Restoring Functionality to Subsurface Safety Valves with Extreme Damaged Seal Bores

Graeme Allan, BP Well Intervention Engineer
Scale of the problem.

- Industry-wide issue
  - 2013 – Sean MacPhee, Enquest “Innovative intervention to restore WRISV Integrity”

- Failure of subsurface safety valves (SSSV) was one of the largest deferrals in BP

- Wells:
  - Magnus E7 - Dave Smart
  - Marnock W108 - Bronson Larkins
Remediation Efforts

- An SSSV’s operation can become impaired over time and a Insert SSSV may be required to straddle across the SSSV to provide the Well Barrier element.
- The SSSV was locked out of service with hydraulic communication to the wellbore established.
- The insert SSSV straddle system isolates the communicated hydraulics which then power the insert SSSV.
- The normal packing systems were unsuccessful and required an alternate means to provide the required isolation due to the damage to the hone bore of the SSSV.
Magnus E7 History

- September 2012
  - One of the biggest producers on Magnus – SSSV failed its pressure build up test (PBU) and was shut in.
  - Slickline was deployed and normal industry practice followed for restoring functionality to a SSSV and clean up for Insert SSSV
  - Insert SSSV with standard V-seal packing was run but could not seal in the bore
- Previous knowledge of the well bore condition indicated that there may be corrosion / damage to the seal bores.
- Seal stack arrangement was insufficient to overcome any irregularities / damage.
Several iterations of seal stack design were used.

Decision was taken to utilise swellable elastomers.

Several runs with a variety of seal configurations, using an increasing number of swellable o-rings.

In live well results showed that there were many myths about seals.

2 Main principles of using swellable elastomers:

- Minimise free space on seal gland – maximise seal expansion force radially
- Use packings to seal not the elastomer.
During the Magnus E7 work, another well had to be shut-in following a SSSV failure - Marnock W108

Marnock W108 has a very similar well history to Magnus E7, and an Insert SSSV failed to set in the seal bore

As a result – Investigative work was carried out:

• Mobilised a variety of seals and solutions
• Multi-finger calliper across the safety valve
• Installed a sleeve when down-manning
  – testing the retrieval ability of swellables
Marnock W108 Calliper Data

• Calliper run confirmed groove within seal bores of approximately 0.1” depth.
  - Most likely due to wireline tracking
  - Historical lack of use of protection sleeves across DHSV’s
First Tests

Marnock W108 first tests of new designs:

- AS Seal - previously worked on Magnus E7
- Weatherford’s Damaged Bore System – the only API 14 compliant valve at the time
- A variety of seal stack designs from major vendors and smaller companies in the industry

Swellable concerns:

- Worked on Magnus E7
- Unknown long term retrieval ability

Test with a sleeve with 3 O-rings – 9 months

- Pulled first time, little overpull.
Objective:

• Compare different types of seal solutions in a test nipple with varying degrees of wire tracking severity

• BP contacted a number of suppliers of sealing solution
  - Using suppliers within and outwith the industry
  - Blue-sky conceptual design
  - Live testing at downhole conditions

Conditions:
Temperature: 80 °C
Pressure Range: 0 – 10,000 psi
Pressure Step: 500 psi / 5 mins
Test Fluid: Brayco Micronic SV3 Hydraulic Oil
Swelling Time: 48 hrs (min).

Test Criteria:
Good Test: 0 PSI per hour leakage
Acceptable Test: <5% Test Pressure per hour AND non-linear decay
Unacceptable Test: >5% Test Pressure per hour OR linear decay
5 Damage Stages

- Mimic wireline tracking
- 7/32” diameter –
- Cut in 0.020” stages
Learnings and Outcomes

Results:

• V – packing stack seals passed Stage 1
• All swellable designs passed Stage 2
• None passed Stage 3
  – One design held 4,500 Psi before shattering its back-up ring.
• AS Seals design with minimal elastomer – best for retrieval

Caution combining metal back-up adaptors and swellables
Conclusion and Next Steps

Result:
- AS Seal is BP’s preferred sealing solution

Next Steps
- Technical Agreement between Weatherford and BP for onshore test to compare Weatherford Damaged Bore System and AS Seal
- Tested in API Specification 14L conditions

If successful
- AS Seal becomes BP’s favoured design for sealing in damaged bore
- Standard off the shelf package offered by Weatherford, available to industry
Thanks

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• Weatherford
• Altus Solutions
• Our many seal suppliers that took part in the onshore testing.

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