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The Systematic Application of Root-Cause Analysis to Failures of Intelligent-Well Completions

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Abstract

When a producing well fails, the engineering team needs to diagnose the failure quickly, in order to determine the best course of remedial action. This is particularly important with an early-life failure when other wells are still being installed using the same design, raising legitimate concern that the failure may be repeated in those other wells. In practice, diagnosis of a failure when evidence is incomplete, and even inconsistent, can lead to conflicting or incorrect conclusions. A systematic method of root cause analysis forces the discussion to converge on a useful outcome. This paper illustrates how such a method can be applied, using a fault-tree structure, to analyze hypothetical failures in two subsea multizone intelligent completions.

The objectives of the analysis is to -

- understand failures as fully as possible;
- determine what steps are needed to prevent failures from recurring on subsequent installations;
- determine what other tests may be useful to help understand the problem.

The work starts by collecting and reviewing the evidence (written reports, and links to knowledgeable people), and defining the symptoms of failure. Then Fault Trees are constructed from all the potential failure modes that fit the symptoms of failure (in this example, 32 in total). These are then used in a structured workshop session to review all those potential failure modes. Those that do not fit the evidence are discarded, in this example leaving just 4 Possible Causes by a process of elimination.

The detailed review of processes and controls required to understand the circumstances of failure is a useful way of identifying improvements to Engineering Processes (documentation control, specification and engineering management) in addition to design and operational issues.

Extra tests are then identified to confirm each Possible Cause, providing further elimination. A structured comparison to find analogues in other similar projects can provide further insight. Finally, further characterisation tests and other actions should be identified to help avoid future failures. Specific recommended actions (in this example, 32 in total) are identified to address Possible Causes and so prevent failures from recurring on subsequent installations.

A FMECA constructed during the well design phase can be consulted to determine any correlation between the failure modes identified therein and the observed failures in the two zones. The conclusions from the FMECA can also be examined to identify whether there are any outstanding recommendations or remedial actions.

This study shows that a systematic application of root cause analysis, using fault trees as the underlying structure, can be very effective in focusing engineering effort on resolving the important issues and avoiding time-wasting distractions.

1. Background - Case Study

This case study assumes a subsea development located in deepwater Gulf of Mexico using wells which are intelligent, stacked frac pack producers. Each intelligent well has two “on/off” Downhole Flow Control (DHFC) Valves. This case study assumes the failure of one of those DHFC Valves.