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# SPE 212530.
# Safe, Robust and Efficient Through Tubing Abandonment.

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# Contents

# Introduction

Through Tubing Abandonment (TTA)

| ***Positives*** | ***Negatives*** |
|---|---|
| **+ Robust and safe abandonment demonstrated in the field** | **- Proper candidate selection necessary** |
| **+ Efficiency better than conventional abandonment** | **Not all wells suited for TTA** |
| **Lighter equipment** | |
| **Less time** | |
| **+ Lower HSSE exposure** | |
| **Less waste, lower emissions** | |
| **Less personnel exposure** | |

***TTA scope is widening:***

- Experience / field history
- Knowledge increase about cementing & handling of challenging downhole conditions (e.g. gauge cables)
- Novel technologies emerging to mitigate cement placement issues

## Selection Criteria

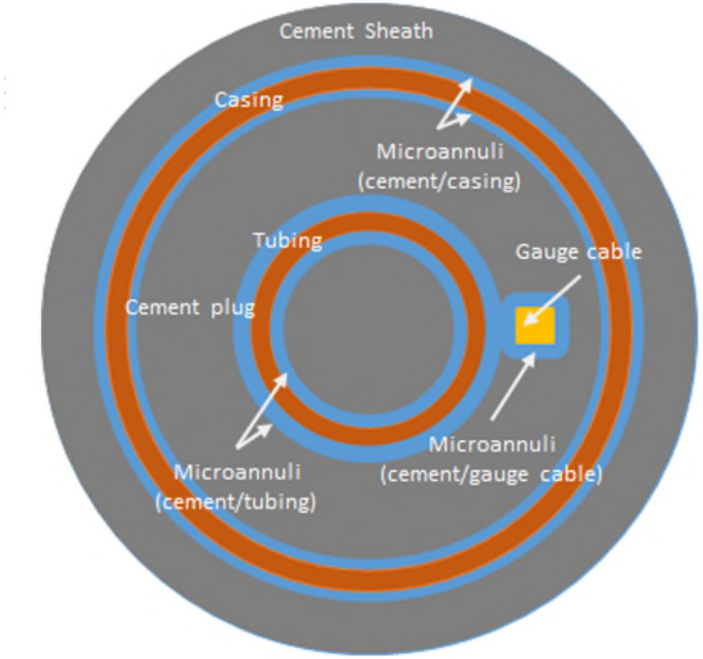
- TTA candidate requirements:
  - Proper cement outside casing at isolation depth; No sustained casing pressure (source below isolation depth)
  - Tubing access sufficiently unobstructed
  - Tubing integrity sufficient to be used as cement placement conduit

- Furthermore, risk assessment (ALARP) necessary including:
  - Suitability of the site
  - Suitability of sub-surface
  - Jewellery/items/conditions present that can impact TTA cementation or longevity (e.g. control lines, cables, valves, scale, coating)?

# Risk Assessment

After selection of a TTA candidate well, a risk assessment to confirm that cement isolation provides sufficient (ALARP) isolation of all zones with flow potential is carried-out.

- Leak path assessment (determine likelyhood of seepage through e.g. packer, casing cement, deep set plug, A-annulus cement etc.) (1)
- Quantitative risk based modelling. A P&A system model is configured using experimental or field data to evaluate seepage potential.




| | Average leak rate @ 3000 yr (Mscf/d) | | |
|---|---|---|---|
| Well | TT 2000ft no GC | TT 3000ft GC (0-2% degradation) | Conventional 1000ft plug |
| Well 2 | 3.80 | 3.89 | 3.74 |

Figure from Proud and Sefat, 2022. *Risk-based design of through-tubing P&A in wells with gauge cable*

(1) See for example: Thom et al., 2020. *Case Study for Rig-Less Subsea Well Abandonment.*

## Cement Placement (1)

- Stable cement interface needed.
- Beneficial for stable interface:
  - Density contrast cement/displaced liquid
  - Vibration
  - Stand-off (near coupling upsets)
- Cement placement optimization modelling advised

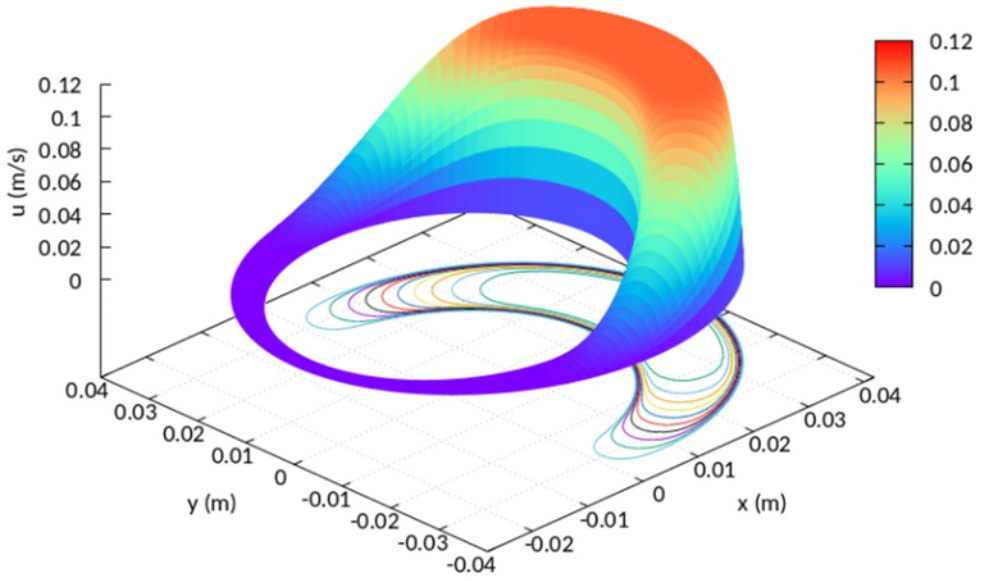



Figure from Skadsem et. al., 2022. *Vibration-assisted annular fluid displacement for rig-less well abandonment operations*

# Cement Placement (2), Fluid-Fluid Displacement, Front Extension

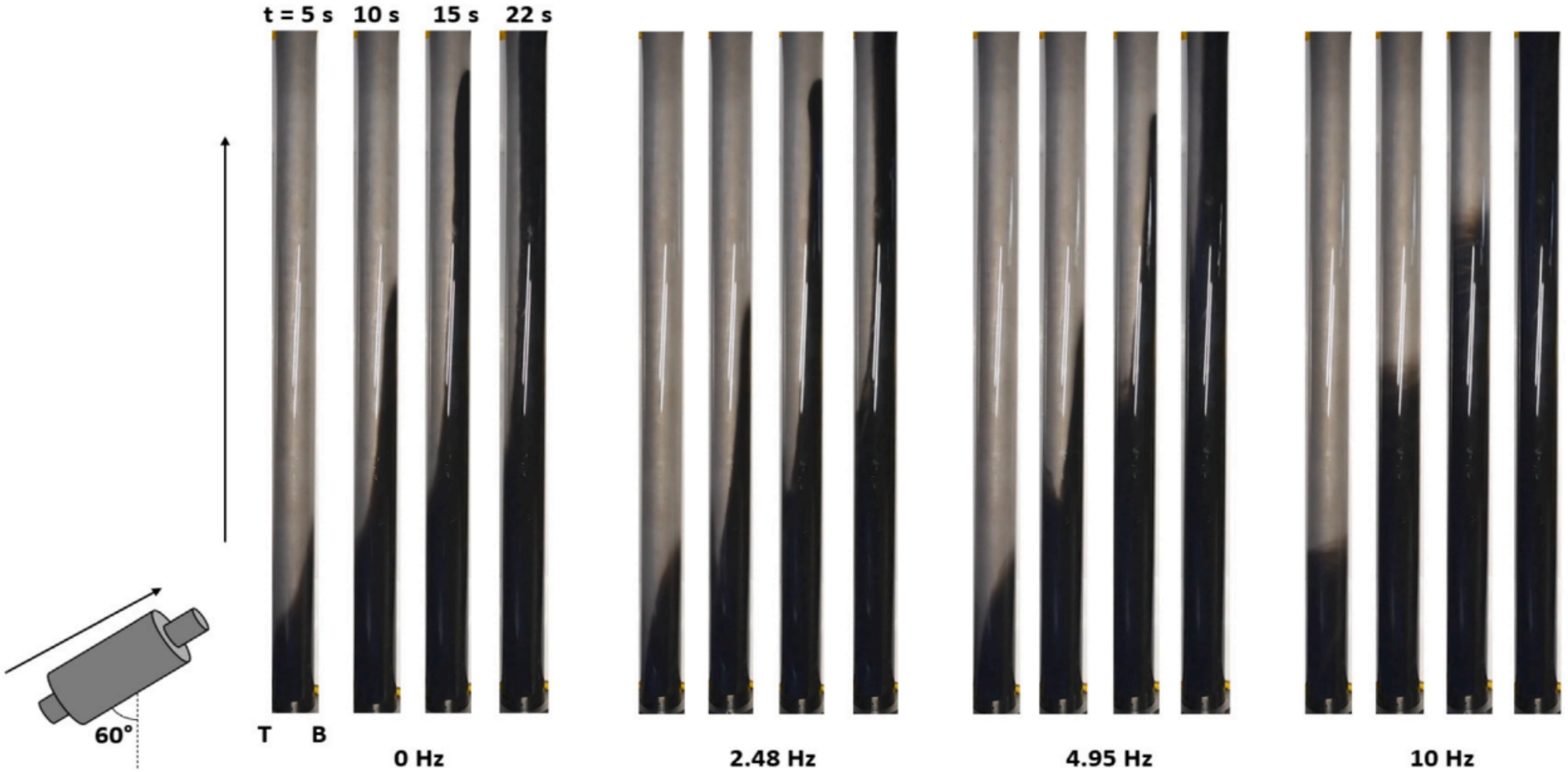



Figure from Skadsem et. al., 2022. *Vibration-assisted annular fluid displacement for rig-less well abandonment operations*

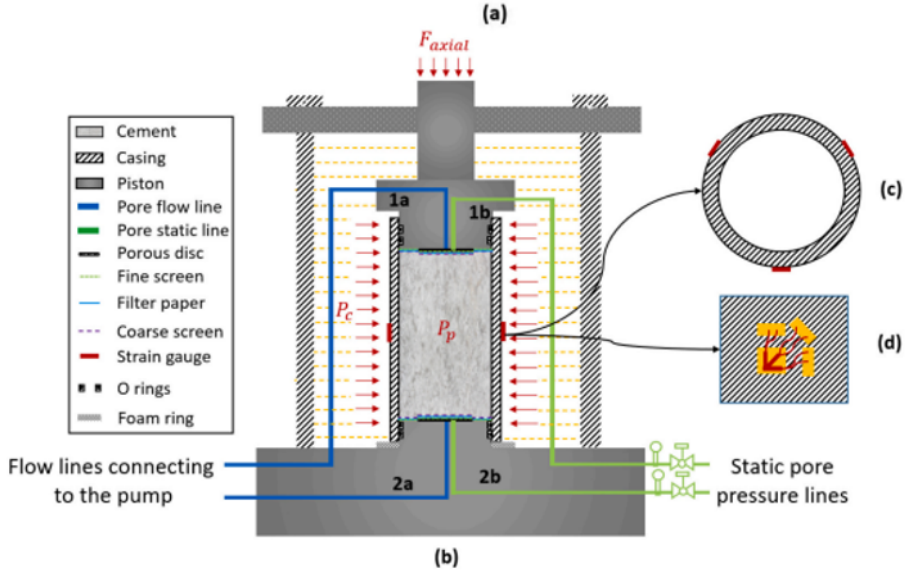
## Cement Placement (3)

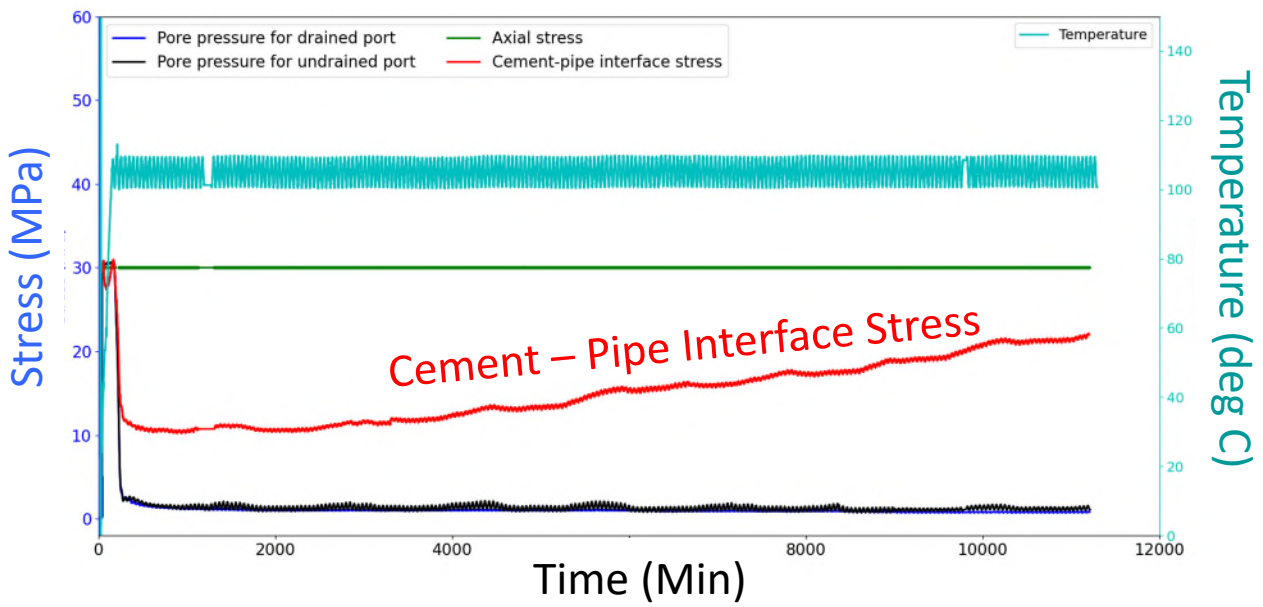
- Avoid
  - Slumping / flipping (e.g. no large fluid pockets below circulation point, optimize rheology)
  - Mixing of cement & liquids during circulation (e.g. use darts, balls, spacers, non return valves)

- To confirm:
  - Cables or lines do not impair cement placement
  - Tubing integrity sufficient to ensure adequate flow to planned isolation depth
  - Gas lift valves or other jewellery do not create undesired flow paths
  - Internal tubing coating: coating suited to remain part of the isolation (longevity verified)
  - Scale presence ALARP
  - No sustained gas flow. Must be remedied before cementing

# Expanding /Non-Shrinking Cement

- Effective to prevent formation of micro annuli due to shrinking of setting cement. Interface stress improves sealability. Proven by test results.
- Working principle:
  - Expanding additives (e.g. MgO) are added to cement mixture. MgO binds with water and expands.
  - Important that the majority of MgO expansion occurs after cement sets and consequently expands the cement matrix.
  - MgO is produced in different varieties. Slow swelling (hard burned) MgO is required, quality control necessary.



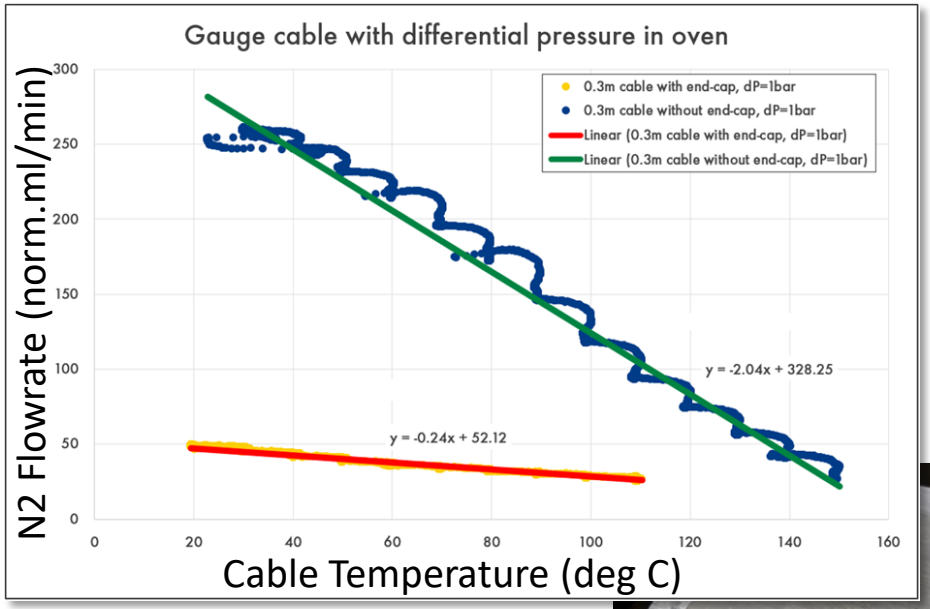
# Gauge Cables

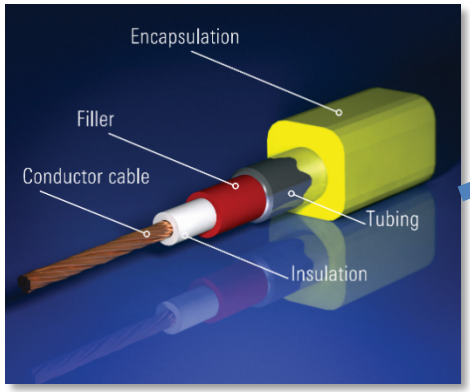
Many different cables in use; behaviour varies.

Cable can be accepted within the cement plug if:

1. **Material longevity sufficient** (see also OEUK guidelines). Longevity usually depends on downhole temperature.
2. **Sealing ability of the cable confirmed**
   - Internals of cable may exhibit seepage between layers depending on type and temperature. Usually less at higher temperatures due to larger thermal expansion of polymers
   - Is cable present over entire isolation length or is there a cement section without cable.
3. **Sealing ability of cement plug with versus without cable similar**
   - Cement exotherm causes thermal expansion of materials. After cooling down a micro annulus between cement and cable can be the result. This can be mitigated by expanding cement and reduction of exotherm (e.g. slower cement)

**Gauge cable sealing temperature response**




## Logging / cement verification

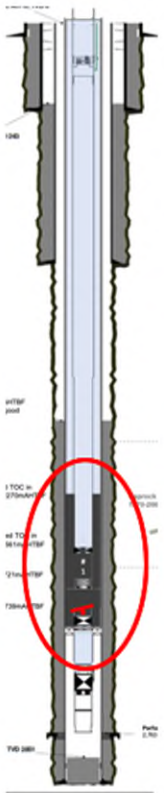
# Verification techniques

| | Overdisplaced Cement Plug | Balanced Cement Plug |
|---|---|---|
| Tagging cement top inside tubing | + | + |
| Logging A-annulus | + | - |
| Perforate & test A-annulus | + | - |
| Cement circulation checklist | + | + |

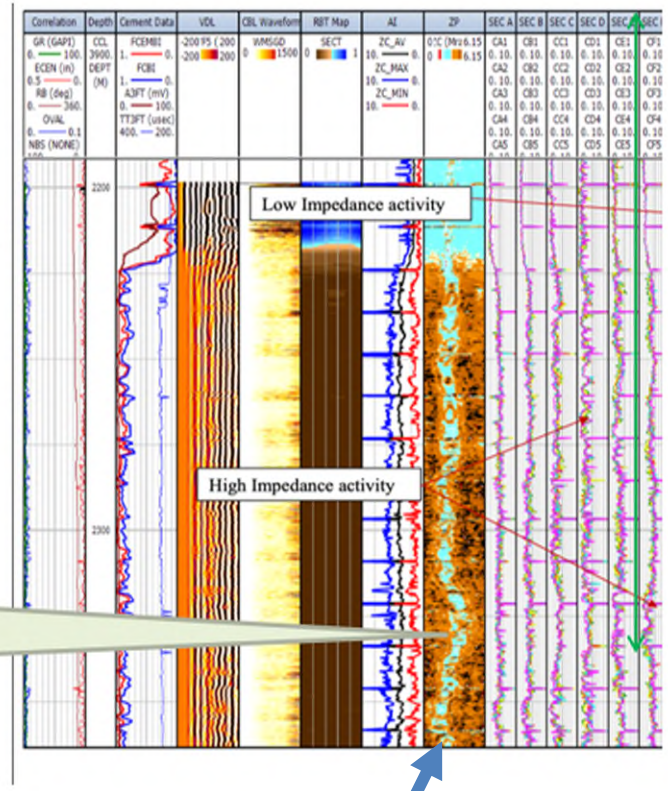
**+ = possible, - = not possible**

## Acoustic logging of A-annulus (over-displaced cement)

Measurement in narrow gap sometimes obscured by artifacts (galaxy patterns)



- Good bonding all around the pipe
- Presence of an artifact channel-like feature due to thin cement of less than 0.75" (19 mm), below which the log tool cannot properly measure cement impedance.



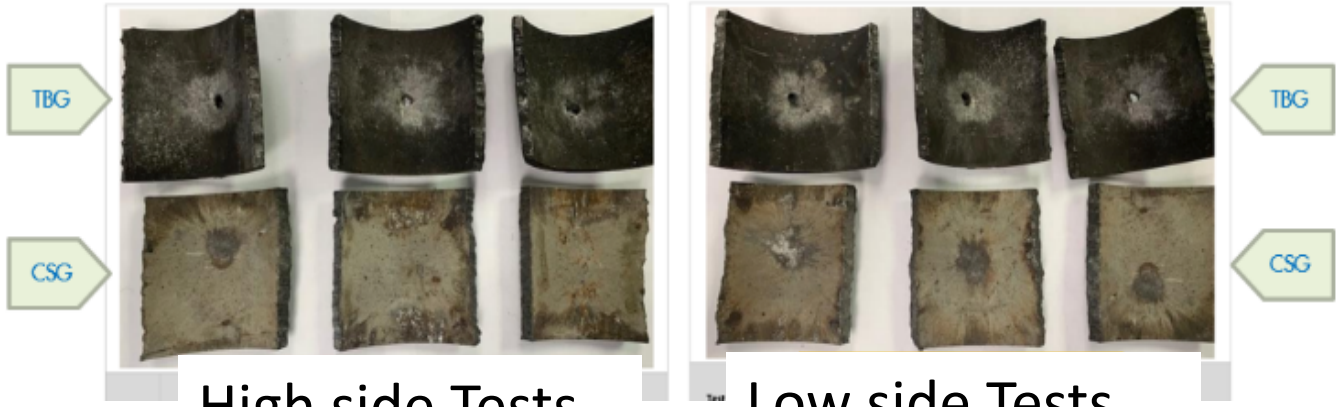

Observed in the field

Verified by full scale rig test
6 5/8" x 10 ¾"

## Punch and Test

‘Punch and Test’ has been applied successfully in the field

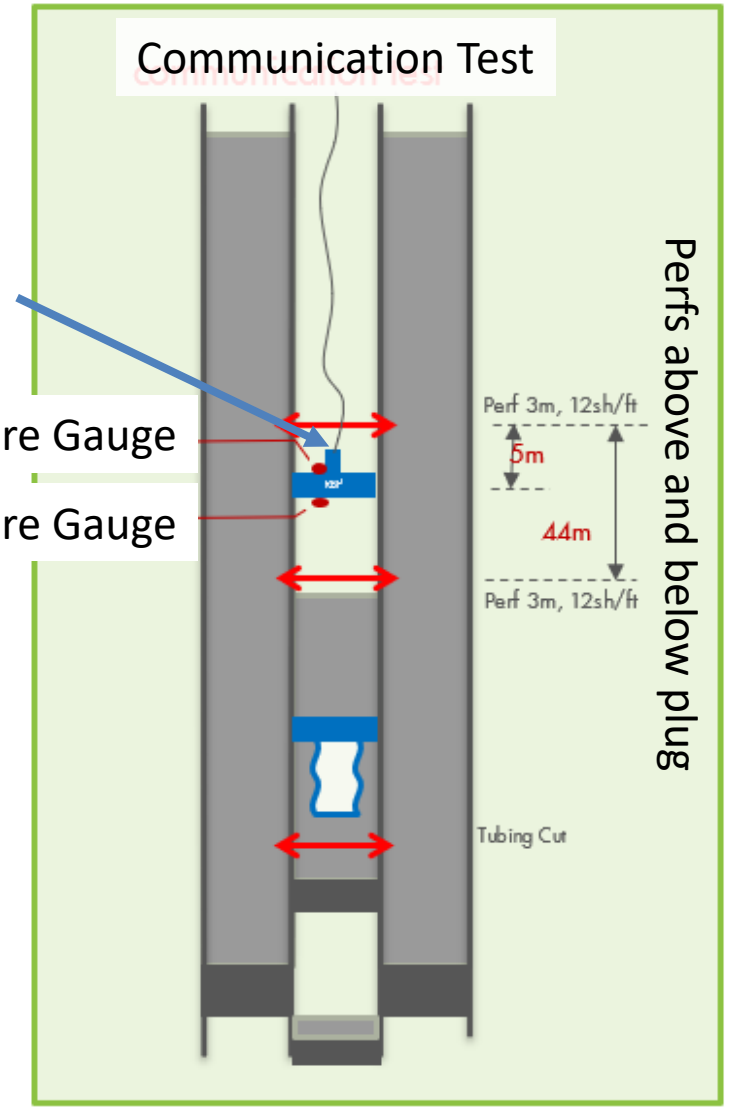
- **Gun testing necessary to avoid casing damage**




High side Tests

Low side Tests

Punch Tool



# Verification checklist

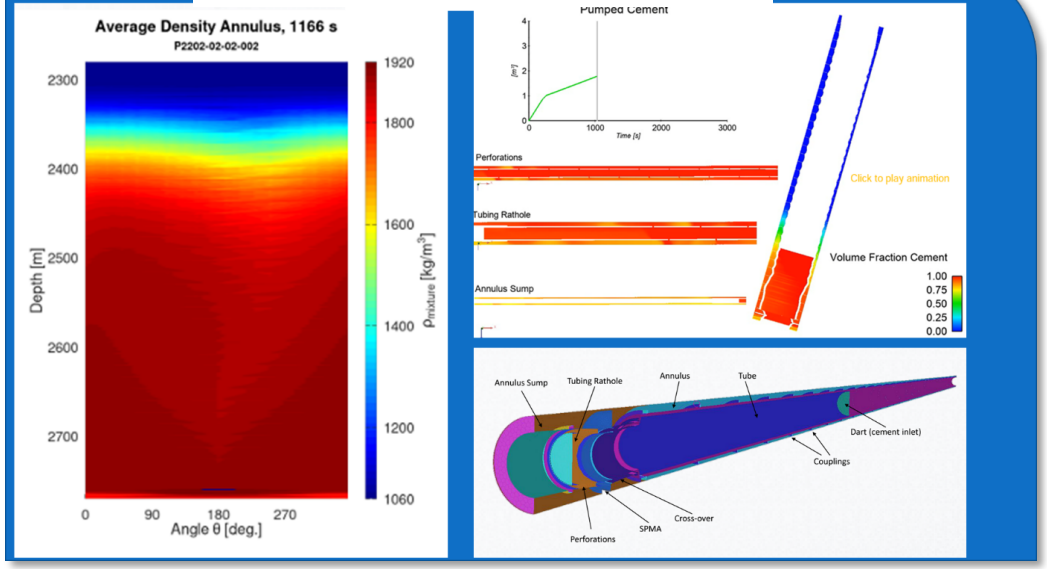
Confidence in the cement job can be obtained by a checklist incl. performance criteria.

Checklists can be tailored to specific field conditions.

**A checklist can include for example:**

- **Cement recipe** verified
- Lab tests **verified cement properties** / composition
- **Well integrity** prior to circulation confirmed by measurements
- **Displacement fluids** correct, verified by field lab tests
- **Cement placement modelling** done and satisfactory, operational measurements aligned
- **Fluid volumes** pumped and returned as designed / targeted
- No negative **unplanned observations** during circulation

Example CFD Results



# Conclusions

- Through Tubing Abandonment is a safe, robust and efficient manner to abandon wells with lower environmental impact when candidate selection, job design and execution are done correctly.

- Existing and novel technologies assist in increasing the TTA scope and reliability
  - Cementing of eccentric annuli possible, when properly designed
  - Non shrinking / expanding cement can prevent micro annulus formation
  - Gauge cables can be accepted as ALARP depending on results of longevity and sealing tests on the cable type
  - Several verification methods have been presented to assess A-annulus cement quality
  - The paper describes a number of field cases executed onshore and offshore in Europe

# THANK YOU & QUESTIONS

## ACKNOWLEDGEMENTS

The authors would like to thank all who contributed and supported this joint-industry collaboration to advance the safe and robust implementation of through-tubing abandonment, a key tool in reducing the industry's well decommissioning liabilities and environmental footprint