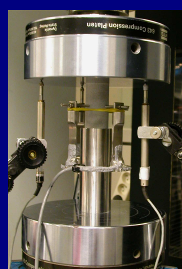
- Understanding failures
  - P or T increases
  - Drilling, milling, repairs
  - P or T decreases
- Modeling capability
  - Parameter sensitivity

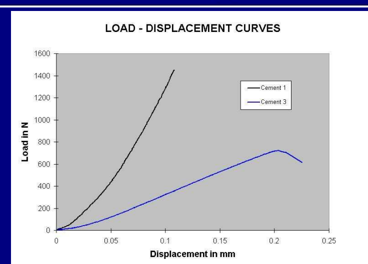


Isolation Made Durable

- Controlled flexibility and expansion
  - Isolation maintained during P, T changes
  - From construction to abandonment







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A Tool in Well Architecture

Summary

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Cement in the Past

- A necessary evil?
- Commodity?

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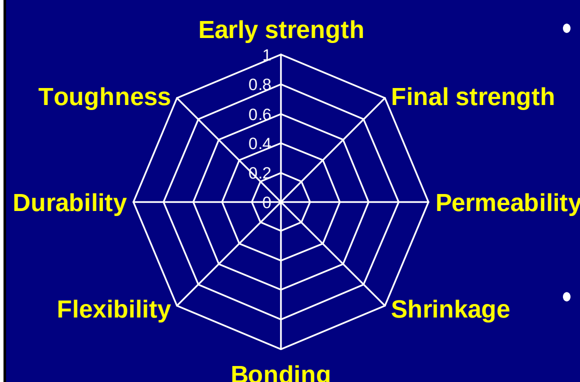
Cementing Today



- Solutions portfolio
  - Not only slurry performance
  - Set material properties
  - Short/long-term well requirements
- Modeling tools
  - Fit-for-purpose, cost-effective system

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Cementing Tomorrow: A Technology for the Future

- Evolving cement industry
  - Still considerable academic research
  - CO_2-emissions
  - Important engineering development
- Oilfield cementing industry
  - More tools in the toolbox
    - Materials, simulators
  - Adapt to tomorrow's well requirements
  - A true well engineering technology

- Oilwell cementing has e
- Oilwell cementing will c
  - New cements from cer
  - New tools from cemen
    - Physically active, che
    - Process design/simu
  - A true well engineering
- An interesting future