DUAL-CASING SECTION MILLING
EXPERIENCES AND LESSONS LEARNED FROM AUSTRALASIA

Dean McTiffen
Steven A Canny

SPE 7th European Well Abandonment Seminar
27th and 28th June 2017, Aberdeen

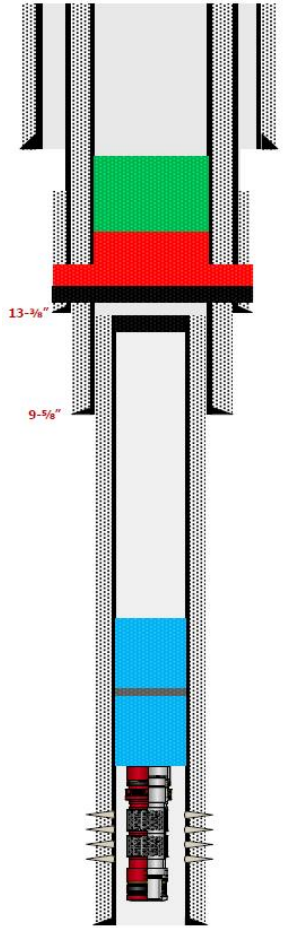
SPE International

Weatherford®

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



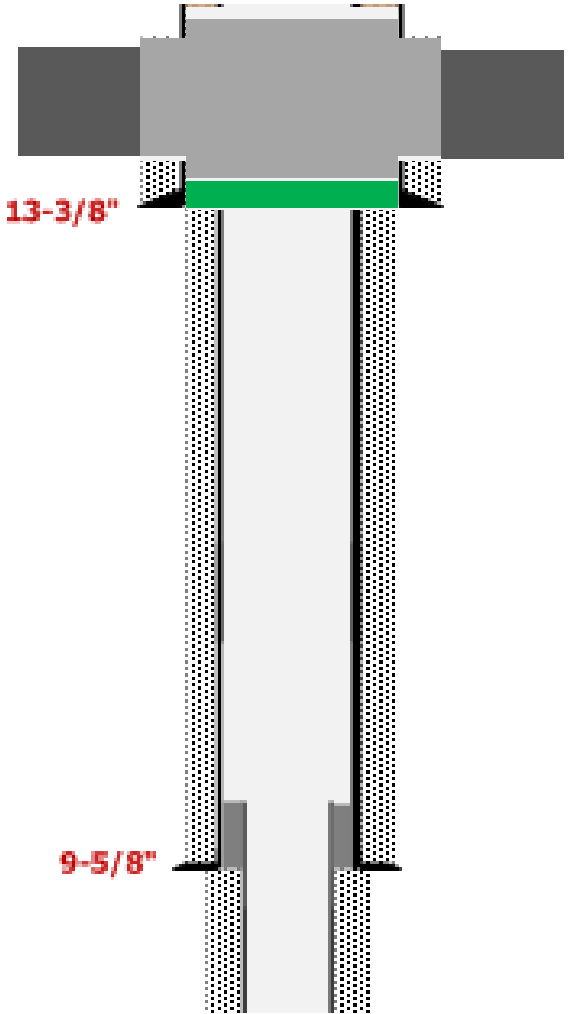
CONVENTIONAL APPROACH

- Well Barrier Target Formation above 13-⅜" Shoe
- Poor Annular Cement in B and C Annulus

Approach:

- Cut 9-⅝" Casing and Recover above TOC
- Pilot Mill 9-⅝" Casing to below 13-⅜"
- Run 11-½" OD Mill to Section Mill 13-⅜" Shoe
- Clean out hole
- Run Cement Retainer Packer
- Set Well Barrier Open Hole Cement Plug

Mill			
Body OD (in./*mm*)	Overall Length (in./*m*)	Approximate Shipping Weight (lb/*kg*)	Casing Sizes (in.)
11-1/2 *292.1*	90 *2.3*	1,725 *782*	13-3/8

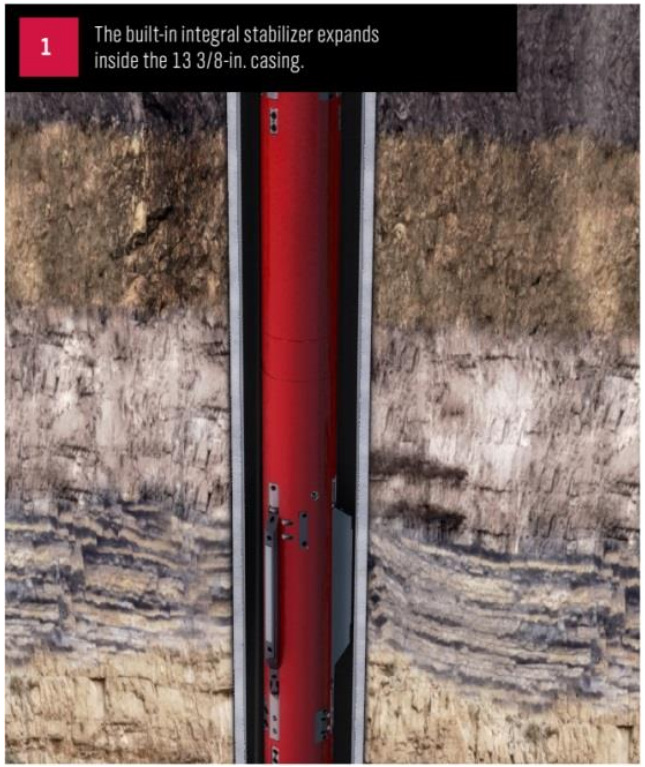


FACILITATING TECHNOLOGY
DUAL STRING SECTION MILL

DUAL STRING SECTION MILLING DEVELOPMENT

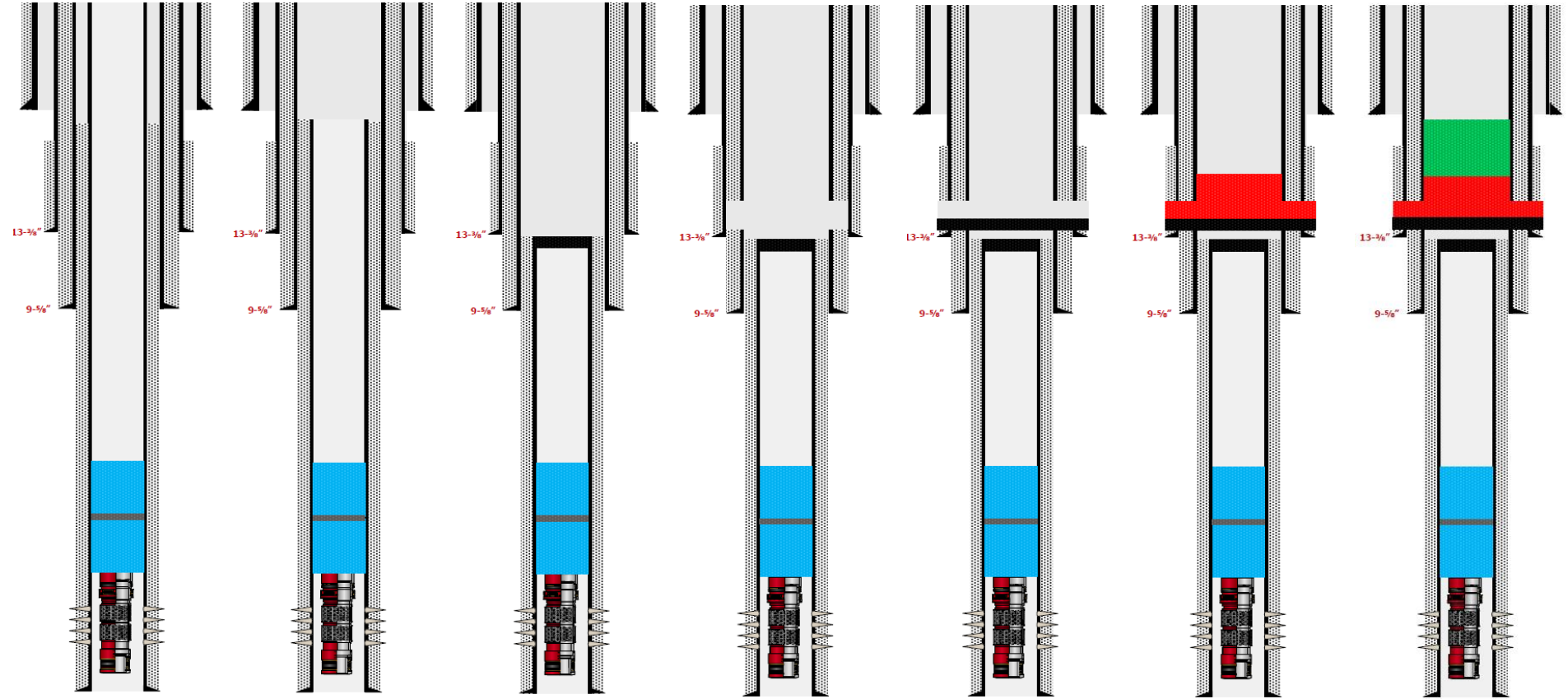
- Conventional approach to removing dual casings to reach formation is
  - casing cutting and recovery
  - pilot milling
  - section milling
- Time, personnel and equipment intensive
- To remove the requirement to cut and recover, then pilot mill the remaining casing, facilitating technology is required to allow the milling an outer string, through an inner string window

OPERATION SEQUENCE – FOR 9-⅝" X 13-⅜"



CASE STUDY AND LESSONS LEARNED

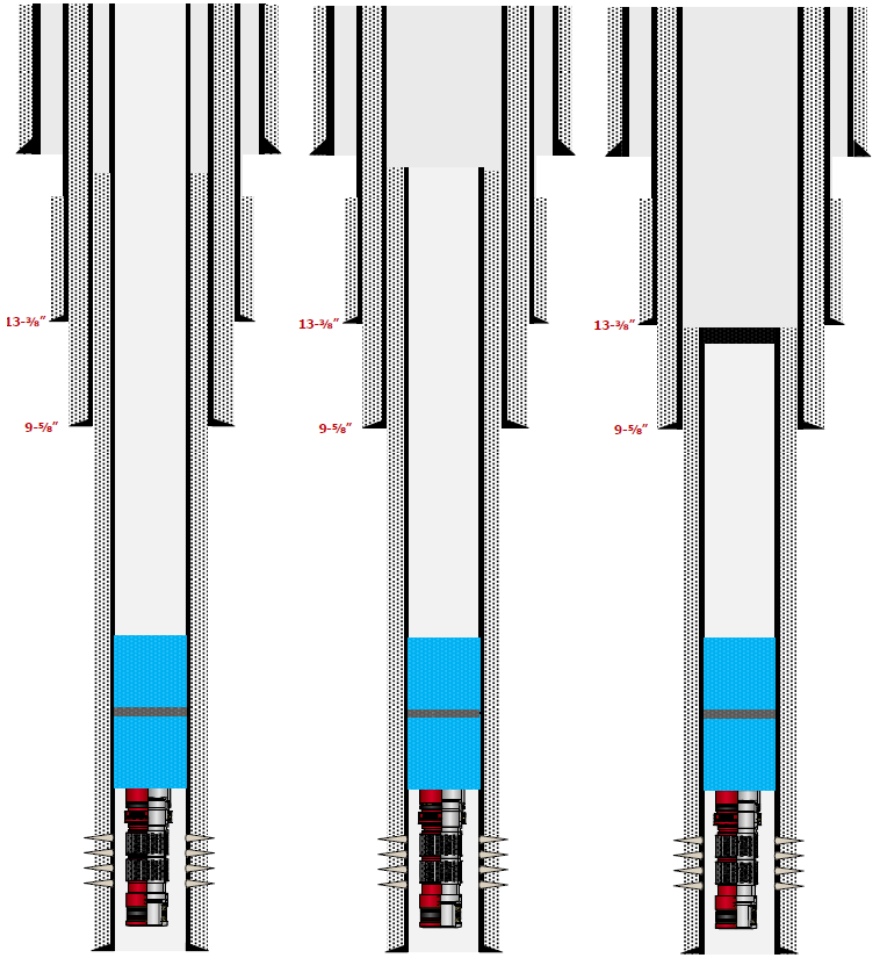
ABANDONMENT BASIS OF DESIGN



ACCESSING THE B-ANNULUS

7" Production Casing Removal

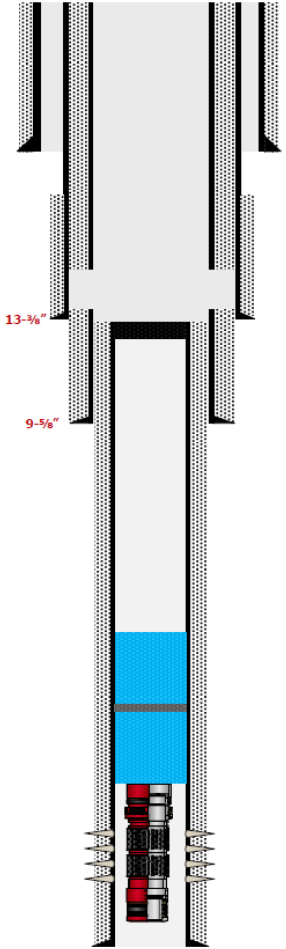
- Run Tubing Conveyed Rotary Casing Cutting tool and cut casing
- Engage Casing Hanger and POOH, breaking and laying down production casing (Spear Contingency)
- Run Pilot Mill BHA into casing stump and mill to target depth
- Run Bridge Plug and set in casing stump



ACCESSING THE C-ANNULUS

9-⅝" Intermediate Casing Removal

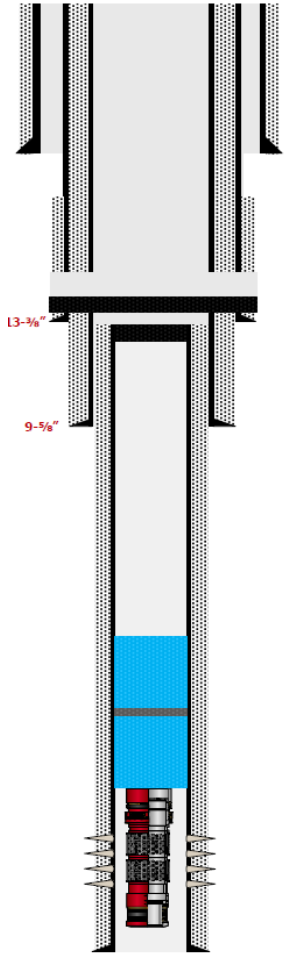
- Displace to milling fluid and condition wellbore for milling operations
- Run conventional 9-⅝" Section Milling BHA and perform cut out
- Continue milling to open up 115 ft window
- POOH and displace well
- Perform BOP jetting run



ACCESSING 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



CHALLENGES OF PRESENT BIOGENIC GAS

Identified Challenges

- Target formation for WB placement is hydrocarbon bearing
- Previous annular cement repair
- Bacterial driven gas was identified in a siltsone 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
- Mud gas cut testing
- 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

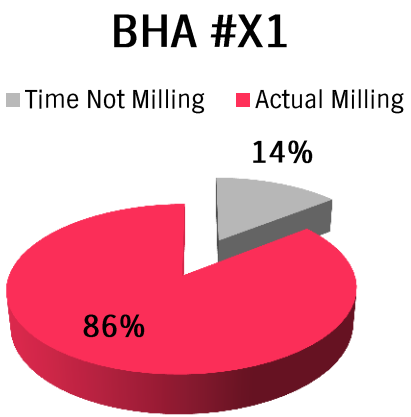
WELL CONTROL CHALLENGES

- Ballooning and Breathing of the Well – or a Kick?
  - With hydrocarbon bearing formation contact expected – how to detect a kick vs well phenomena
  - Trip tank returns increase however no returns during pressure bleed off
  - What degree of confidence is there in it not being a kick?
- Gas Detection Scenario
  - Shut in well at annular
  - Controlled bleed off at surface and monitoring
  - **18.5%** of NPT associated to Flowdown in one day
- 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

HOLE CLEANING CHALLENGES

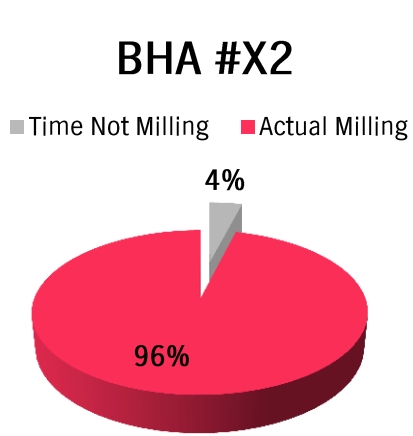
During BHA #X1 runs, packoffs were observed

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



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

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

- 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

TIME COMPARISON – CONVENTIONAL APPROACH

Operation	Time (hours)	Cumulative Time
Cut & Pull Free Section of 9-⅝" Casing	5	5
Pilot Mill 9-⅝" Casing *(Assume 2m/hr & 4x Trips @ 6 Hours per trip– Total Circulation & flow checking @ 3 hours per trip)*	24 – Tripping 178 – Milling	207
Section Mill 13-3/8" Casing *(Assume 1m/hr & 2 trips @ 8 Hours per trip – Total Circulation & flow checking 3 hours per trip)*	16 – Tripping 37 – Milling	53
	Total Time	265 hours

TIME COMPARISON – MILLING THROUGH THE 9-⅝”

- A conventional section mill was used to remove a 115 ft (35 m) section of 9-⅝” 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 13-⅜” casing, enabling the operator to install a rock-to-rock cement barrier within the operator’s Well Integrity regulations

Operation	Time (hours)	Cumulative Time
Section Mill 9-⅝”Casing	**8** – Tripping **61** - Milling	**69**
DSSM 13-⅜” Casing	**24** – Tripping **54** – Milling	**78**
	Total Time	**147 hours**

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 hole cleaning regime adjusted*
- 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 required an increase in anticipated handling requirements*
- Single Trip DSSM has potential to further reduce the already **43%** rig time reduction, in comparison to conventional casing removal techniques

Weatherford®