Cement Evaluation – A Risky Business

Glen Benge
Benge Consulting

SPE 170712

Cement Evaluation Requirements

Knowing the objectives of the job, and the design limitations required to meet those objectives, a decision can be made as to how the job will be evaluated.

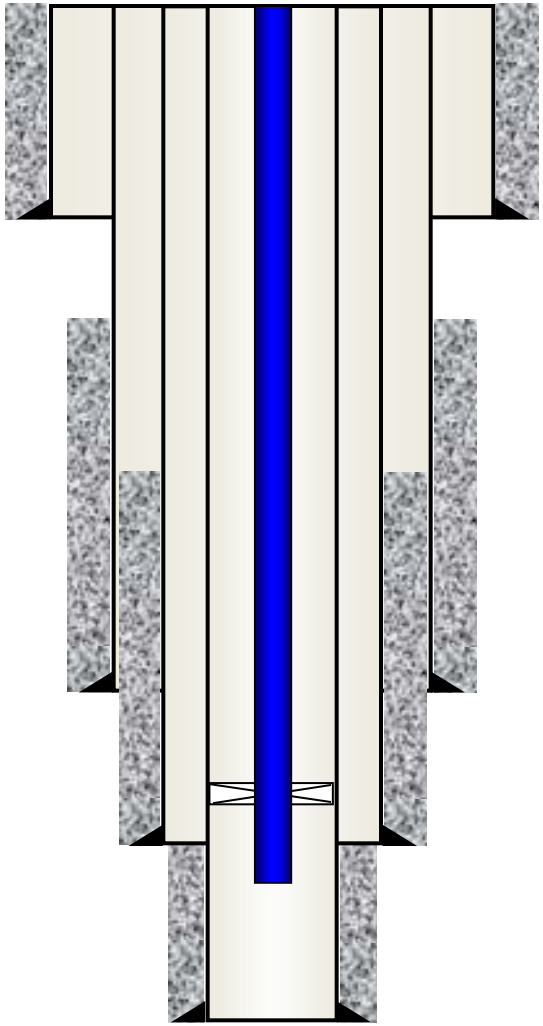
Lacking understanding of the objectives, and limiting evaluation data increases the risk of a poor or more expensive evaluation decision.

If you don't know where you are going, any road will get you there.

(paraphrased from Lewis Carroll)

Types of Evaluations

- Field Data Analysis
- Pressure Testing
- Passive logs
  - Temperature and noise
- Active logs
  - CBL, Pad Tools, Pulse Echo



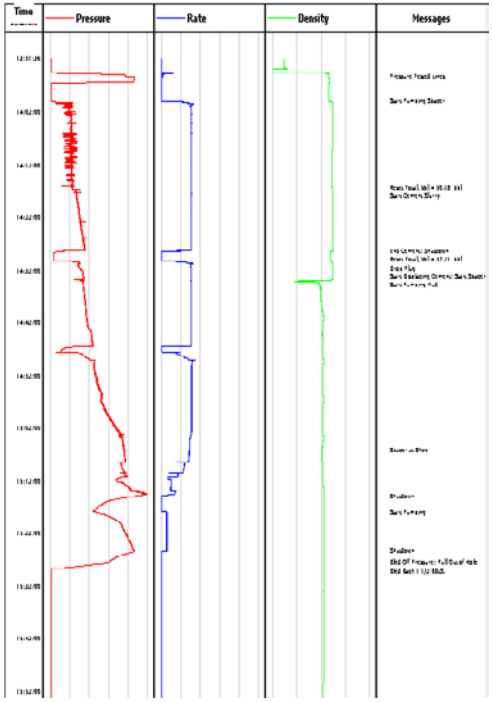
Field Data Uncertainties

Return Rates

Displacement Efficiencies

Hole size and fluid volumes

Pump volumes based on strokes vs actual volumes



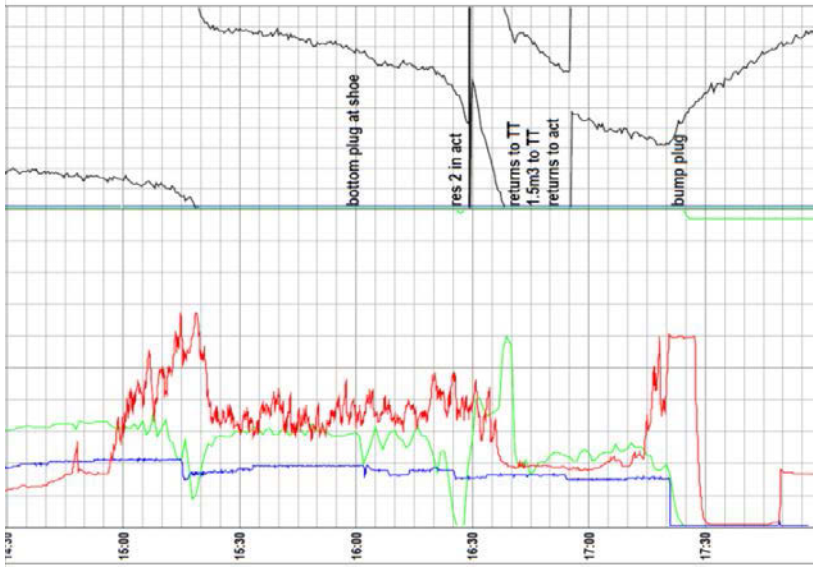
Depending on the requirements of the job, use of field data for decisions may be sufficient.

Pressure data

Can not test individual components

- Checking the floats may not actually test float equipment
- “Failure” is of the system – all individual components “fail”
- Success can be the system or one individual component

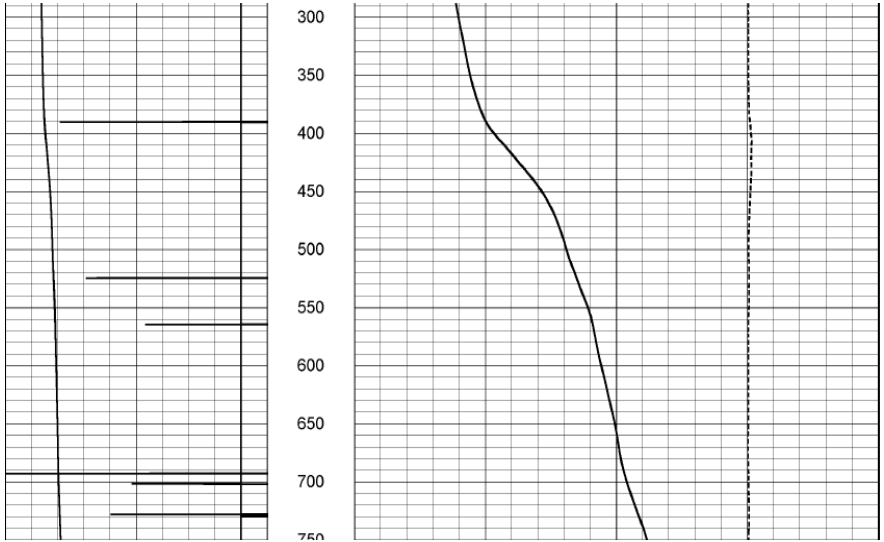
Must understand what is being tested and the limits of the test.



Passive logs – Noise and Temperature

Used to examine larger intervals

- May not give precise data on location of barrier
- Temperature movement in the well
- Time dependent (especially temperature)



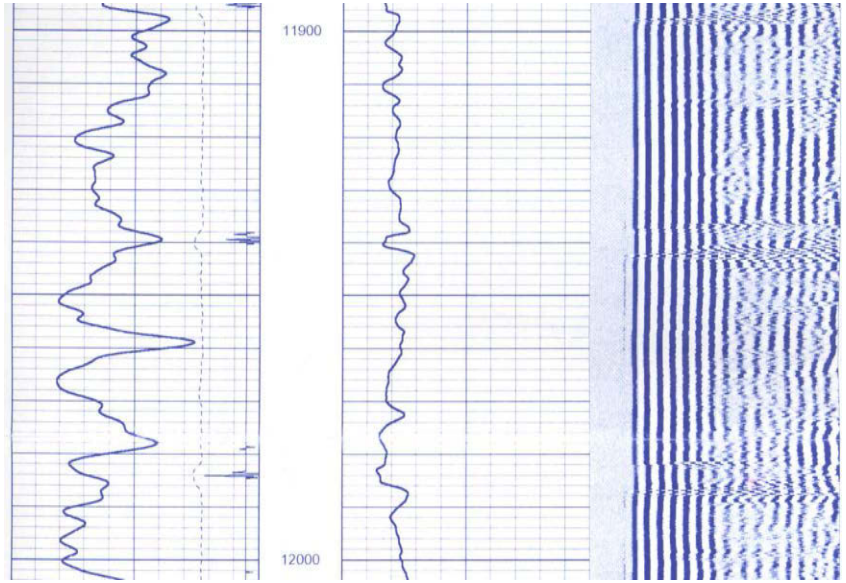
Cement Evaluation Logs

"If all we obtain from the logs is comfort when they look good, or discomfort when they look bad, but no confident remedial option, why do we waste time and money running the logs?"

API 10 TR-01
Cement Sheath Evaluation
Second Edition, September 2008

CBL

"Despite its potential, the cement bond log is probably one of the most abused, misused, and misunderstood logs used in the oil field today. Miscalibration, inadequate information, and a severe lack of standardization are enough to push petroleum engineers into a morass of bewilderment."



Fertl, Pilkington, and Scott
"A Look at Cement Bond Logs"
JPT, June, 1974

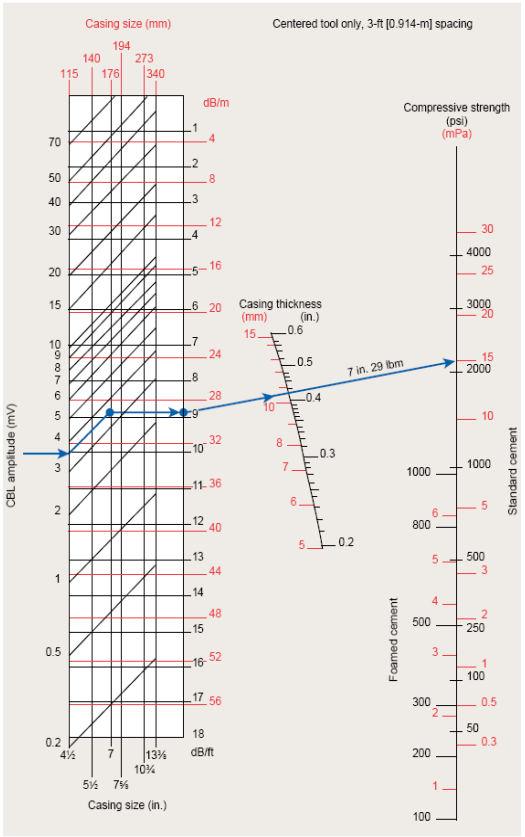
Sonic logs - CBL

Omnidirectional signal

- 3 & 5 ft. receivers

Bond index interpretation

- **HIGHLY** dependent on “baseline” chosen for 100% cement
- Incorrect assumption will result in poor analysis
- Bond index concept carried forward to many other logs in the form of a color map



Example Bond Index Calculation

Bond index:

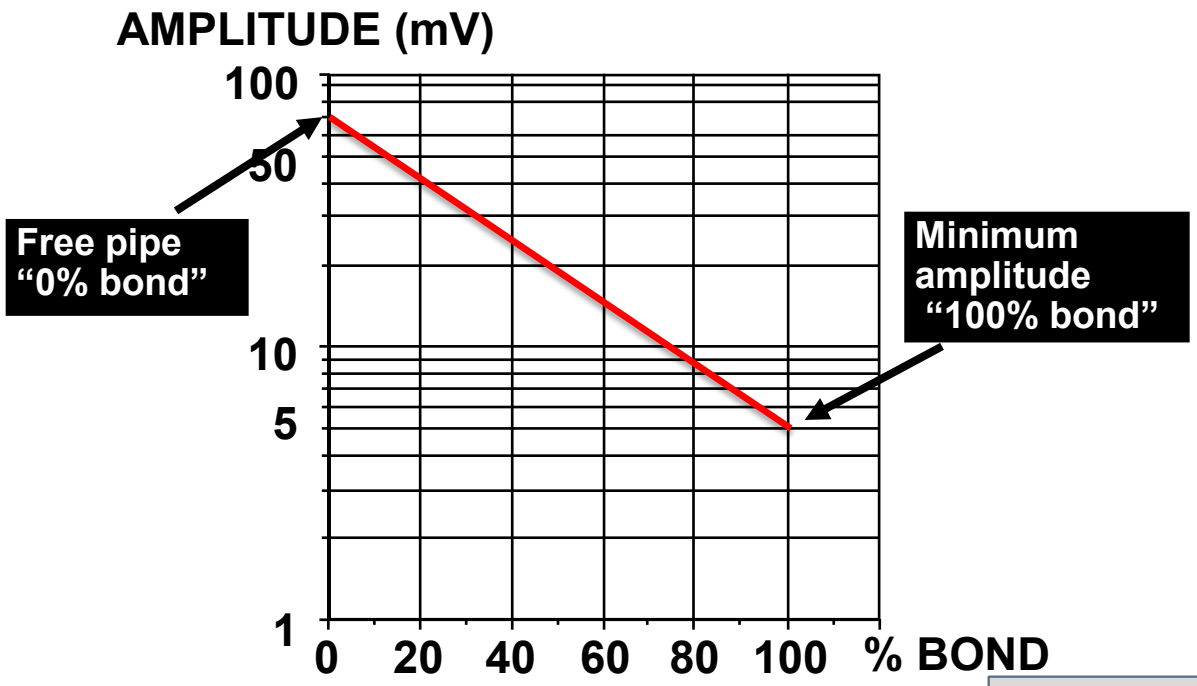
$$\frac{\log_{10}(E_{meas}/E_{free})}{\log_{10}(E_{100\%}/E_{free})}$$

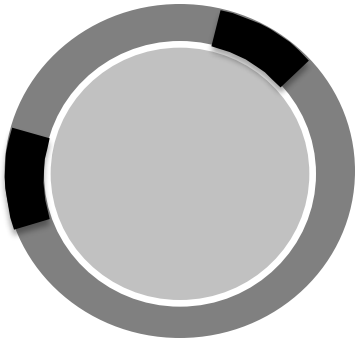
$E_{100\%}$ for 2100 psi ≈ 3.5

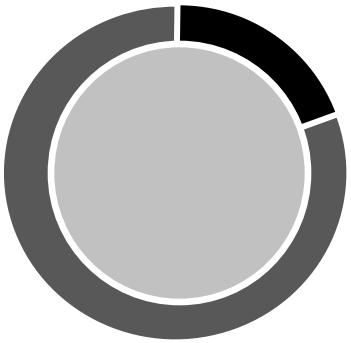
$E_{100\%}$ for 500 psi ≈ 12

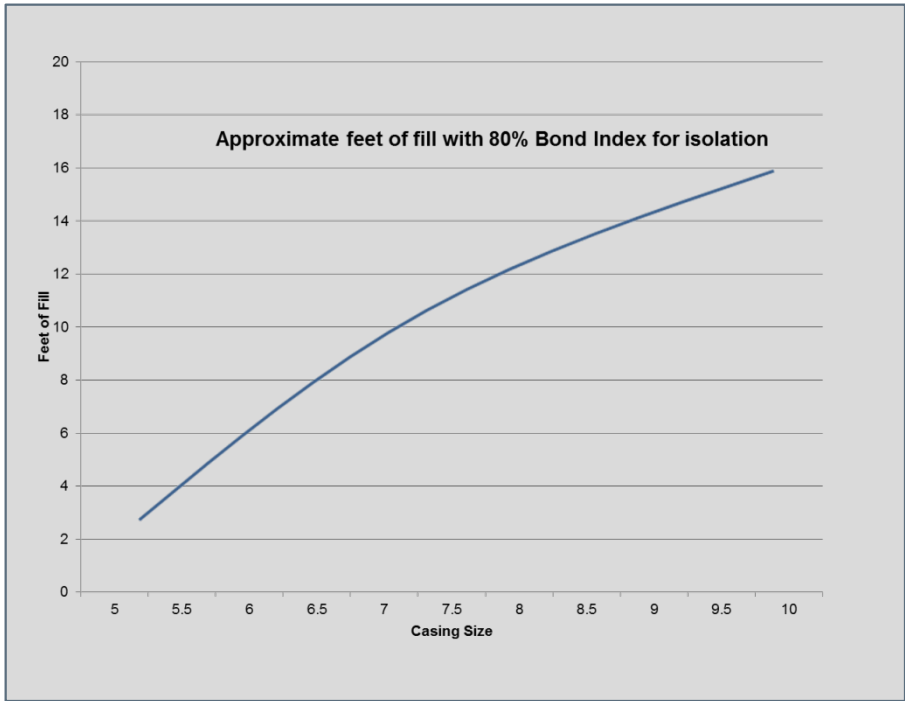
$$\frac{\text{Log}_{10}(12/69)}{\text{Log}_{10}(3.5/69)} = \frac{\text{Log}_{10}(0.17)}{\text{Log}_{10}(0.05)} = \mathbf{0.59}$$

Using 2100 psi as the strength for cement, the bond index calculation yields 0.59 for a system having 100% cement coverage at a strength of 500 psi


AMPLITUDE (mV)
100
50
10
5
1
0
20
40
60
80
100
% BOND
Free pipe
“0% bond”
Minimum
amplitude
“100% bond”






Approximate feet of fill with 80% Bond Index for isolation
Feet of Fill
20
18
16
14
12
10
8
6
4
2
0
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
Casing Size

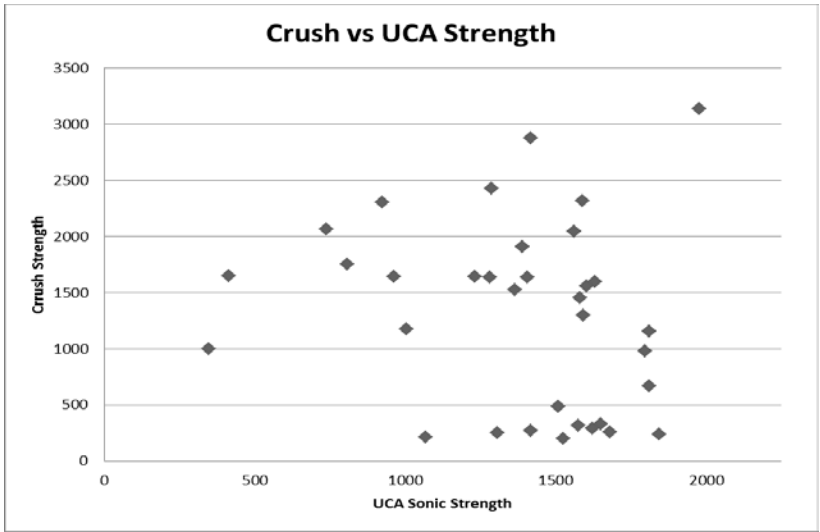
Pulse Echo - Impact of “Boutique” Systems

High concentrations of certain additives can change the acoustic response of the cement system

May not respond the same as similar systems with “equivalent strength”

Can make calibration of the log more challenging

Calibration based on lab UCA data may be wrong



Conclusions

Do not depend on a single set of data for interpretation

Risk reduction occurs when more data is available

Lacking sufficient data drives very conservative decisions from available logging data

Use extreme care when evaluating boutique cement systems

Bond index is HIGHLY dependent on what is considered 100% cement and will be wrong in most wells

Recommendations

Determine the objectives of the job

Understand the design limitations required to meet those objectives

Execute the job as per the design

Make a decision as to how the job will be evaluated based on the available data.

Questions