Dual-Casing Section Milling
Experiences and Lessons Learned from Australasia

Dean McTiffen
Steven A Canny
David S Murray
The Goal

- Reduce liability by abandoning mature well stock that have reached cessation of production
- Perform operations with no harm to personnel or the environment
- Perform operations per operator standard and local legislative requirements
- Perform operations at as low a cost as possible, achieving all key performance targets
The Challenge

Well Abandonment basis of design indicated:

- **Primary Well Barrier window above production packer**
  - Thru Tubing Conveyance onto gas tight base

- **Secondary Well Barrier Window across 17-½” section at surface casing shoe, suspected C and D annuli integrity concerns** –
  - Casing Removal Required – Production, Intermediate and Surface

- **Surface Well Barrier Window on top of Secondary Well Barrier**
  - Drill Pipe Conveyance onto gas tight base
Conventional Approach

- Well Barrier Target Formation above 13-3/8” Shoe
- Poor Annular Cement in B and C Annulus

Approach:
- Cut 9-5/8” Casing and Recover above TOC
- Pilot Mill 9-5/8” Casing to below 13-3/8”
- Run 11-1/2” OD Mill to Section Mill 13-3/8” Shoe
- Clean out hole
- Run Cement Retainer Packer
- Set Well Barrier Open Hole Cement Plug

<table>
<thead>
<tr>
<th>Mill</th>
<th>Body OD (in./mm)</th>
<th>Overall Length (in./m)</th>
<th>Approximate Shipping Weight (lb/kg)</th>
<th>Casing Sizes (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11-1/2</td>
<td>90</td>
<td>1,725</td>
<td>13-3/8</td>
</tr>
<tr>
<td></td>
<td>292.1</td>
<td>2.3</td>
<td>782</td>
<td></td>
</tr>
</tbody>
</table>
Facilitating Technology
Dual String Section Milling
Dual String Section Milling Development

- Conventional approach to removing dual casings to reach formation is
  - casing cutting and recovery
  - pilot milling
  - section milling

- Time, personnel and equipment intensive

- To remove the requirement to cut and recover, then pilot mill the remaining casing, facilitating technology is required to allow the milling an outer string, through an inner string window
Overview – 9-5/8” x 13-3/8” DSSM

Housing (Cutting)  Housing (Stabilizer)

Section A-A  Section B-B

Top Sub
Cutter Blades
Integral Stabilizer
Bottom Sub  Bull Nose

Section A-A  Section B-B
Operation Sequence – for 9-5/8” x 13-3/8”

1. The built-in integral stabilizer expands inside the 13 3/8-in. casing.

2. Cutting blades cut a window through the 13 3/8-in. casing to prepare for the milling blades.

3. The 17-in. (0.43-m) milling blades mill the remainder of the 100-ft (30-m) section.
Case Study and Lessons Learned
Abandonment Basis of Design
Heavy Fishing Operations

Typical BHAs Used for Scope

- Tubing Conveyed Rotary Cutting for Production and Intermediate Casing
- Contingency Spears for casing recovery
- Pilot Milling for Production Casing
- Section Milling for Intermediate Casing
- DSSM for the Surface casing through the Intermediate Casing
- Casing Scrapers to prepare Bridge Plug setting zones
- Drill Bit and Watermelon Mill for dressing cement
Access the B Annulus

**7” Production Casing Removal**

- Run Tubing Conveyed Rotary Casing Cutting tool and cut casing

- Engage Casing Hanger and POOH, breaking and laying down production casing (Spear Contingency)

- Run Pilot Mill BHA into casing stump and mill to target depth

- Run Bridge Plug and set in casing stump
Access to the C Annulus

9-5/8” Intermediate Casing Removal

- Displace to milling fluid and condition wellbore for milling operations
- Run conventional 9-5/8” Section Milling BHA and perform cut out
- Continue milling to open up 115 ft window
- POOH and displace well
- Perform BOP jetting run
Access to the D Annulus

13-⅜” Surface Casing Removal

- Displace to milling fluid and condition wellbore for milling operations
- Run DSSM 13-⅜” Section Milling BHA dressed for cut out, through 9-⅝” casing to target depth
- Perform surface casing cut out then POOH and run DSSM 13-⅜” Section Milling BHA dressed for window milling to target depth
- Mill to 115 ft window length and POOH
- Run Inflate Packer and set across 17-½” open hole section
- Condition hole for cementation
Biogenic Gas Challenges

**Identified Challenges**

- Target formation for WB placement is hydrocarbon bearing
- Previous annular cement repair
- Bacterial driven gas was identified in a siltstone formation in previous well operations
- Well control diagnosis challenges with Swarf handling surface equipment present in LP return side
- Gas migration through WB during open hole cement plug curing

**Mitigation Measures**

- Mudlogging system installed with gas detection at critical areas and drill floor
- Mandated well shut in procedures should a kick be detected
- Sampling loop in fluid system for testing
- Well monitoring steps during milling operations – after cut out, during window milling
- Setting open hole inflatable retainer to give a gastight base to spot WB upon
Well Control Challenges

- Circulation whilst milling resulted in Ballooning and Breathing of the Well
  - With hydrocarbon bearing formation contact expected – how to detect a kick vs well phenomena
  - What degree of confidence is there in it not being a kick?
- Swarf handling interfacing
  - Large diameter flow line required
  - Ability to choke on flow line is diminished
- Integration of Managed Pressure Techniques during section milling
  - Early Kick Detection sensors are typically for 2” lines
  - High packoff risk if circulation is via choke line during milling operations
  - Currently no technology solution in the supply chain

The diagnosis of the well behaviour resulted in XX% of the cumulative NPT for operations.
Hole Cleaning Challenges

During BHA #X1 runs, packoffs were observed

- Viscous Milling Fluid used
- Consistent swarf produced
- Longest remediation: 1hr 55min
- Cleaning regime suspected

During BHA #X2 runs, significant improvement in packoff occurrence

- Viscous Milling Fluid used
- Consistent swarf produced
- Cleaning every 0.5 m milled
- Vastly improved performance
Hole Cleaning Summary

<table>
<thead>
<tr>
<th>Operation</th>
<th>BHA #X1</th>
<th>BHA #X2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start to End of Milling on Bottom</td>
<td>15 hr 28 mins</td>
<td>31 hr 35 mins</td>
</tr>
<tr>
<td>Non-Milling Time due to Wiping Pipe or Packoffs</td>
<td>2 hr 35 mins</td>
<td>1 hr 18 mins</td>
</tr>
<tr>
<td></td>
<td>16.7%</td>
<td>4.2%</td>
</tr>
<tr>
<td>Maximum Time Spent Clearing x1 Packoff</td>
<td>1 hr 55 mins</td>
<td>0</td>
</tr>
</tbody>
</table>

- Results present that by spending 4.2% of the total milling time cleaning the hole after every 0.5m milled, it mitigated the potential of packing off where the time wasted to clear packoffs increased to 16.7%.

- The time invested in hole cleaning translated into a 14.3% increase in the ROP and a 95.8% milling time on bottom.
Cut Out Knives being run

Cut Out Knives after run

Full Gauge Mill Out Knives
## Time Comparison – Conventional Approach

<table>
<thead>
<tr>
<th>Operation</th>
<th>Time (hours)</th>
<th>Cumulative Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut &amp; Pull Free Section of 9-5/8” Casing</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>(Assume 2m/hr &amp; 4x Trips @ 6 Hours per trip – Total Circulation &amp; flow checking @ 3 hours per trip)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section Mill 13-3/8” Casing</td>
<td>16 – Tripping 37 – Milling</td>
<td>53</td>
</tr>
<tr>
<td>(Assume 1m/hr &amp; 2 trips @ 8 Hours per trip – Total Circulation &amp; flow checking 3 hours per trip)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Time</td>
<td>256 hours</td>
<td></td>
</tr>
</tbody>
</table>
Time Comparison – Milling through the 9-5/8”

- A conventional section mill was used to remove a 115 ft (35 m) section of 9-5/8” casing, facilitating a clean, usable window
- The DSSM was deployed, reaching TD and performing the cut out successfully
- A milling-blade tool was run in hole, removing 98 ft (30 m) of 13-3/8” casing, enabling the operator to install a rock-to-rock cement barrier within the operator’s Well Integrity regulations

<table>
<thead>
<tr>
<th>Operation</th>
<th>Time (hours)</th>
<th>Cumulative Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section Mill 9-5/8” Casing</td>
<td>8 – Tripping 61 - Milling</td>
<td>69</td>
</tr>
<tr>
<td>DSSM 13-3/8” Casing</td>
<td>24 – Tripping 54 – Milling</td>
<td>78</td>
</tr>
<tr>
<td>Total Time</td>
<td></td>
<td>147 hours</td>
</tr>
</tbody>
</table>

Total time saved = 118 Hours | 43%
Lessons Learned

- Breathing and Ballooning was experienced when milling in D-Annulus – *Increased pre-job planning and interpretation to diagnose this vs kick*
- Rate of penetration is limited significantly by the well conditioning and cleaning – *BHA design and flow adjusted to improve*
- Support of the Flowline helped to significantly reduce pack off occurrences – *Auxiliary Winches used to support flowline to reduced bending*
- Swarf handling at surface and logistics improved as operations progressed – *The volume of milled casing req*
- Single Trip DSSM has potential to further reduce the already 43% rig time reduction, in comparison to conventional casing removal techniques