Design Process for Sustainable Long-Term Wellbore Integrity

Building the Well Right

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Barrier Definition

A component or practice that contributes to the total system reliability by preventing liquid or gas flow if properly installed.*

How is this achieved ?

* API Standard 65 - Part 2
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Design Process

Gather the Right People

Identify and Document Objectives and Goals

Resolve Conflicts

Core Principles

Protect groundwater and the environment

- Proper wellbore construction and installation of barriers

Well design and construction

- Ensure environmentally sound, safe production of hydrocarbons

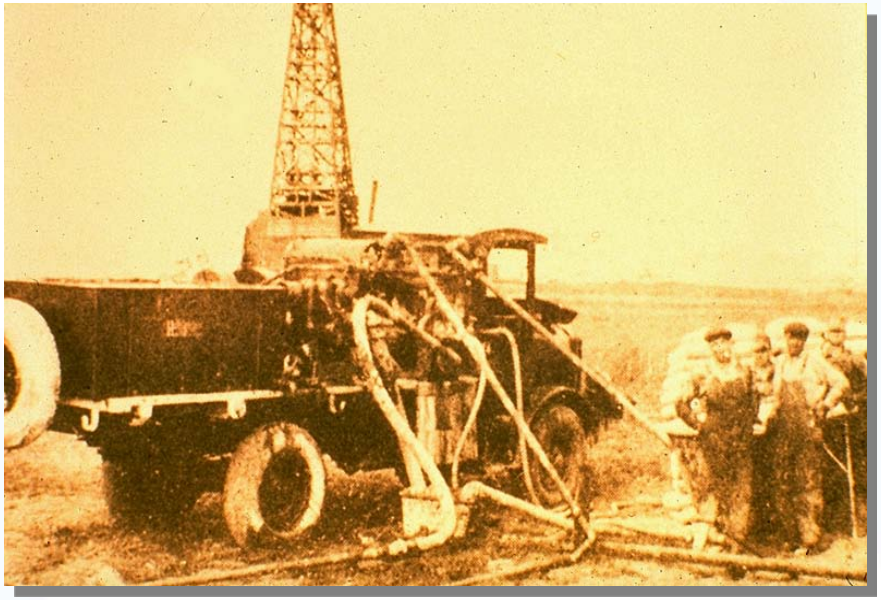
Cementing Design Process

Understand the Chemistry of the system

Optimize the Physics of Cement Placement

Determine Well Site Logistics and Equipment Limits

Evaluate to Confirm Objectives are Met



API Standard 65 – Part 2

- Industry accepted design best practices
  - Hole quality - Drilling fluid properties
  - Engineering design
  - Mud removal - Slurry design & testing
- Industry accepted execution best practices
  - QA/QC - Execute as per design

Pre Job Engineering

Pre-Job Laboratory Data – Slurry Design

- Design the cement slurry to meet well requirements

Utilize Pre-Job Engineering Software

- Simulate fluid placement and pressures
- Optimizes rates and volumes for cement placement

Slurry Design

Evaluate well requirements

- Short term - during cement placement
- Long term - throughout entire well life

Customize material usage for cement design

- Fit-for-purpose design
- Customize for each well / field

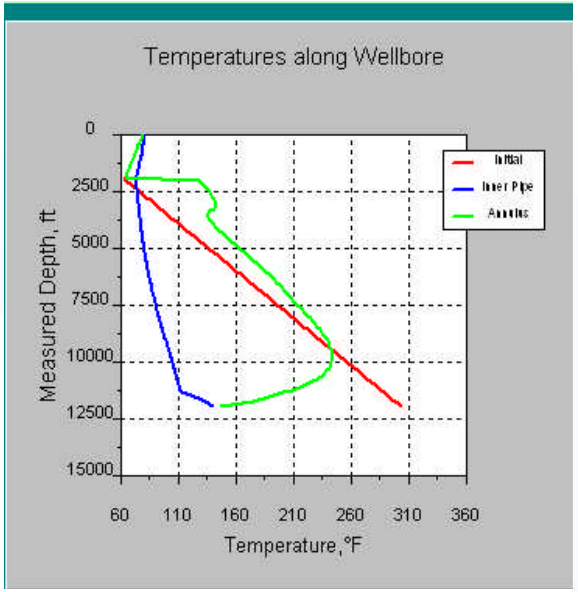
Slurry design is not a “one size fits all” process

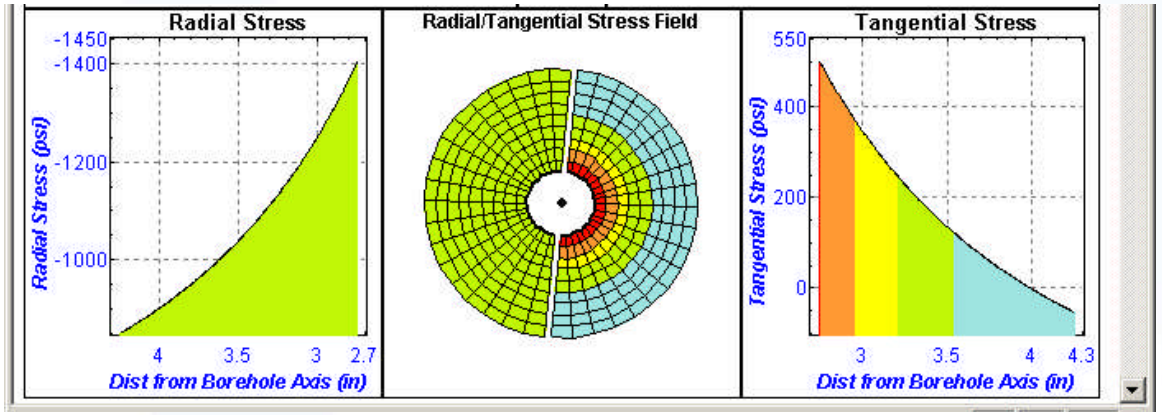
Engineering Software

Placement Modeling

Temperature Modeling

Wellbore Stress Analysis





Placement Modeling

Placement rates

Pipe movement

Pre-job drilling fluid circulation rates and volumes

Utilization of downhole tools

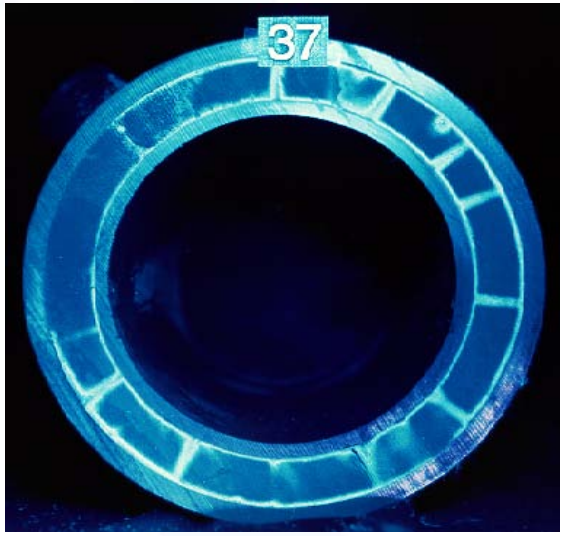
- Centralizers, float equipment, etc.

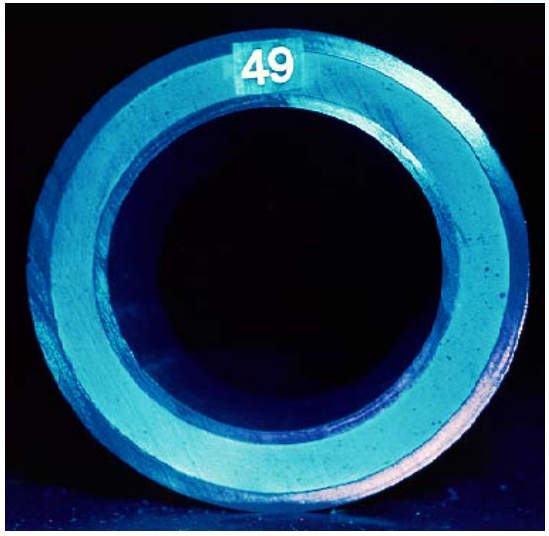
Stress Modeling

Cement Compressive Strength

Young’s Modulus

Tensile Strengths





Stress Solutions

"Flexible" Cement Systems

- Function by altering the mechanical properties of the set cement
- Generally have lower strengths due to dilution of the base cement
- Can alter the methods used for cement evaluation
  - May not show up well on conventional bond logs

Mechanical Barriers

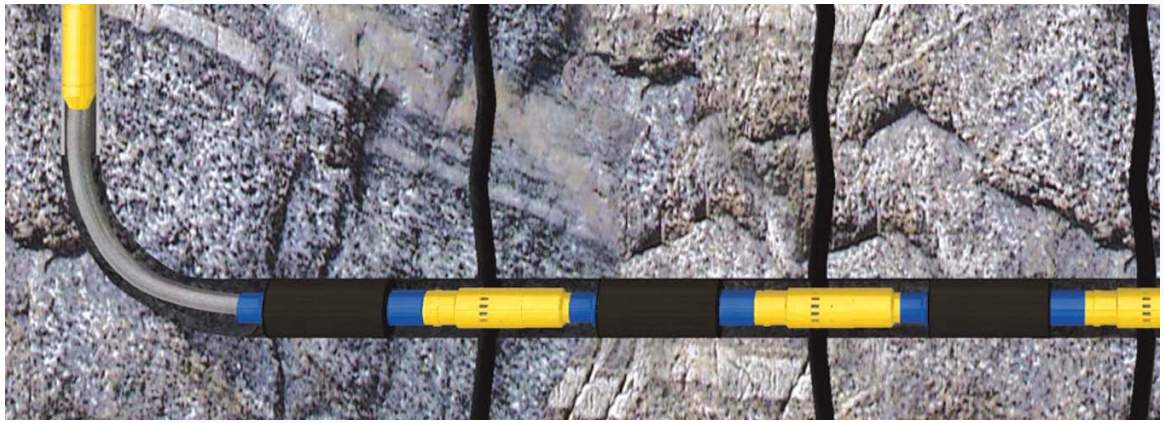
Swelling Technologies

Swell Packers

Annular Inflatable Packers

“Self Healing” Cement Materials

Use with cement



Job Execution Planning

Anticipated Pressures

Design Fluid Rates

Volumes for all fluids

Density control of spacers and cement slurries

Data Recording

Case History

Western Pennsylvania

Challenges:

- Shallow Gas Migration
- Lost Circulation
- Poor Bond Log Responses

Case History

Western Pennsylvania

Solutions:

- Fit-for-purpose slurry design
  - Incorporation of gas migration materials
- Improved cement placement
  - Optimized spacer systems
  - Customized displacement process

Conclusions

Successful barrier installation requires:

Understanding the objectives of the operation

Identification of methods and materials to be used to achieve the objectives

Adherence to design plans

Proper evaluation of the final operation to assure objectives have been met