

# Well Integrity: Multiple Casing & Liner Failures

Viking's Full Court Press process solves back-to-back casing failures, strategy proven to mitigate well failures

An independent oil operator experienced four back-to-back casing failures in his Oklahoma shale program. These current failures and set backs were eating into his budget and eroding stakeholder faith in the ability to complete wells.

His initial comment was, "I'm not getting any sleep – I need some help. You've got to help me stop the leaks!"

The operator's completion hardware lent itself to pumping the hydraulic stimulation down the 7" casing into a 4-1/2" liner. Multiple failures occurred in the liner, but a subsequent failure in the 7" casing led to an ugly, uncontrolled surface flow – blowout.

## PLAN OF EXECUTION

Viking proposed a list of 6 critical steps that Viking and the Operator needed to review and evaluate to fully implement to create a successful frac program. Viking calls it their Full Court Press process.

Engineering, Quality Assurance, Third Party inspectors (TPI's), and rig site auditors were on the job by the beginning of the following week. The Full Court Press was applied to both the 7" production casing and the 4-1/2" liner. Multiple design problems were identified by stress analysis performed with Tubular Design and Analysis (TDAS®) proprietary software.

The 3-rig drilling program continued. It took several weeks for the old equipment scheme to work itself out and the new measures to be implemented for wells that were already completed, frac'ed – and failed. The tubular failure rate continued to rise – from 4 in a row to 8 of 10.

## A STRATEGY PROVEN TO MITIGATE WELL FAILURES - VIKING'S FULL COURT PRESS PROCESS

The Operator fully committed to implementing the Full Court Press process to create a successful frac program:

### 1. Review Casing Design

Is there sufficient steel in the casing to resist the frac loads? A detailed casing analysis showed the existing casing program fell short of Viking's minimum design criteria. "Beefing up" the production liner from 4-1/2" 11.6 ppf to 13.5 ppf and the 7" casing from 26 ppf to 29 ppf was recommended and adopted.



## LOCATION

Oklahoma (US)

## SCOPE OF WORK

Viking's Full Court Press Process:

1. Review Casing Design
2. Inventory Sourcing-Pipe & Coupling Manufacturers
3. Utilize Controlled Yield P110 (110-125 ksi)
4. Utilize Proprietary Connections
5. Evaluate Rig Practices
6. Implement Quality Assurance & TPI Surveillance

## CHALLENGE

- The initial objective - stop the failures – was accomplished, but at an additional expense. Once issues were resolved, the operator expressed a desire to back off any measures that are not essential to continued success.
- Moving from a Full Court Press program to any other program involves evaluating savings and the potential for increased risk. Every operator wants to save money, but has a different risk tolerance.

# Well Integrity: Multiple Casing & Liner Failures

## 2. Inventory Sourcing - Pipe & Coupling Manufacturers

The operator and his service providers were in the habit of running the lowest bid casing available. Not all mills are created equal and poor performance parameters, including low Charpy impact values and very high yield strength, contributed to brittle pipe with little resistance to crack propagation. Viking recommended a half-dozen world class OCTG manufacturers and the operator restricted casing orders to that short list.

## 3. Utilize Controlled Yield P110 (110-125 ksi)

Much of the existing inventory was made up of high collapse, high strength casing with measured yield strengths in the 135 to 140 ksi range. Viking prefers working with the lower half of the API P110 range (110 ksi to 140 ksi). Casing and couplings limited to 125 ksi yield strengths exhibit more ductility and cracking resistance in hydrogen enriched environments.

## 4. Utilize Proprietary Connections

The original liner program utilized API Buttress connections, which can generate stresses beyond yield due to standard make-up practices. Downhole cameras run in several of the failed wells documented coupling splits. In order to reduce hoop stress, Viking recommended a proprietary metal-to-metal seal connection. A metal-to-metal seal is not necessary for well integrity during frac'ing operations, but the free running thread lowers make-up stresses.

## 5. Evaluate Rig Practices

In order to ensure that the revised hardware program was being installed correctly, Viking sent an experienced rig auditor to the well site during casing running operations. The procedures, attitude, and lack of attention to detail alarmed the auditor. Based on this evaluation, casing crews were redirected to implement appropriate and more comprehensive rig running practices, such as closer inspection of the visual thread on location, proper doping practices, torque/turn monitoring, and monitoring of tong and slip indentations. In some cases, entire crews were run off and better communication with the new crews was established.

## 6. Implement Quality Assurance & TPI Surveillance

A major portion of the "new" program involved Quality Assurance. Among the procedures implemented were:

### Mill Quality Program

A material specification was developed by Viking to address some of the deficiencies within API 5CT, such as

CVN values and NDE inspection to satisfy the operator's specific needs.

### Mill Process Qualification

The audit included an on-site visit to the mill by Viking's QA lead to ensure the mill had the capability to follow-through on the specified quality. In addition, establishment and implementation of specific QA/QC plans with the qualified mills defined specific requirements on testing and inspection frequencies and traceability of the produced pipe and coupling stock.

### Post Mill Inspection Program

The finished product is qualified after monitored inspections at several local inspection sites. In addition, establishment and implementation of specific QA/QC Plans with the qualified 3rd party inspection company defined specific requirements for inspection and calibration based on enhanced inspection notches.

### Accessories Coordination

Crossovers, pup joints, hangers, and packers were coordinated with monitored transportation to ensure no time was lost at the rig waiting on downhole assemblies.

### Traceability

A tracking program was implemented to allow correlation and verification of specific casing heats tracked by pipe identification from the manufacturer to final position in the well.

## TECHNICAL ACHIEVEMENTS & BENEFITS

- Each step in the Full Court Press process addresses a different aspect of the no-failure strategy.
- Once the Viking's program was fully implemented, the failures stopped. Since initially implementing the Full Court Press the operator has not had a casing failure in over 200 frac jobs. At 40 stages per well that's over 8,000 stages!
- Although the operator has taken on several of the functions Viking initiated, a close and cooperative communication remains in place today.
- Incorporation of Viking's failure database, which contains details of approximately 500 failures investigated and costs associated with 4-1/2" liner material obtained by the operator, allowed Viking to estimate the savings and additional risk incurred by backing away from an element of the no-failure program.