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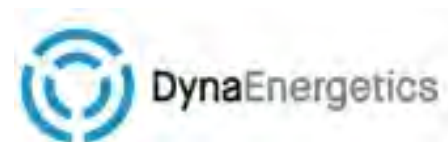
MIDDLE EAST AND NORTH AFRICA PERFORATING SYMPOSIUM



World's Highest Gun Phasing Angel for Oriented Perforation in Fiber Optic Well in Oman

Presenter:

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MENAPS-23-22 AUTHORS:

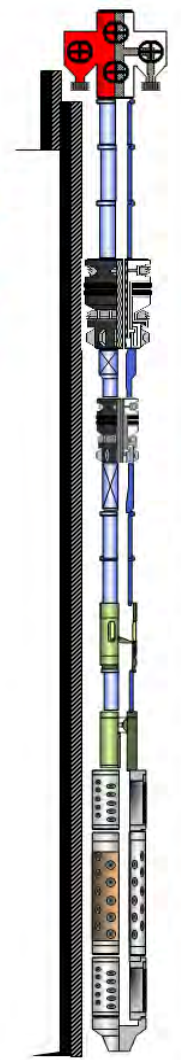
Faiza Al Jadidi (PDO), Sultan Al Bahri (PDO), Mohammed Taiwani (RAY International), Hanaey Ibrahim (DYNA Energetics)

- Project Overview
- TCP Oriented Perforation
- Well Objective and Challenges
- Completion Design
- Oriented Gun Phasing
- Perforation Job Results
- Conclusion

- Complete wells with cemented 7” casing and Fiber Optic line to surface.
- Perforate without compromising on injection/production rates.
- Perforate well without damaging the fiber optic cable.
- Consider the recommendations of Gun Phasing (180° margin) and operational errors to avoid risk of hitting the cable.
- Consider maxim shot density.

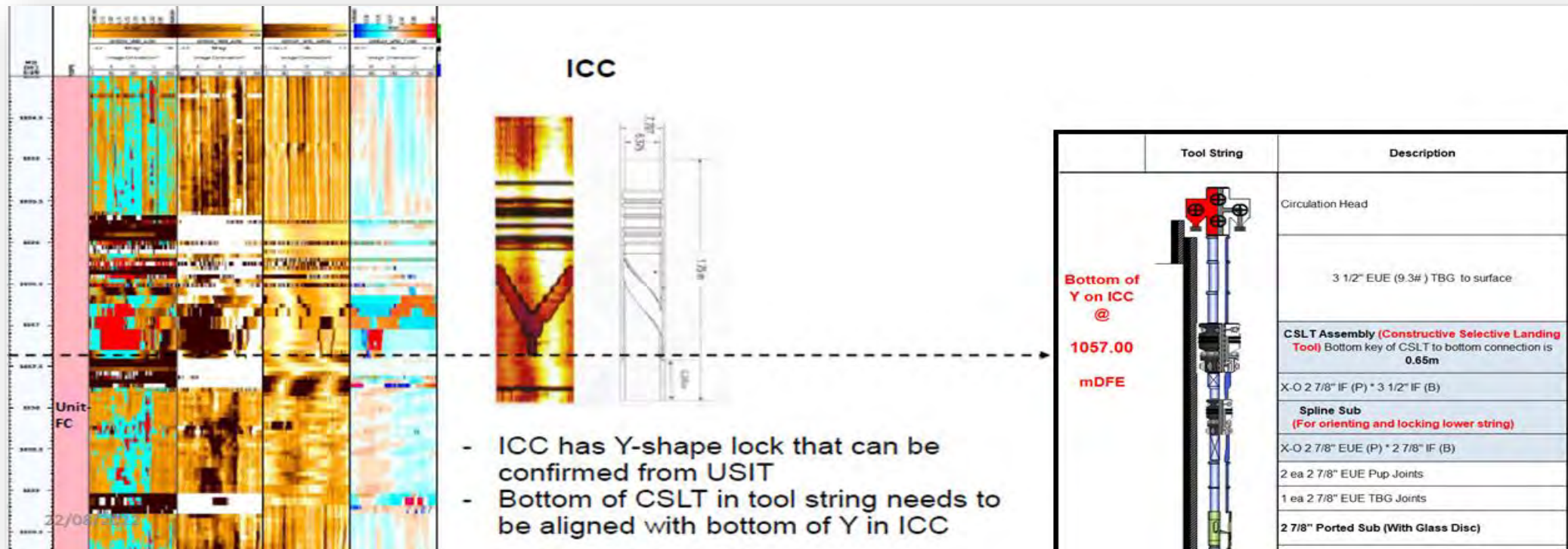
TCP Oriented Perforation

- An ICC (Index Casing Collar) is RIH with 7" CSG.
- After completion; log the well to confirm:
 1. ICC landing profile depth.
 2. Fiber optic cable straightness (ICC to Top shot).
- Based on log results; guns are loaded and TCP tally is designed to match the distance from top shot to ICC.
- TCP guns are loaded and RIH with Constructive Selective Landing Tool (CSLT) to rotate string opposite fiber optic cable direction.

Tool String	Description
 <p>Bottom of Y on ICC @ 1057.00 mDFE</p>	Circulation Head
	3 1/2" EUE (9.3#) TBG to surface
	CSLT Assembly (Constructive Selective Landing Tool) Bottom key of CSLT to bottom connection is 0.65m
	X-O 2 7/8" IF (P) * 3 1/2" IF (B)
	Spline Sub (For orienting and locking lower string)
	X-O 2 7/8" EUE (P) * 2 7/8" IF (B)
	2 ea 2 7/8" EUE Pup Joints
	1 ea 2 7/8" EUE TBG Joints
	2 7/8" Ported Sub (With Glass Disc)
	1 ea 2 7/8" EUE TBG Joints
	Drop Bar Firing Head (2-7/8") with Pup joint
	4.5" Safety Spacer
	4.50" HSD, DP, RDX, 12 SPF (Loaded @ 8 SPF) 180° Blank section to be placed opposite Fiber Optic Cable using CSLT Spline Sub
	4.5" Blank Spacer
	Bottom Plug

Rotating TCP Guns away Fiber Optic

- During RIH the CSLT key will land and set at ICC landing profile with the guidance of Y-shape slot; where string will rotate and guns will stop at perforations depth.
- Guns will be perforated using a drop bar firing head.



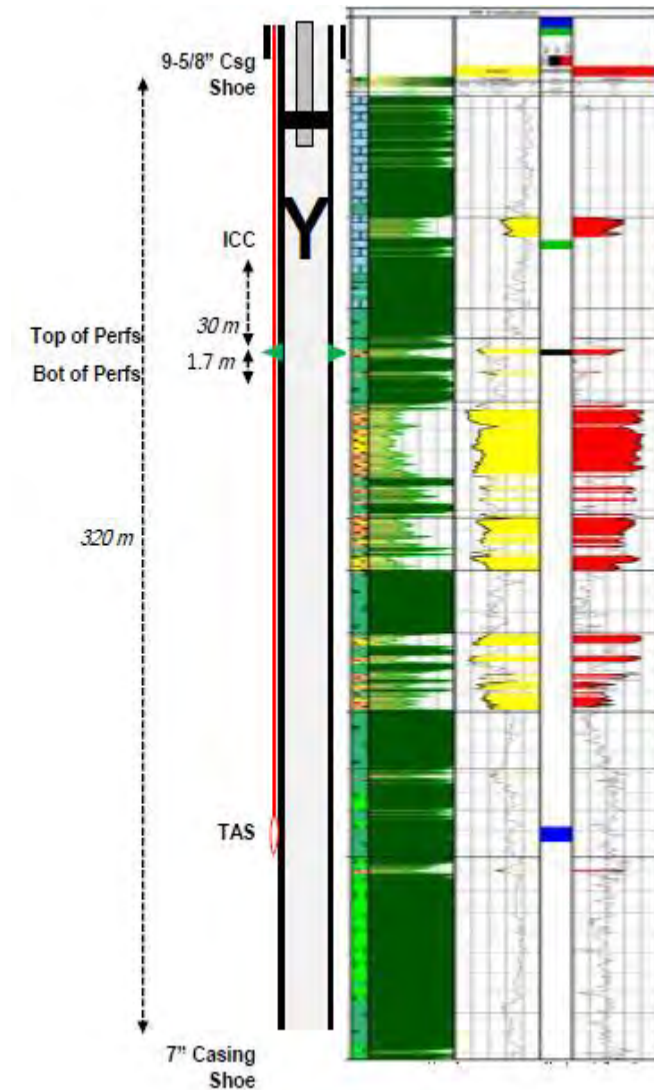


- Well-61 is a vertical oil producer located in filed-A, South of Oman.
- The well is completed with slim design (9-5/8" and 7" csg).
- 7" CSG is equipped from outside with a Fiber Optic TD to surface.
- The main objective of Well-61 is to produce from Unit 1 and Unit 2
- Clear identification of Cable direction and perforations direction.
- Perform TCP oriented perforation using 4 ½" 12 SPF guns with reduced shot density.



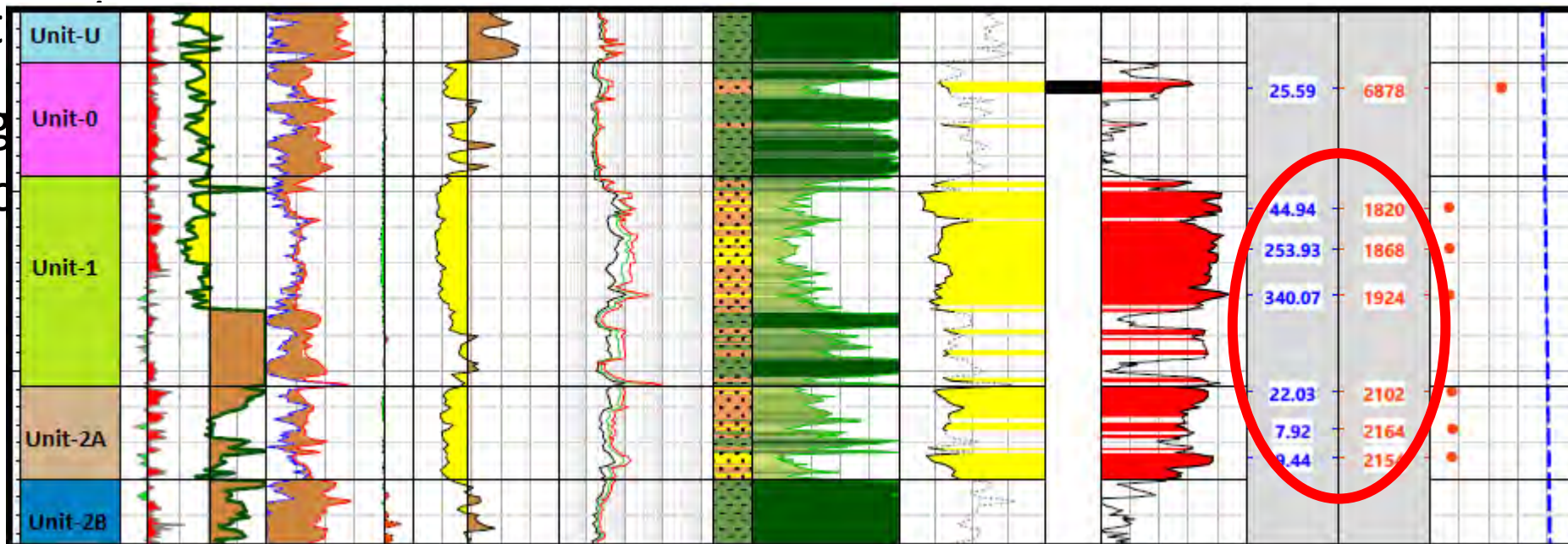
Completion Design - Well-61

- **Slim Vertical Oil producer with Fiber Optic on casing**
 - 12.25" hole size with 9-5/8" casing shoe (40#) in unit- E
 - 8.75" hole size with 7" casing (23#) to surface.
 - Indexing Casing Collar (ICC) should be part of 7" casing tally (~ 30m above top perf)
 - Centralizers should be run with 7" casing (mid-joint)
- **3.5" tubing, at least 50 m above top of perforation**
- **1/4" control line clamped on the outside of 7" casing**
 - Secured with mid-joint clamps and metal bands
 - Turn-Around Sub (TAS) at bottom of control line
 - 2 fibers (SM & MM) were pre-installed
- **Expansion agent was used in cement recipe and cement to surface.**



Well-61 Logging Results

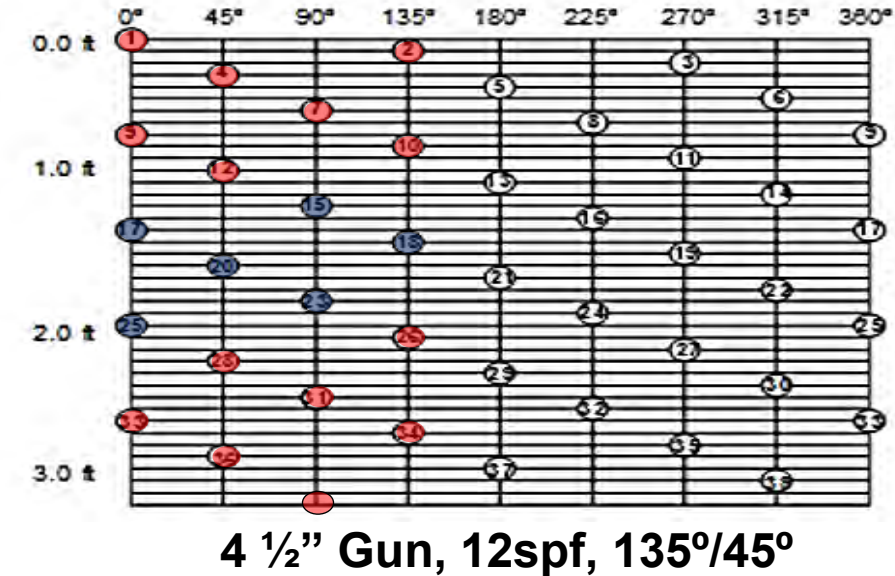
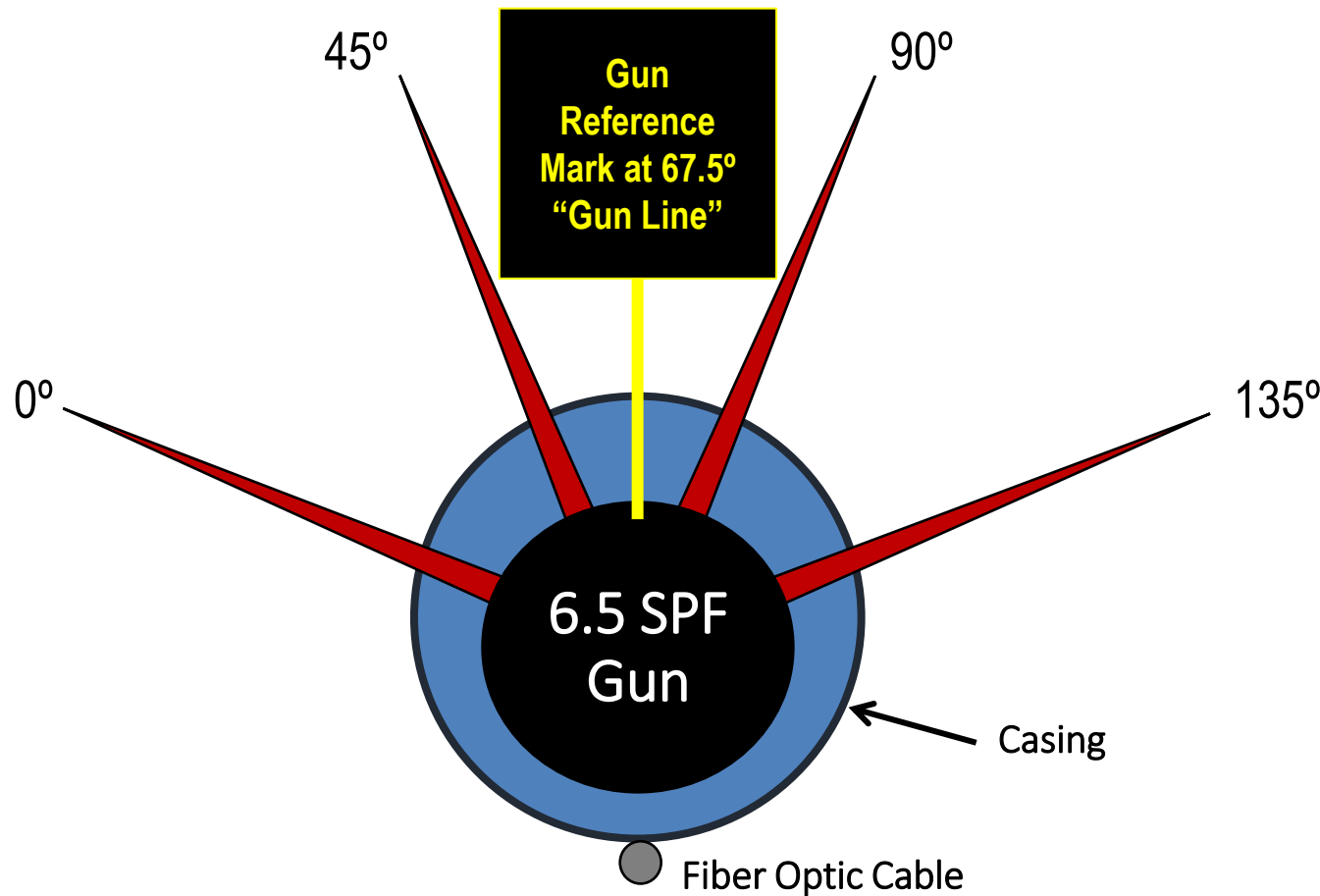
- The main pay zones are unit-1, unit-2A and Unit-2C. However, due to severe pressure depletion in Unit-1, 2A & 2C and to avoid further depletion, unit-0 has been perforated.
- Unit-0 has a short reservoir thickness with less net pay, shows pressure of + 6000 kPa and as a result managed to perforate only 1.7 m
- Due to high depletion, shooting the well with 8 SPF will lead to 67% product
- Running operatio



and faces

Gun Phasing Option 1

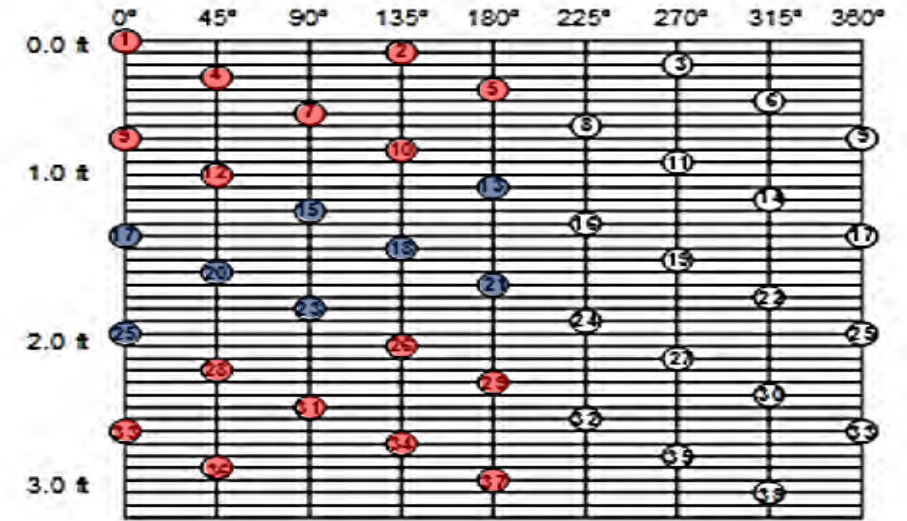
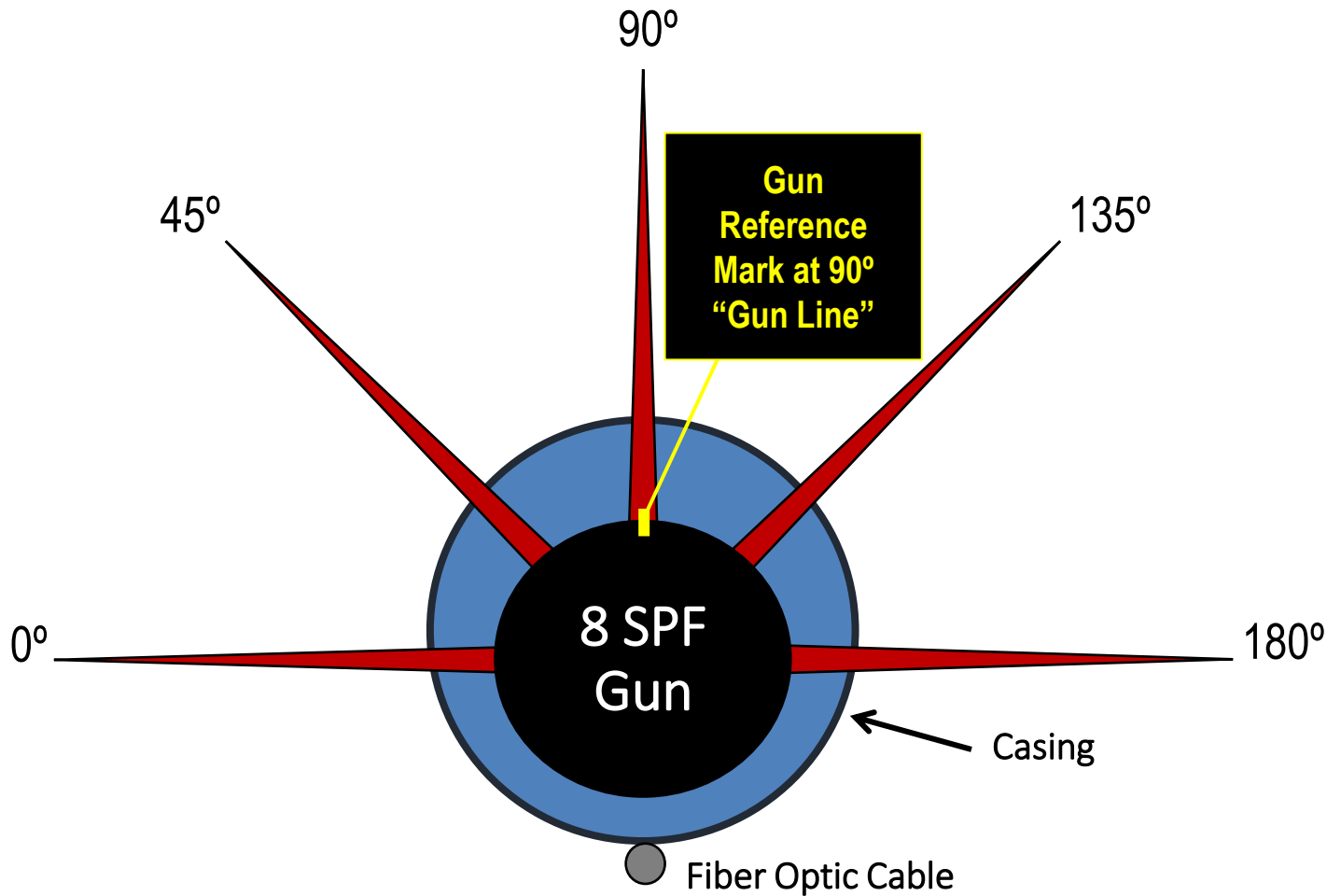
6.5 SPF in two run **135° loaded** / **225° Blank**



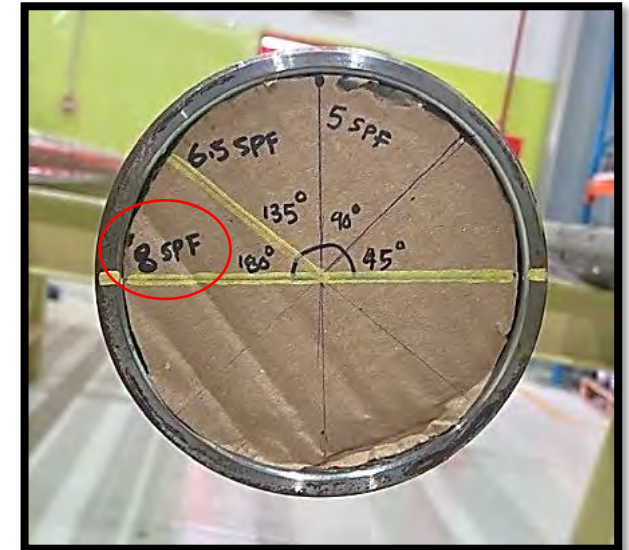
Well-61 Recommended Shot Density



8 SPF in one run **180° loaded** / **180° Blank**

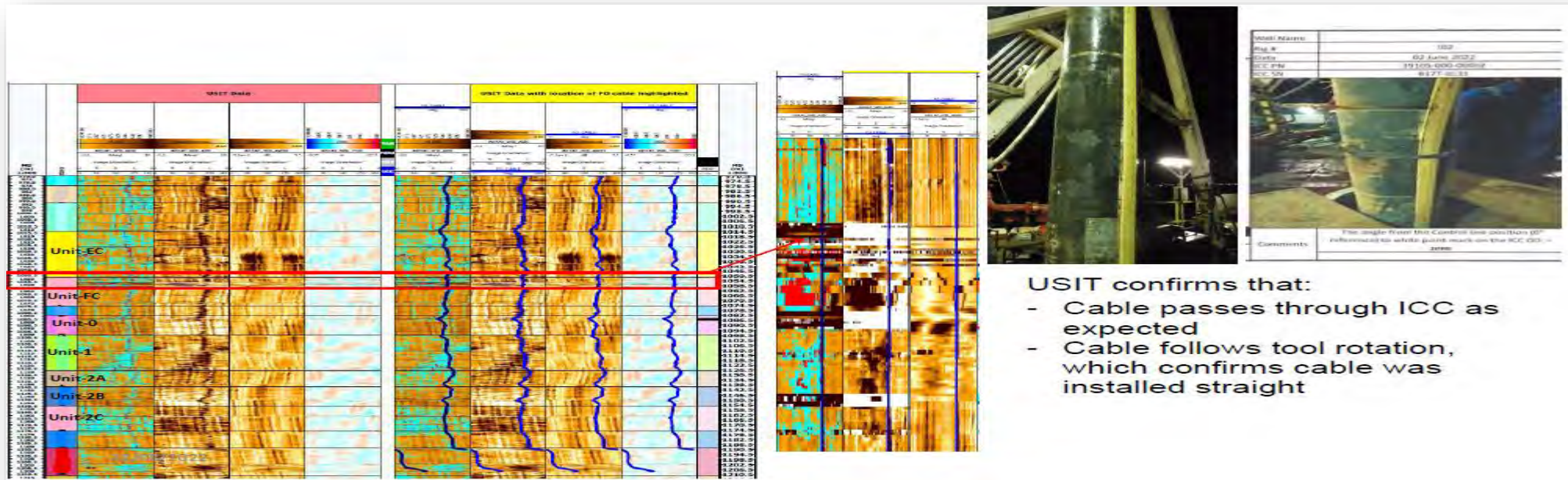


4 1/2" Gun, 12spf, 135°/45°



Confirming Cable Position

- SOP executed in Well-61 resulted in straight FO cable installation and also confirmed by ultrasonic logs.
- Due to depleted reservoir the 8spf gun will not provide good AoF.
- The maximum shot phasing in Oman was 135° @ 6.5spf and no experience with 180° @ 8spf.
- Anything over 180° phasing was not done before.

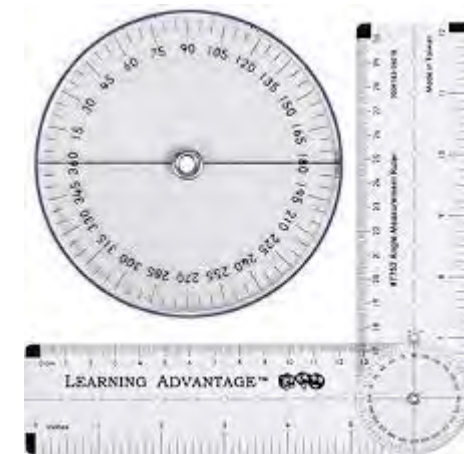
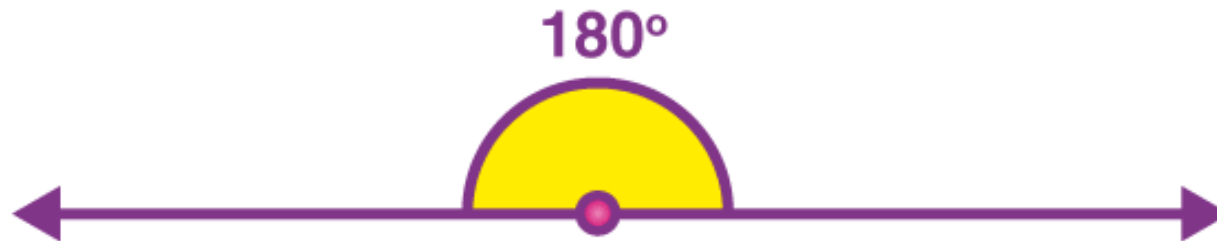


USIT confirms that:

- Cable passes through ICC as expected
- Cable follows tool rotation, which confirms cable was installed straight

PDO, RAY and Dyna worked together to provide the most suitable gun phasing option and for the well considering below facts:

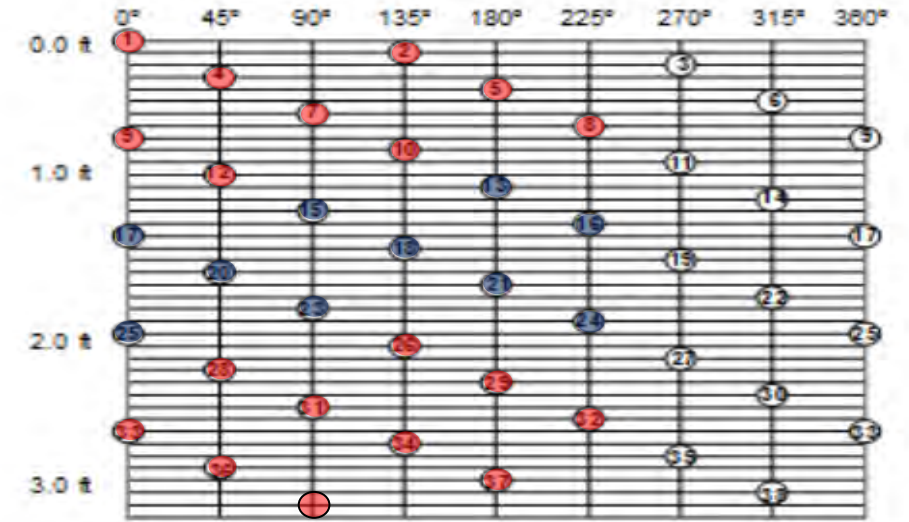
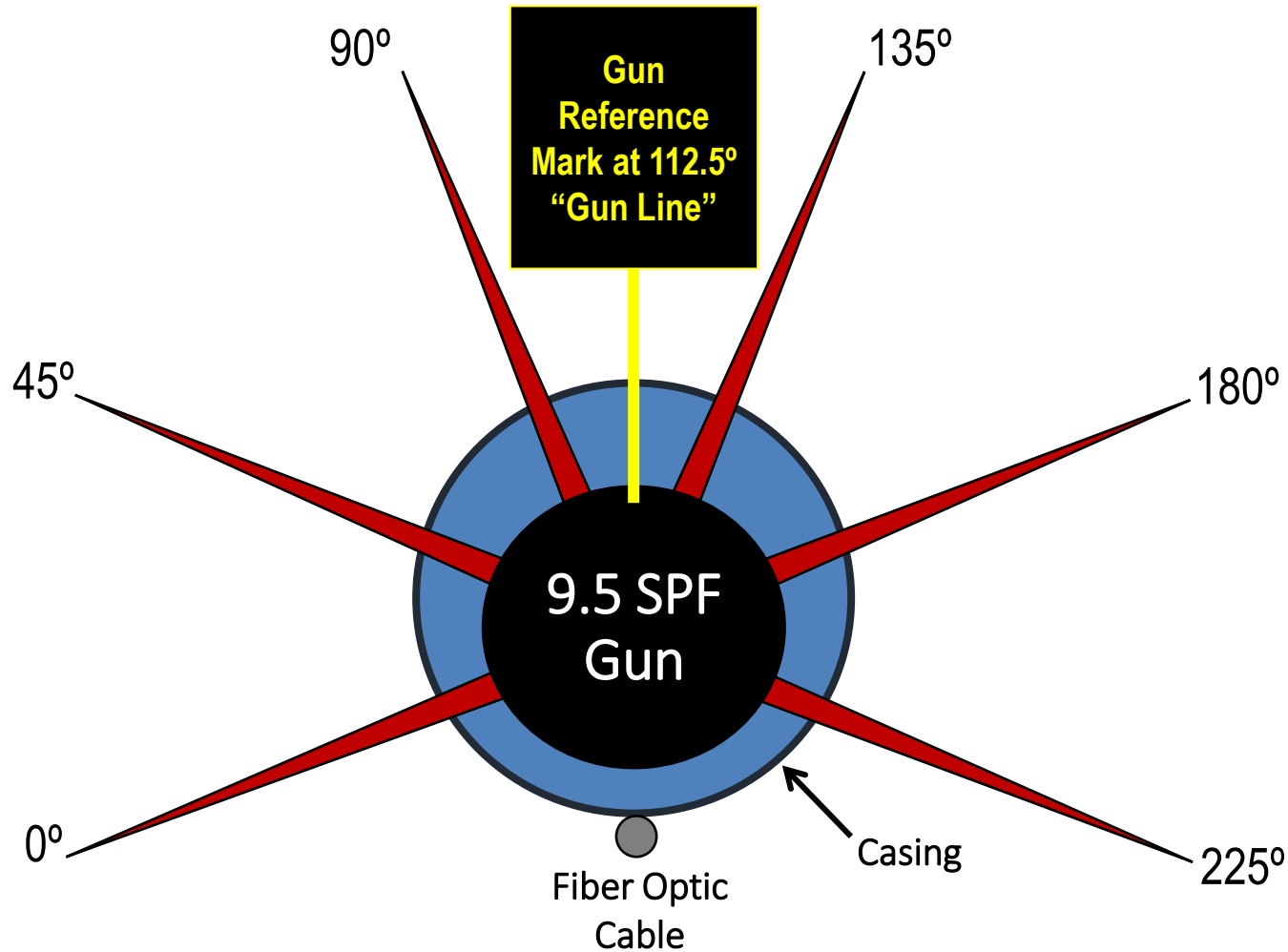
- Well-61 planned with short interval. Only 1x gun will be required.
- Fiber Optic Cable was confirmed to be straight.
- Maximum total offset error from cable/guns and CSLT is expected 30° max.



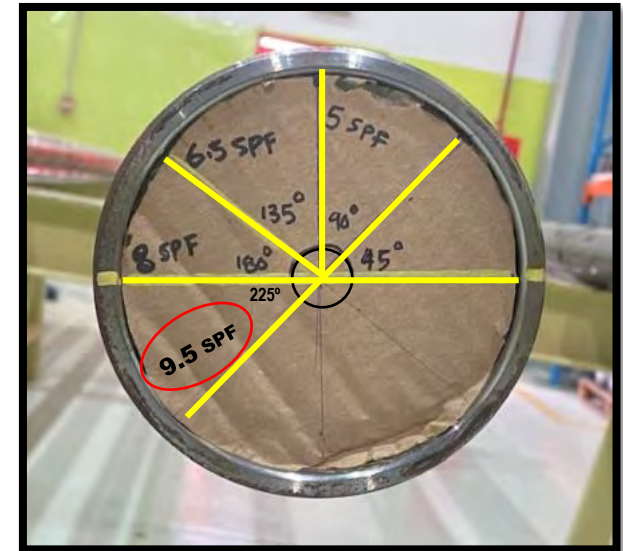
225° Gun Phasing for Oriented Perforation



9.5 SPF in one run **225° loaded** / **135° Blank**

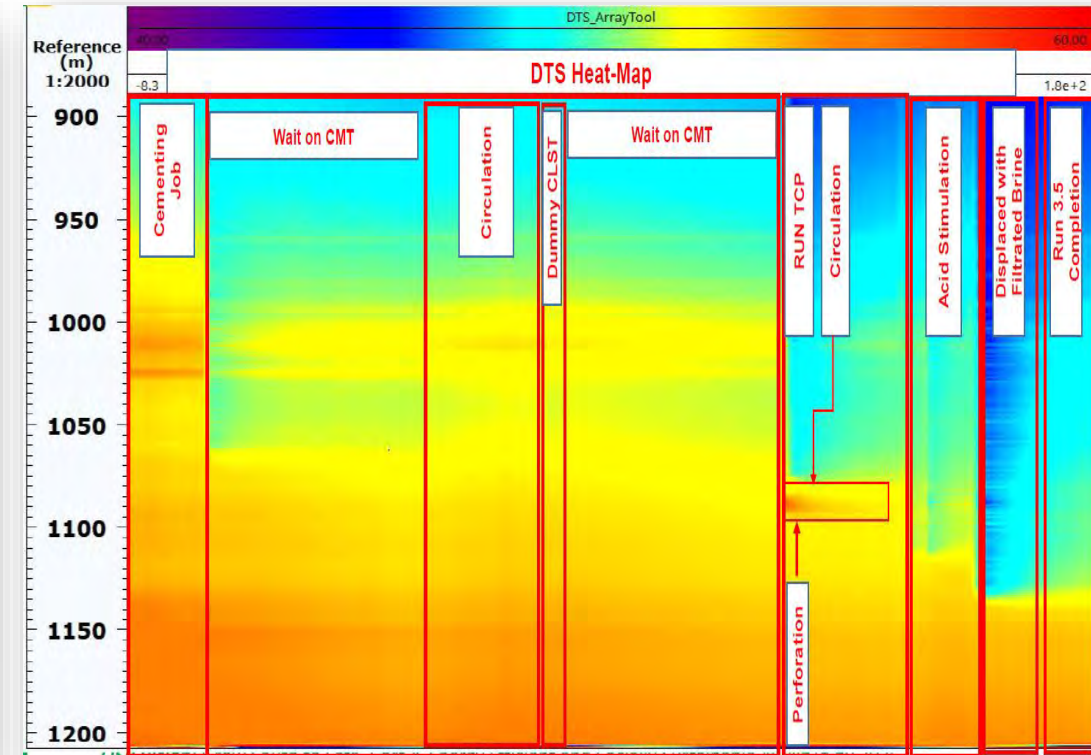
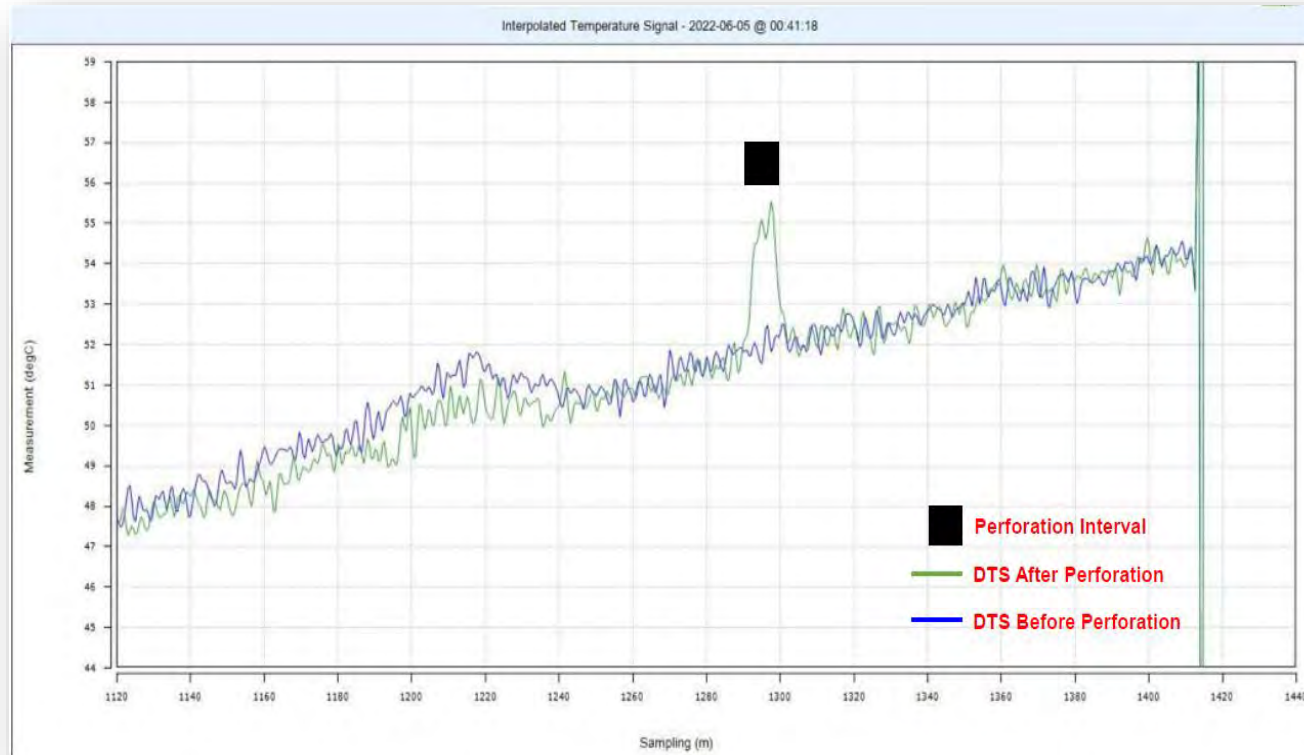


4 1/2" Gun, 12spf, 135°/45°



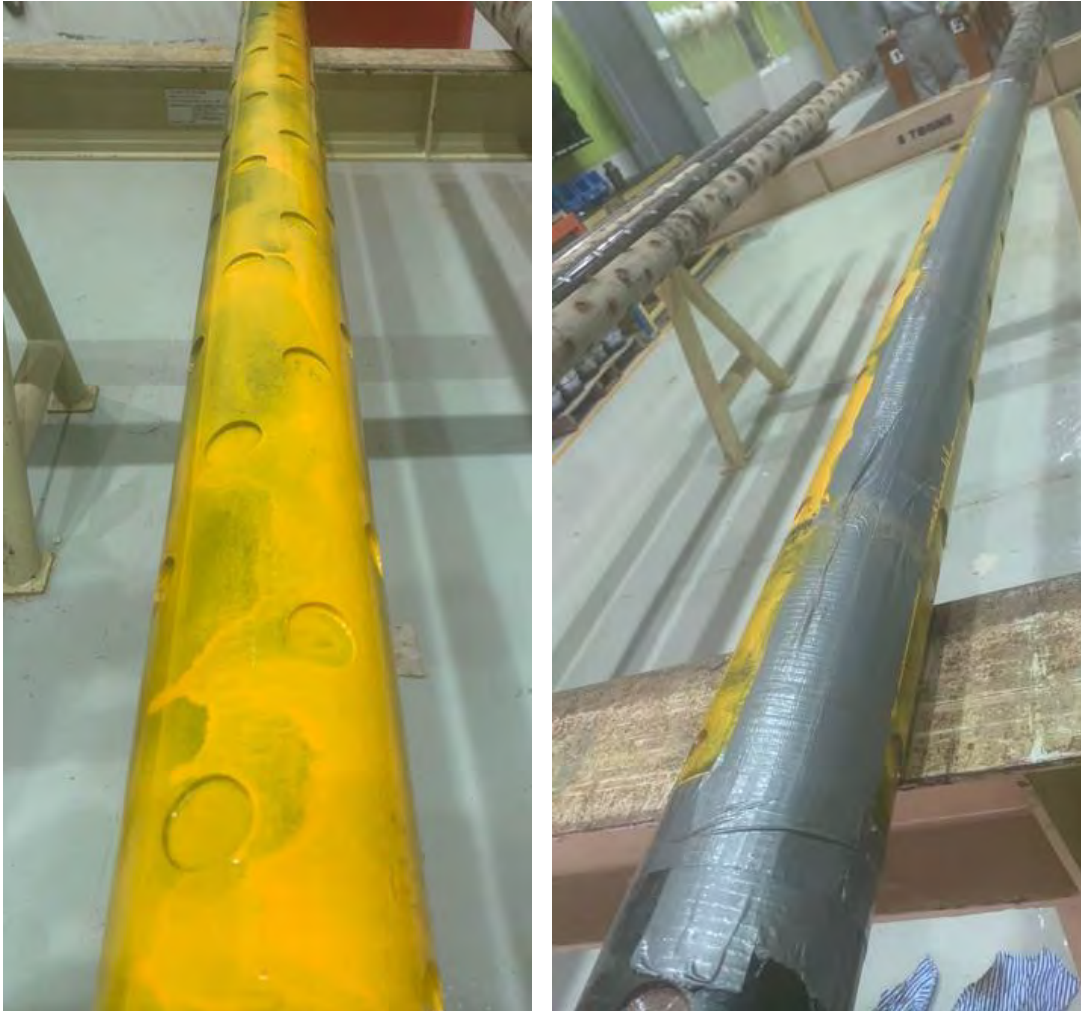
Perforation Job Results

- TCP guns was loaded with 9.5 SPF and reached 225° deg phasing for the first time globally.
- Guns were successfully fired and indication was observed from the fiber optic real-time data reading.



Gun Photos Before after Firing

Guns Loaded @ 9.5 SPF



Guns after POOH



- Exceptional Project Management for PDO's first full-ICV driven planning and execution of Fiber Optic Installation at Well-61.
- The accomplishment for the first time in the business as PDO is the first company to implement oriented perforation for fiber optic cable with 9.5 SPF and 225-degree angle.

“I would like to acknowledge PDO and the Ministry of Energy and Minerals to allow me to participate in this conference and share the great achievement the company did and will continue to do for Sultanate of Oman and the nation.”



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Q&A

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