BOP Shear and Pressure Testing of Intelligent Completion Tubing

Results and Lessons Learned
A Short History

In March 2012 it was made known to WEL that Hydril had attempted to shear an EXPRO shear sub, dressed with 15 x 3/8-inch stainless steel control lines, utilizing their standard blind shear rams. There was no problem shearing the sub itself but a seal could not be obtained due to pieces of control lines being drawn in between the upper and lower shear blades then compromising the lateral seal.

It was incidents such as this that prompted the development of improved shear ram assemblies such as the Hydril WSR (wireline shear rams), Cameron’s CDVS (cable dual V-shear rams) and Shaffer’s CVX-W (wireline shear rams).

Both of these shear rams are able to successfully shear and seal when cutting production tubing and SLS shear subs when fitted with a variety of control tubing sizes and electrical cables.

The interlocking features of these rams enable them to cut slack tubing and cables without compromising the sealing qualities of the rams.
Cameron CDVS Shear Rams

Note: CDVS Cutting Blade does cover full wellbore.

18-3/4" Wellbore

"V" Cutting Edge on Bottom Blade

"V" Cutting Edge on Top Blade

A Short History cont’d
A Short History cont’d

Hydril WSR (wireline shear rams)

Engineering Data

- Completed 266+ open/close cycles and 38+ pressure tests at 15,000 psi
- Sheared 5” drill pipe with three wireline cables
- Sheared 5½” drill pipe with single wireline cable
- Sheared wireline cable in center of wellbore and at wellbore wall with no cable tension
- Sheared 8.28” OD, 0.66” wall, 95 ksi drill pipe with three pieces of coiled tubing, three pieces of ¾” wireline cable, and 16 hydraulic control lines made of ⅛” 316 stainless steel
The Atwood Eagle & GWF

The Atwood Eagle is fitted with a Cameron Type U BOP. This BOP type can only be fitted with the SBR (shear blind ram). The SBR shear ram Upper blade has a shallow ‘V’ profile and the Lower blade has a straight edge profile.
Standard blind shear rams exhibit varying degrees of vertical separation between the upper and lower blades during the shearing action.

The result of this separation can be seen in the following video clip, observe the size of the “toe nails” that break away at pipe separation.

What wasn’t known was just how much separation would the Cameron SBR rams exhibit and what effect would that have on shearing/sealing tubing, the SLS shear joint and control lines.
GWF Smart Completions & the SLS Shear Joint

**SLS Shear Joint**
8.16” OD, 0.5” WT, P110 grade

**Sample Smart Completion Joint**
7-inch, 29 ppf, 13Cr, L-80
Atwood Oceanics and WEL cooperated on an arrangement to conduct shear testing at the Cameron Services facility in Louisiana. Samples of the smart completion system and the SLS shear joint were shipped to the facility along with SBR ram blocks from the Atwood Eagle and video recording equipment. The facility was equipped with shielded high-pressure testing bays and a Type U single ram body, fitted with tandem booster operators, had been installed on a blind hub test assembly.

*Tandem boosters and shear rams identical to Eagle BOP*
Smart Completion First Cut

Control tubing package parallel to ram lower (straight) blade

7-inch tubing sheared at 2400 psi
Smart Completion First Cut

Upper section cut

Lower section cut & fold

GWF Shear & Seal Testing at Cameron Services, Patterson, Louisiana DRIMS #8936221
Smart Completion First Cut – Pressure Test

Low Pressure – 270 psi

High Pressure – 5000 psi
Smart Completion Second Cut

Control tubing package @ 90° to ram blade travel

7-inch tubing sheared at 2300 psi
With the control packages @ 90° to the blade travel the second cut of the encapsulated lines was considerably cleaner than when facing the blades.

Upper section of second 7-inch tubing cut
Smart Completion Second Cut – Pressure Test

Low Pressure – 290 psi

High Pressure – 5000 psi
• The shear and seal exercise on both configurations of the Smart Completion Packages was successful.

• The attitude of the encapsulated packages with respect to blade travel had no effect on the sealing capability of the rams – although the shear of the control line package was much cleaner when placed adjacent to the blade travel.

• The current plan for the clamping of the control line packages on the production tubing appears to be adequate.
The original SLS shear joint

Original SLS joint was geometrically unshearable in Atwood Eagle BOP

- OD = 8.625”
- ID = 7.165”
- WT = 0.73”

Cameron SBR Limits in Type-U BOP

- OD = 8.84”
- ID = 7.74”
- WT = 0.55”
Agreement was reached with FMC Technologies to re-size the SLS shear joint to accommodate the capability of the Atwood Eagle BOP.

The shearable section of the joint was machined down to an OD of 8.17”. This resulted in a wall thickness of 0.5”.

The SLS shear joint was now within the geometric limits of the Type-U BOP and SBR shear rams.
The two samples of SLS shear joint material were only 1.0 M long.

As the actual shear joint is almost 3.8 M long it was decided to loosely mount the control tubing arrangement to simulate the unrestrained length of the control lines.

This arrangement would allow for a fair indication of how far the control lines may be displaced before being sheared.
SLS joint sample sheared at 2400 psi
Five of the six control lines were pushed to the outer edges of the ram blocks.

Two of the five displaced lines did not shear resulting in a failed pressure test.
SLS @ Cameron Services – First Cut

SLS first cut Upper & Lower sections

Upper

Lower cut & fold
Control line that did not shear became trapped between the faces of the side packers.
Low pressure test failed

Rams were opened and inspected

Rams closed (no tubulars)

LP / HP tests conducted successfully
Second SLS sample control lines were securely clamped and the tubing ends bent to assist in preventing excessive displacement.

It was necessary to make use of the encapsulated tubing as the SLS samples were delivered without the requested stock of ¼” stainless steel lines.
SLS @ Cameron Services – Second Cut

SLS sample #2 sheared at 2270 psi

All six control lines sheared and broke away cleanly when upper section was lifted
Control tubing was still displaced towards the edges of the ram blocks.

However all control tubing had been sheared before reaching the packer areas.

The SLS control tubing clamping arrangement will have to be reviewed.
SLS 2nd cut Upper & Lower sections

GWF Shear & Seal Testing at Cameron Services, Patterson, Louisiana DRIMS #8936221
SLS Second Cut – Pressure Test

Low Pressure – 280 psi

High Pressure – 5000 psi
Lower section Cut & Fold – All control lines cleanly severed
SLS Shear Exercise Summary

• The SLS tubular sheared at well below the BOP max system pressure

• Control lines will need to be clamped above and below the shear rams

• Suggest the use of encapsulated control line packages to eliminate line displacement during shear action
SLS Shear Exercise Summary