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MENAPS 2022

MIDDLE EAST AND NORTH AFRICA PERFORATING SYMPOSIUM

PERFORATING SOLUTIONS FOR WELL INTEGRITY CHALLENGES DURING A WELL'S LIFE CYCLE

DynaEnergetics™ DynaSlot™

MENAPS-06-22 AUTHORS: S. Purcelean, L. McNelis

Summary

An Introduction to Well Integrity

- Definitions
- Statistics
- Cementing related well integrity challenges

Perforating Solutions

- Slotted shaped charges
- Specially engineered shaped charges for multiple casing strings applications.

Conclusion

Figure 1: Offshore drilling rig

An Introduction to Well Integrity

Definitions

- Well integrity according to NORSOK Standard D-010:

"Application of technical, operational and organizational solutions to reduce the risk of uncontrolled release of formation fluids throughout the life cycle of a well."

- Well barriers:

"Envelopes of one or several dependent well barrier elements preventing fluids or gases from flowing unintentionally from the formation, into another formation or to surface."

- Two well barriers philosophy:

A minimum of two independent well barrier envelopes, **primary barrier** and **secondary barrier**, are required during all well activities and operations,.

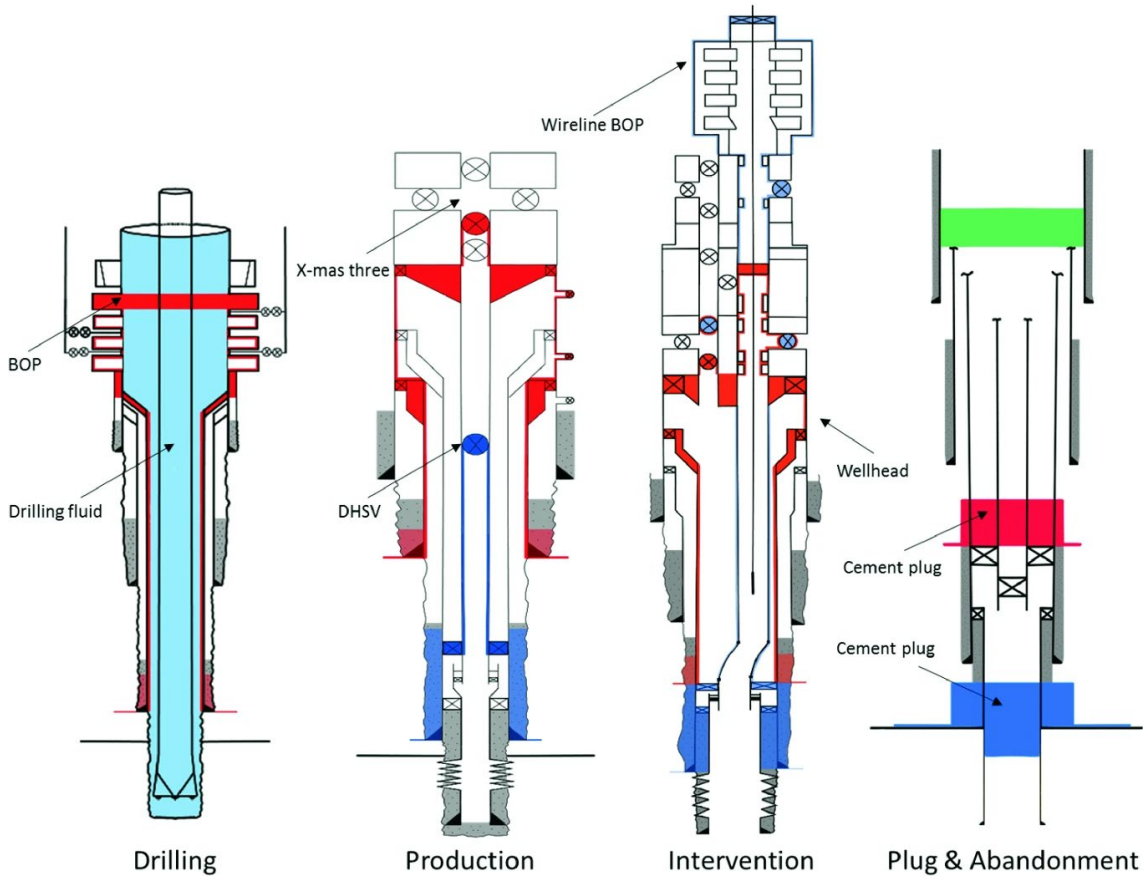

Figure 2: Two barrier concept throughout a well's lifecycle. Adapted from **Introduction to Permanent Plug and Abandonment of Wells** by Mahmoud Khalifeh and Arild Saasen, Springer Open, 28-Jan-2020

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- Severe examples of losing well integrity:

1977 - Ekofisk Bravo Blowout due to an incorrectly installed DHSV.
2010 – Deepwater Horizon explosion due to incomplete well barriers.

Figure 3: Platform supply vessels battle the blazing remnants of the Deepwater Horizon. Adapted from **US Coast Guard Media Archive**.

An Introduction to Well Integrity

Statistics

- Petroleum Safety Authority Norway Pilot Survey (2006)

A representative selection of 406 production and injection wells from 12 offshore facilities and 7 operating companies on the NCS.

18% of the wells had integrity failures, issues or uncertainties.

7% of the wells were shut in because of the well integrity issues.
8 wells had cement problems and another 8 wells had casing problems.

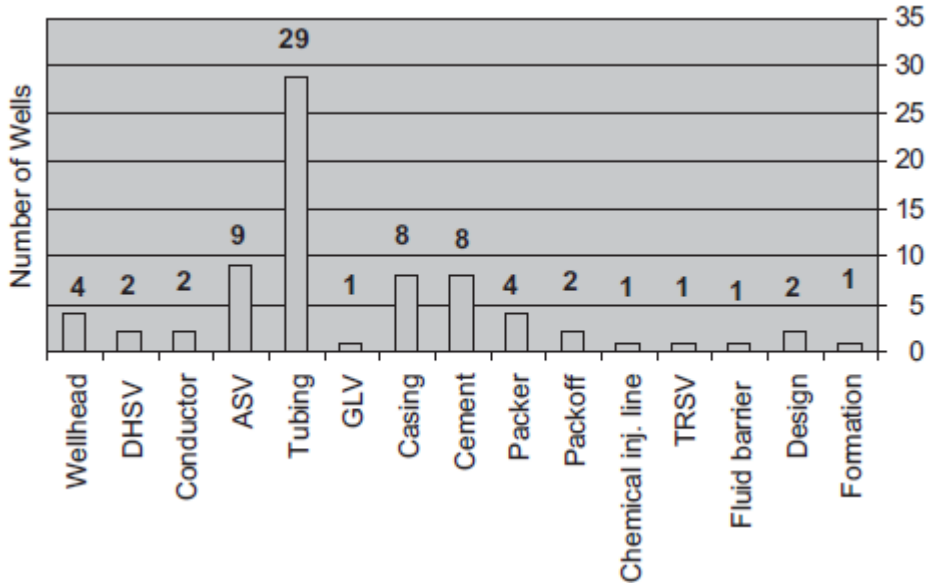

Figure 4: Category of barrier element failure, according to PSA survey. Adapted from SPE 112535.

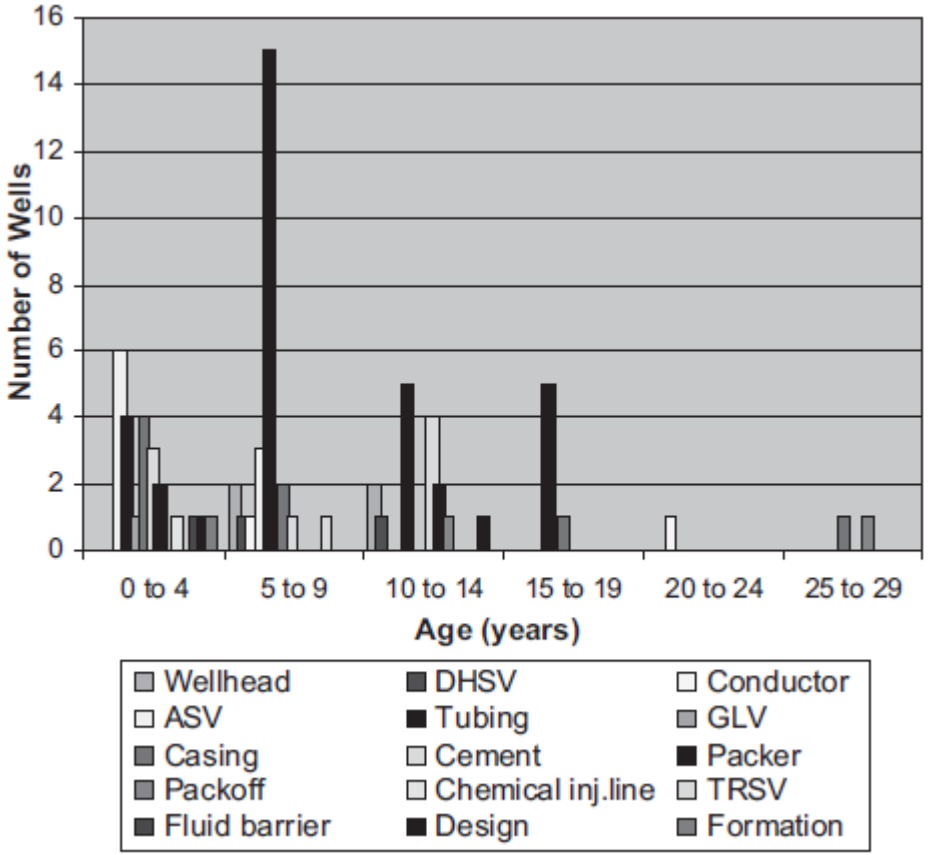

Figure 5: Age and category of barrier element failure, according to PSA survey. Adapted from SPE 112535.

An Introduction to Well Integrity

Cementing related well integrity challenges

- Importance of successful primary cement jobs

The cemented casings of a well are part of either primary, secondary or both primary and secondary well barries.

The cement seals the anulus, provides support for the casing, creates zonal insulation and protects the casing from outer corrosion.

Cement quality needs to be evaluated in order to confirm the integrity of the well barrier of which the cemented casing is part of.

- Importance of remedial cement jobs

Performed to re-establish the integrity of well barriers by repairing poor primary cement jobs, cementing sections above the previous top of cement or repair damaged casings.

The well's future depends on the success of the remedial cement job.

The success of the remedial cement job largely depends on the access the cement has to reach the damaged zone zone.

Remedial cement jobs can be performed throughout well's lifecycle, from the drilling phase to the final plug and abandonment of the well.

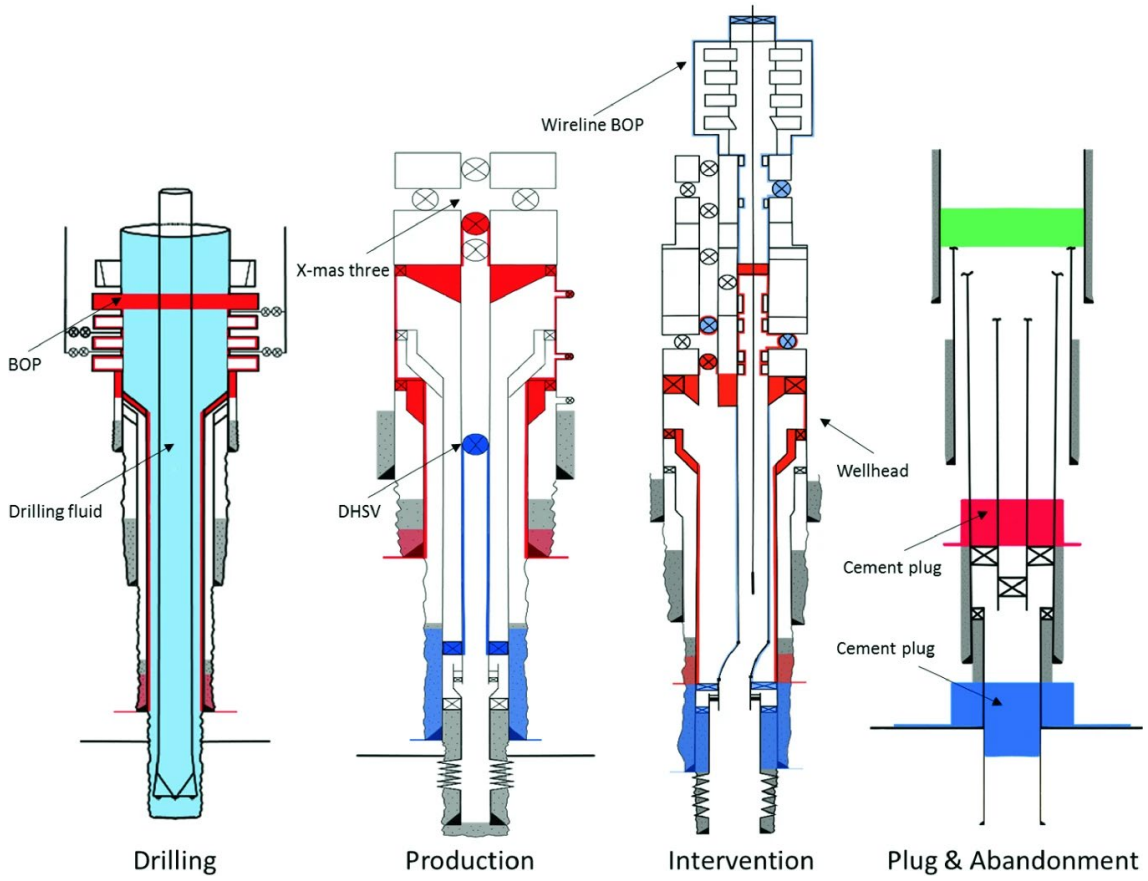

Figure 6: Two barrier concept throughout a well's lifecycle. Adapted from **Introduction to Permanent Plug and Abandonment of Wells** by Mahmoud Khalifeh and Arild Saasen, Springer Open, 28-Jan-2020

Perforating Solutions

Slotted shaped charges

- Design and applications

Unique rectangular design.

Very versatile tools when combined with the corresponding hardware.

Can be used for a range of well integrity related applications:

  - Can replace traditional squeeze guns for cement repair operations.
  - Can cut control lines and flatpacks outside downhole tubulars, for example, to remove fluid migration paths during P&A operations.
  - Can create ultra large areas open to flow (AOF) when used as circulation punchers.

- Available configurations

Currently offered in several hollow carrier gun systems.

Tailored shooting patterns and configurations that fit specific completions and applications, can be designed ad tested on demand

Figure 7: Slotted shaped charges, here in the 32g and 61g versions. Adapted from **www.DynaEnergetics.com**

Slotted shaped charges

- Cement repair operations

The slotted shaped charges are a highly compelling alternative to traditional guns when it comes to remedial cement operations.

The helical perforating pattern combined with the rectangular casing slots guarantee 360° access to the area behind the tubing or casing. All voids between the cement and casing and between cement and formation / next casing are intersected.

The rectangular slots can be produced in a way to optimize overlap.

The first casing is precisely perforated, leaving the exterior casing strings intact and undamaged.

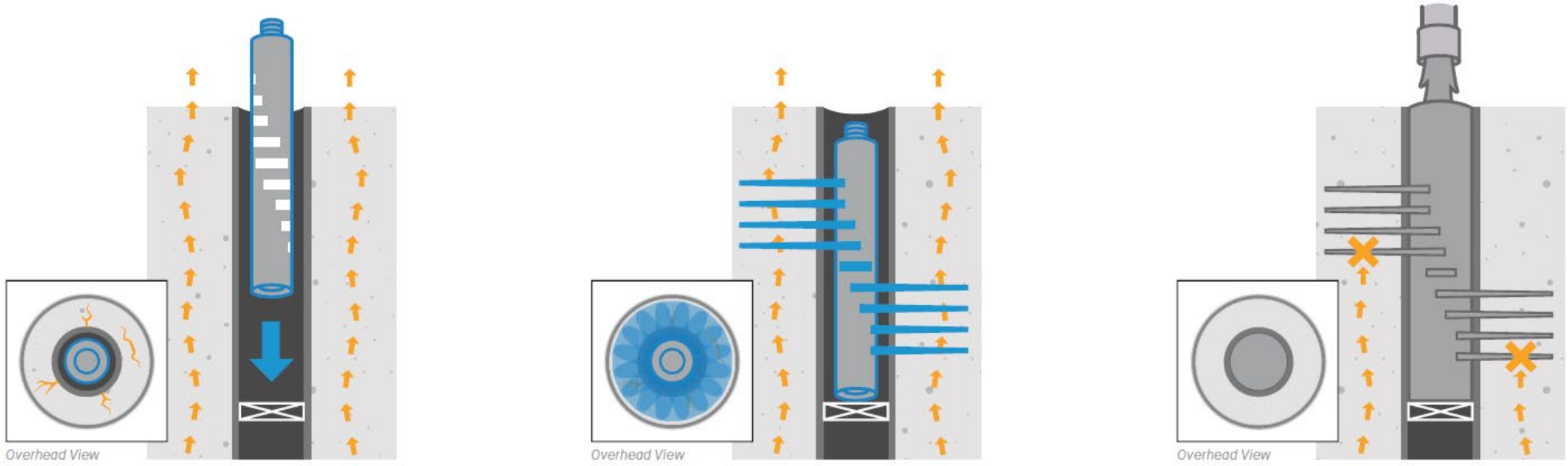

Figure 8: Slotted shaped charges, for remedial cement operations. Adapted from **www.DynaEnergetics.com**

Slotted shaped charges

- Cement repair operations

Reduction in workover costs, as there is no need to reperforate a second or third time, as with traditional squeeze guns.

Substantially less time consuming also when compared to other 360° access methods such as section milling or abrasive slot cutting.

Minimizes hardware removal from the well, reducing onshore waste handling requirements and eliminates the risk of personnel exposure to contaminants, such as NORM.

Suitable for complex perf-wash-cement operations as illustrated in a soon to be released SPE paper.

Figure 9: Slotted perforating systems, for remedial cement operations. Adapted from **www.DynaEnergetics.com**

Slotted shaped charges

- Control lines and flatpacks ablation

Slotted shaped charges already successfully cut control lines both in laboratory and downhole.

A considerable number of tests, using different tubing sizes, weights, steel grades and different control lines and flatpacks.

As each completion combination is unique, several testing methods were developed to confirm the shaped charge performance and cutting capabilities:

- Coupon testing:
  - Single shot at atmospheric conditions
  - Offers a reliable indication of the gun system performance

Figure 10: Coupon test setup, for cutting capabilities confirmation.
Adapted from **DynaEnergetics** media library.

Perforating Solutions

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- Coupon testing:
  - Single shot at atmospheric conditions
  - Offers a reliable indication of the gun system performance
- Pressure vessel testing testing:
  - Single shot at downhole temperature and pressure

Figure 11: Pressure vessel test setup, for cutting capabilities confirmation. Adapted from **DynaEnergetics** media library.

Perforating Solutions

Slotted shaped charges

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As each completion combination is unique, several testing methods were developed to confirm the shaped charge performance and cutting capabilities:

- Coupon testing:
  - Single shot at atmospheric conditions
  - Offers a reliable indication of the gun system performance
- Pressure vessel testing testing:
  - Single shot at downhole temperature and pressure
- Gun testing:
  - Multishot testing at atmospheric conditions

Figure 12: Gun test setup, for cutting capabilities confirmation.
Adapted from **DynaEnergetics** media library.

Slotted shaped charges

- Slotted shaped charges as circulation punchers

Ultra large areas open to flow are created in the tubing when using slotted charges.

Tubing size	Average slot dimensions (in x in)	AOF (in^2)
4-1/2 in	0.26 x 1.24	0.32
5-1/2 in	0.30 x 1.45	0.44
7 in	0.40 x 1.75	0.70
9-5/8 in	0.32 x 1.6	0.51

Very reliable in in heavy and high-grade tubulars.

No damage to the outer casing.

Figure 13: Slot opened in a 4-1/2 inch tubing.
Adapted from **DynaEnergetics** media library.

Specially engineered shaped charges for multiple casing applications

- Limited entry shaped charges

Specially engineered shaped charges for cement sealing operations in multiple casing completions, where the exterior casings shall not be damaged.

Offering large and consistent entry holes across entire tubular circumference, for optimum cement placement.

Limited damage to the outer casing strings, independent of their position.

Recommended for complex perf-wash-cement operations.

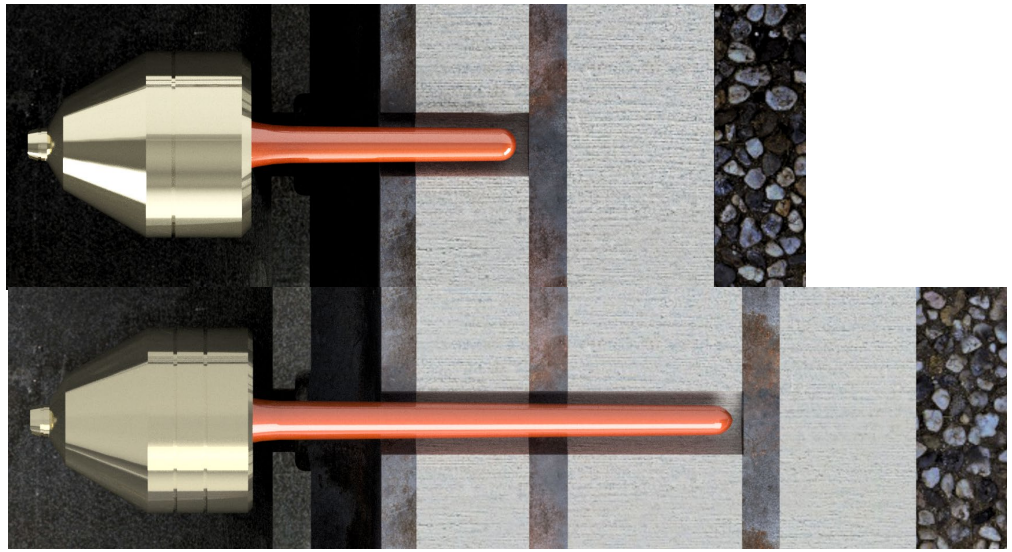

Figure 14: Limited entry shaped charges illustration. Adapted from **DynaEnergetics** media library.

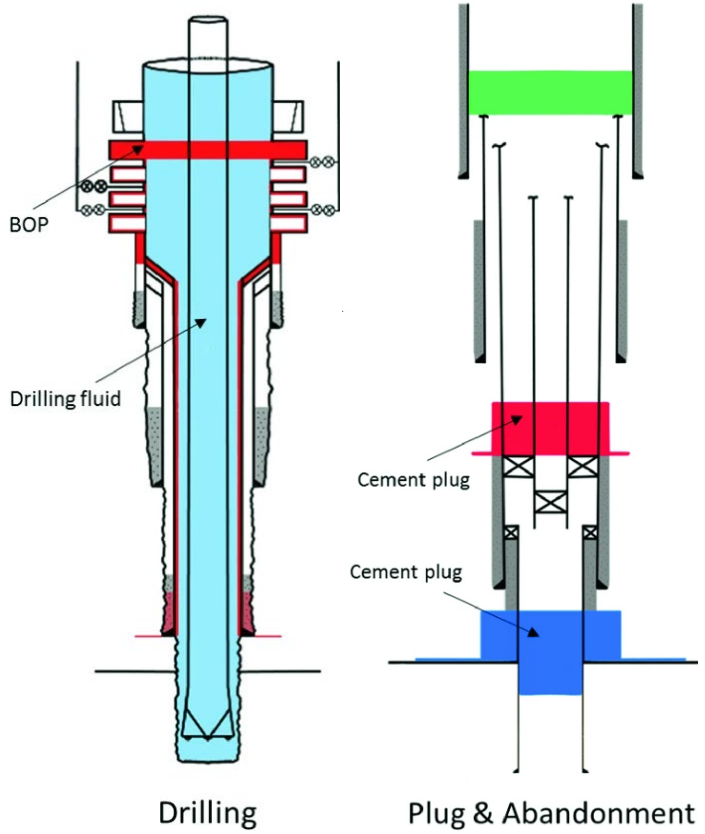

Figure 15: Slot opened in a 4-1/2 inch tubing. Adapted from **Introduction to Permanent Plug and Abandonment of Wells** by Mahmoud Khalifeh and Arild Saasen, Springer Open, 28-Jan-2020

Perforating Solutions

Specially engineered shaped charges for multiple casing applications

- Multiple casing, formation reaching, shaped charges

Specially engineered shaped charges offer access to the most outer annulus and to the neighboring formation, in multiple casing completions.

Cylindrically jet which creates large and nearly constant entry holes through multiple casing strings.

Recommended for complex perf-wash-cement operations.

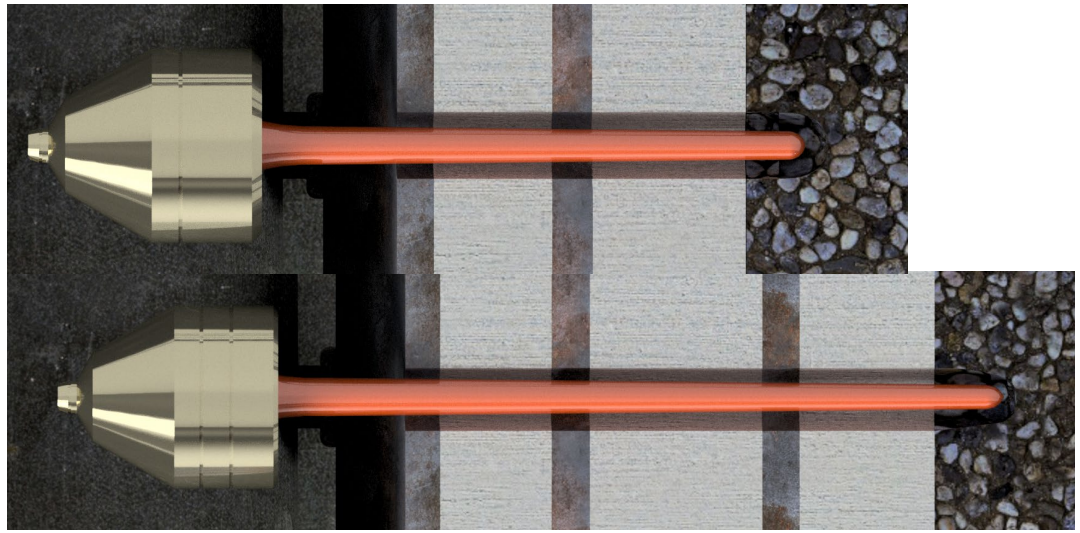

Figure 16: Multiple casing, formation reaching, shaped charges illustration.
Adapted from **DynaEnergetics** media library.

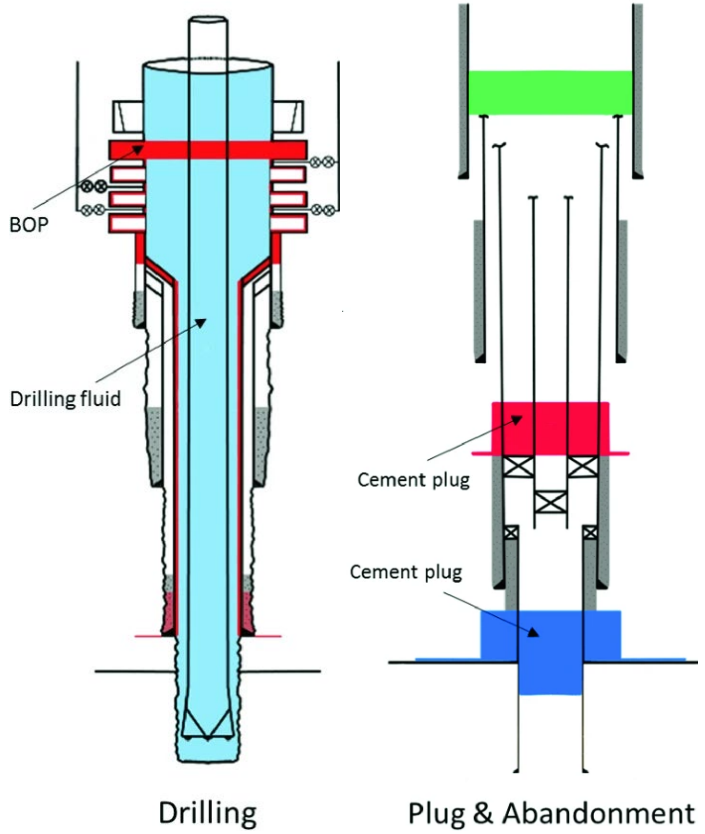

Figure 17: Slot opened in a 4-1/2 inch tubing. Adapted from **Introduction to Permanent Plug and Abandonment of Wells** by Mahmoud Khalifeh and Arild Saasen, Springer Open, 28-Jan-2020.

Conclusion

- Compromised well integrity may often result in serious accidents, if not identified and remediated in a timely manner.
- The cemented casings are important well barriers and poorly performed primary cement jobs will impact the effectiveness of the barrier.
- Perforating solutions can assure access to the poorly cemented annulus and allow for a successful repair job to be performed.
- Both the slotted shaped charges and the multiple casing entry shaped charges allow the user to perform successful repair jobs in very complex completions.

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Q&A

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