STRAIGHT GAS PREVENTION:
INDUSTRY INITIATIVES
"But I don't want to go among mad people," Alice remarked.

"Oh, you can't help that," said the Cat: "we're all mad here. I'm mad. You're mad."

"How do you know I'm mad?" said Alice.

"You must be," said the Cat, "or you wouldn't have come here."

Alice's Adventures in Wonderland, Lewis Carroll
INDUSTRY INITIATIVES – API ACTIVITIES

• Updating of current API Practices
  • Changing some from recommended practice to a standard
  • Combining some practices to reduce duplication

• Development of new API Standards
  • Separating land and offshore wells

Core Principles
• Protect the environment
• Full life cycle analysis
API INDUSTRY PRACTICES - CURRENT

- RP 51R – Environmental Protection for Onshore Oil and Gas Production Operations and Leases
- RP 54 – Recommended Practice for Occupational Safety of Oil and Gas Well Drilling and Servicing Operations
- Standard 65-2 – Isolating Potential Flow Zones During Well Construction
- RP 90 – 1 - Annular Casing Pressure Management for Offshore Wells
- Guidance Documents:
  - HF1 – Hydraulic Fracturing Operations – Well Construction and Integrity Guidelines
  - HF2 – Water Management Associated with Hydraulic Fracturing
  - HF3 – Practices for Mitigating Surface Impacts Associated with Hydraulic Fracturing
API INDUSTRY PRACTICES – IN DEVELOPMENT

- RP 90 – 2 Annular Casing Pressure Management for Land Wells

- RP 100 – 1 – Hydraulic Fracturing: Well Integrity and Fracture Containment

- RP 100 – 2 – Environmental Aspects Related to E & P Including Hydraulic Fracturing

- HF 4 – Community Engagement
WELLBORE INTEGRITY
API RP 100 – PART 1

The document contains recommended practices for well construction and fracture stimulation design and execution as it relates to well integrity and fracture containment for onshore wells. The recommended practices of the document relate to the following two areas;

1. Well Integrity: the design and installation of all well equipment to a standard that ensures

   a. the protection and isolation of ground water aquifers and
   
   b. the safe containment of the hydraulic fracture treatment
2. Fracture containment: the design and execution of hydraulic fracturing treatments in order to ensure the fracture is contained within the intended target. Fracture containment combines those parameters that are existing, those that can be established at installation and those that can be controlled during execution:

   c. Existing: Formation parameters with associated range of uncertainties.

   d. Established: Well barriers and integrity as created during well construction.

   e. Controllable: Fracture design and execution parameters.
ISOLATING POTENTIAL FLOW ZONES
STANDARD 65 - 2

• Standard contains practices for isolating potential flow zones
• The focus is on the prevention of flow through or past installed barriers
• Barriers include mechanical barriers such as seals, cement, or hydrostatic head, or operational barriers such as flow detection practices.
• Operational barriers are practices that result in activation of a physical barrier.
• While physical barriers dominate the process, the total system reliability of a particular design is dependent on the existence of both types of barriers.
CEMENTING DESIGN PROCESS

API Standard 65 (Part 2)

• Industry accepted **design** best practices include:

• Industry accepted **execution** best practices
STANDARD 65 - 2

- Employs standard engineering rigor to the design and execution process
- Risk identification and mitigation are key elements of the standard
- Evaluation to assure adherence with designs and execution is a key part
- NOT a one size fits all document
- Standard has been adopted into regulation in several states and US code
SUSTAINED CASING PRESSURE
API RP 90 – 2 – Annular Casing Pressure Management for Onshore Wells

- Onshore edition of Sustained Casing Pressure Document
- Highlights evaluation, diagnosis and mitigation steps to be taken
- Some times the best forward plan is so do nothing
- Includes sections on monitoring requirements

- Do we really want zero annular pressure?
WELLBORE EVALUATION
WELLOBORE EVALUATION OBJECTIVES

Does the well, as it currently is constructed, meet the requirements set out in the construction process?

What evaluation techniques should be used to assure the well has been properly constructed?

What data do we believe?
WELL CONSTRUCTION

• Define the design objectives of the well
• Establish plan to meet the objectives
• Develop plan to evaluate the execution
• Assure the execution meets the well objectives
CEMENT EVALUATION OBJECTIVES

Is the material behind the pipe a solid or liquid
  - Solids can’t be “fixed”

Is there isolation in the annulus

Where is the cement (TOC)
EVALUATION

Data Sets Available:
• Pre-job engineering, and laboratory data
• Job execution logs
• Post job testing and logging

Evaluation & Verification
• Should not depend on a single set of data
• Compare “as designed” to “as built”
• Combined data should be evaluated “Does It Make Sense?”
In the absence of cement job data, the slurries pumped, and formations involved, cement evaluation is **VERY** difficult and subject to extreme interpretation errors.

For optimum evaluation, cement job data, pressure data and wellbore architecture must be included in the evaluation.
EVALUATION TECHNIQUES

Radioactive Tracer Surveys
Hydraulic (Pressure) Testing
Temperature Surveys
Acoustic Logging
TEMPERATURE LOGS

Generally used for determining top of cement or lost circulation zone

Can be used to determine underground flow

- Flow must be sufficient to change well temperatures
- Often run in conjunction with noise log
Is this temperature change due to the top of cement, or a change in the hole size?
FULL WELL TEMPERATURE SURVEY

Probable Top of Cement
ACOUSTIC LOGGING

Noise Logs

Sonic Logs

- Conventional CBL
- Advanced Sonic Tools – SBT

Ultrasonic Logs

- USIT, CAST V, ISO Scanner
NOISE LOG

Used to determine flow in the annulus

Should be run with a temperature log

Discontinuous – log readings taken at several “stations”

Spectral Noise Log
NOISE LOGS

Depending on the frequencies recorded, a determination of the type of material flowing in the annulus can be made.

Interpretation of the material flowing can be very difficult.

Log must be run deep enough to eliminate influence of rig noise.
SONIC LOGS
CONVENTIONAL CEMENT BOND LOG (CBL)

- 20 kHz Transmitter
- 3 ft. receiver
- 5 ft. receiver

Amplitude
VDL

Casing
Cement
Formation
CONVENTIONAL CBL

Assumes the cement is homogeneous
same density, same strength, same annular gap
throughout the well

Signal is transmitted and picked up on receivers spaced at 3 and 5 feet

3 foot receiver used for pipe / cement “bonding”

5 foot receiver used to get a qualitative indication of formation bonding
BOND INDEX

Bond index:

\[ \frac{\log_{10}(E_{\text{meas}}/E_{\text{free}})}{\log_{10}(E_{100\%}/E_{\text{free}})} \]

Traditional Interpretation

- 80% < BI < 100%: “Good” cement
- 80% > BI: “Bad” cement

Bond index has been used to determine how many feet of “good” cement is required to give isolation in various casing : hole size combinations.
CBL STRENGTHS

Works in most well fluids

Tolerates corrosion

Responds to solidity (shear coupling)

Qualitative cement-formation bond from VDL

Inexpensive
CBL WEAKNESSES

High CBL amplitude can be ambiguous

- Liquid microannulus Channel
- Contaminated cement Casing Coating

Low amplitude doesn’t ensure 100% bond

Vertical Resolution ~ 3 ft.

Knowledge of cement compressive strength is key

The CBL is an **AVERAGE** around the wellbore

Do not attempt to depend on a CBL to evaluate isolation over short intervals
ADVANCED SONIC TOOLS

Segmented Bond Tool (SBT)

- Pad Mounted Radial Tool – 6 pads, 60 degree investigation angle
- Measurements are made in two directions
- Effective acoustic energy is increased by a factor of 4
- Results do not depend on receiver sensitivities or transmitter power
- Vertical Resolution ~ 6 inches
SBT – WELL CEMENTED PIPE
SBT – HIGH SIDE CHANNEL
ULTRASONIC TOOLS

Send a directional 200-700 kHz signal from a rotating transmitter/receiver

Can infer the acoustic impedance of the material directly behind the pipe

– Function of density and velocity

\[ C_r = \frac{(Z_1 - Z_2)}{(Z_1 + Z_2)} \]

\[ Z_1 \]

= Acoustic Impedance of the casing,

\[ Z_2 \]

= Acoustic Impedance of the material in contact with either the inner or outer casing surface
ULTRASONIC TOOLS

Tolerate liquid microannulus (vibrations normal to surface)

Full coverage, 30 mm resolution image

• Detailed picture of material distribution: solid, liquid, gas
• Detects narrow channels

Less uncertainty than CBL logs

Casing inspection in same pass
ULTRASONIC LOGS - CAUTIONS

must look at casing data to confirm cement data is valid

  – Any “defect” on the casing will be transferred across the log
  – Resulting cement data will not be valid

Process flags can indicate invalid data
SUMMARY

SONIC TOOLS

- Work in virtually any mud weight
- Qualitative formation evaluation
- Sensitive to microannulus
- Sensitive to material contacting pipe

ULTRASONIC TOOLS

- Limited mud weights
- No formation evaluation
- Insensitive to microannulus
- Independent of cement properties
SONIC TOOLS

• Very limited in lightweight cmts
• Average over 3’ of wellbore
• Advanced tool resolution is 6”

ULTRASONIC TOOLS

Can include casing inspection
No averaging of the wellbore
Preferred for low density, low strength cement systems
IMPACT ON LOG RESPONSES FROM CEMENT SLURRY DESIGNS
DESIGN IMPACTS ON LOG RESPONSE

The basis for most cement evaluation logs is “neat” cement

- Compressive strength is assumed to be 3,000 psi
- There is some “compensation” for lower strengths and lower densities

The closer the cement density is to that of the drilling fluid used, the more difficult it is to distinguish between a solid & a liquid

The lower the compressive strength of the cement, the more difficult it is to “find” on a log
LOOKING AT THE TOTAL PICTURE

There are multiple data sets available for cement evaluation.

There must be an understanding of the importance and credibility of the data sets.

And “conflicts” between different data sets must be resolved.
SUMMARY

Successful wellbore installation requires:

1. Understanding the objectives of the operation
2. Identification of methods and materials to be used to achieve the objectives
3. Adherence to design plans
4. Proper evaluation to assure objectives have been met
Log Examples
Well in Pacific Rim

All well-site data showed what should be a good job.

What Happened?
CBL in Lightweight Cement
USIT in Lightweight Cement
Isolation Scanner in Lightweight Cement
CBL ACROSS SWELL PACKER
USIT ACROSS COLLAPSED SHALES

- Bond logs over shale zone with chalk beds
- Non cemented zone
- Sinusoidal features correlate with chalk
  - Indicates annular material is geological beds
- Barrier occurs only in the shale sections
  - No evidence of rubble filled annulus
  - No evidence of thermal expansion
- Similar effects in OBM and WBM wells
- **Creep is the primary mechanism**