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# The Qualification and Verification of Thermite as an Alternative Plug and Abandonment Technology

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June 2019

# Introduction

The aim of my thesis:

- To progress the qualification and verification process of thermite barriers
    - Interwell P&A
    - The Oil and Gas Technology Centre (OGTC)

- The approach taken was:
    - Canvas industry expert opinion on forming an effective barrier
    - ‘Qualification and Verification’ workshop - root cause failure modes
    - Mitigation strategy to maximise the probability of success

# Background

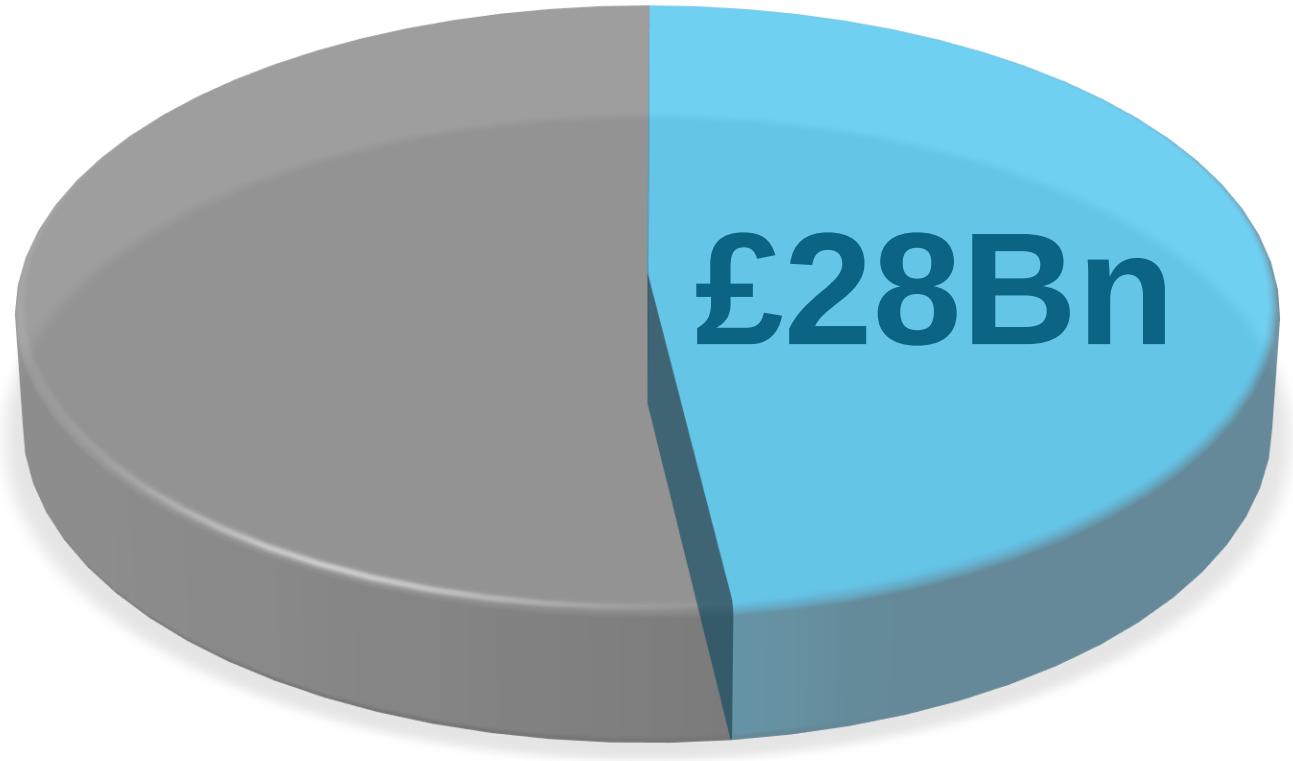
UKCS Decom spend = £58 billion

Well P&A = 48% of forecast Decom expenditure

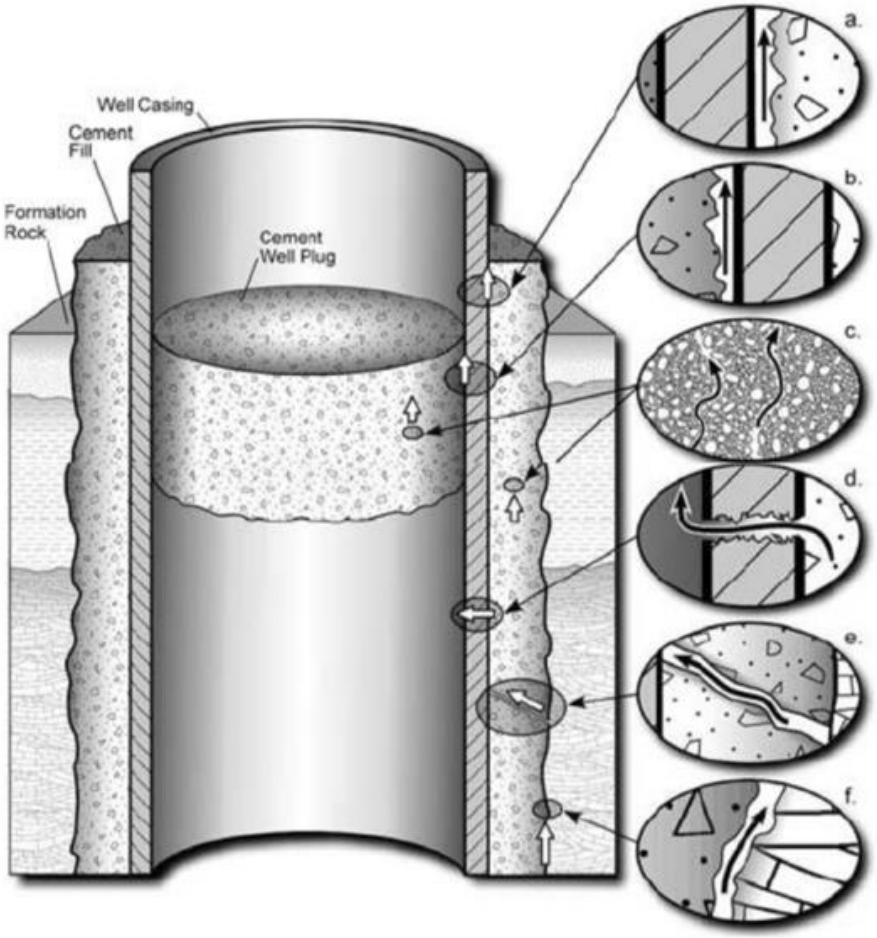
£28 billion P&A

Oil & Gas Authority is seeking a 35% cost reduction

**Well P&A 48% of Decom Cost**



# Traditional P&A Techniques are Problematic




Current industry standard is cement

- Not impermeable
- Prone to shrinkage
- Progressive deterioration

- Rig-Based Operations
- Time consuming and expensive technique

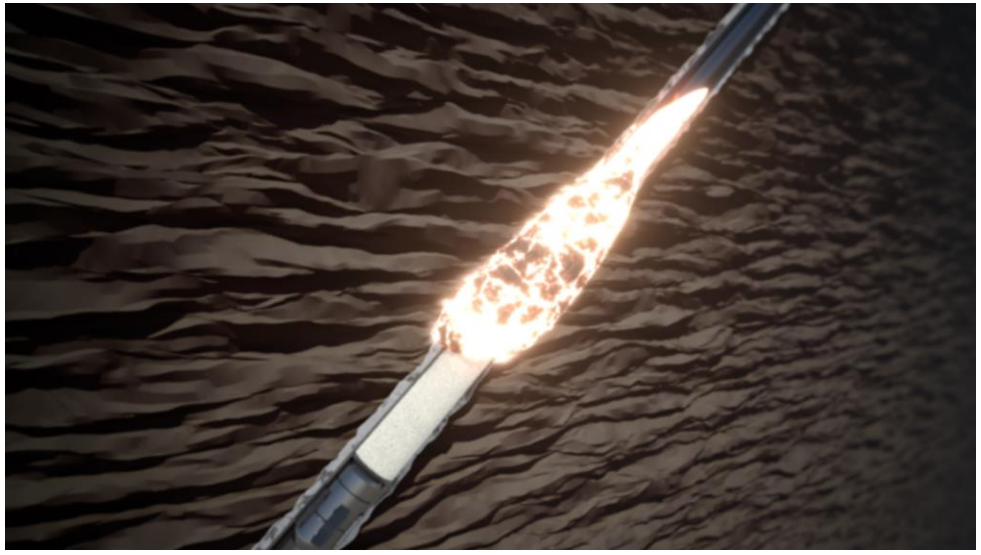
  - Pulling casing
  - Section milling
  - Cement squeeze

RIG-LESS P&A TECHNNOLOGY IS THE ANSWER

# Thermite P&A Technology - A Rig-less Technology using Wireline

- $Fe_2O_3 + 2\,Al \rightarrow 2\,Fe + Al_2O_3 + 2Fe$ + INTENSE HEAT (approx. 2500°C)

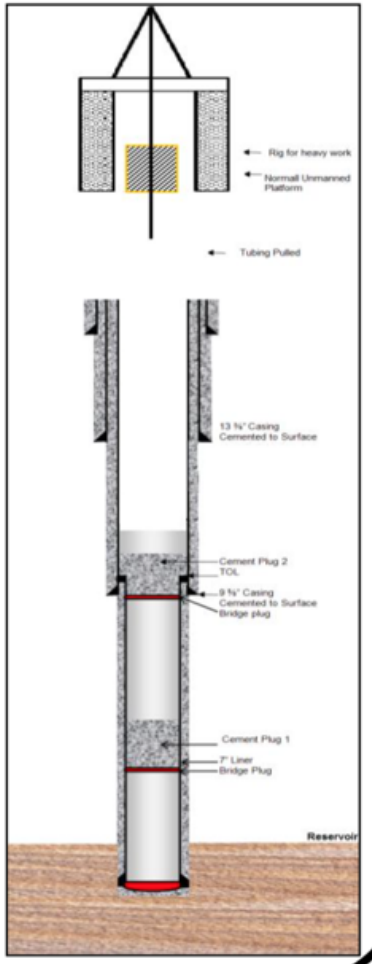
- Non explosive exothermic reaction
- This heat creates molten magma
- The magma solidifies against the formation
- The cooled magma aims to re-establish the cap rock



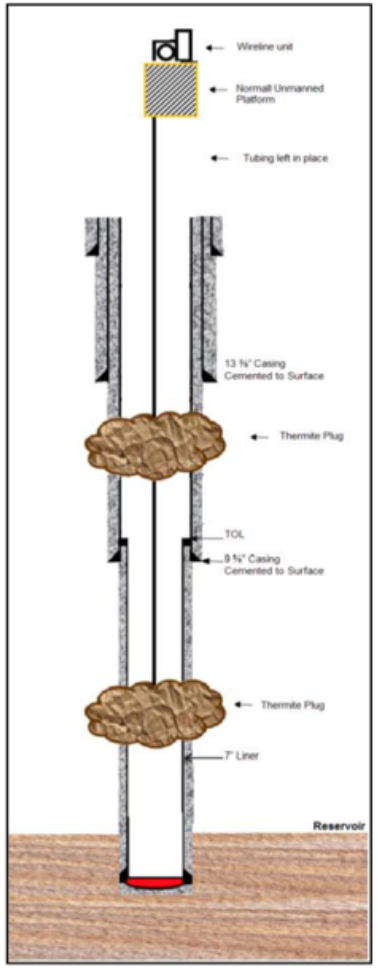
# An Industry Game Changer?

## Conventional P&A (Cement)

- Cement plugs placed with rig
- Tried and tested technique
- Access to annuli to re-establish integrity
- Expensive and time consuming




## Thermite P&A




- Wireline deployed with no rig
- Recreate the cap rock
- Melt the well components and adjacent formation
- Quick, easy, cheap and effective

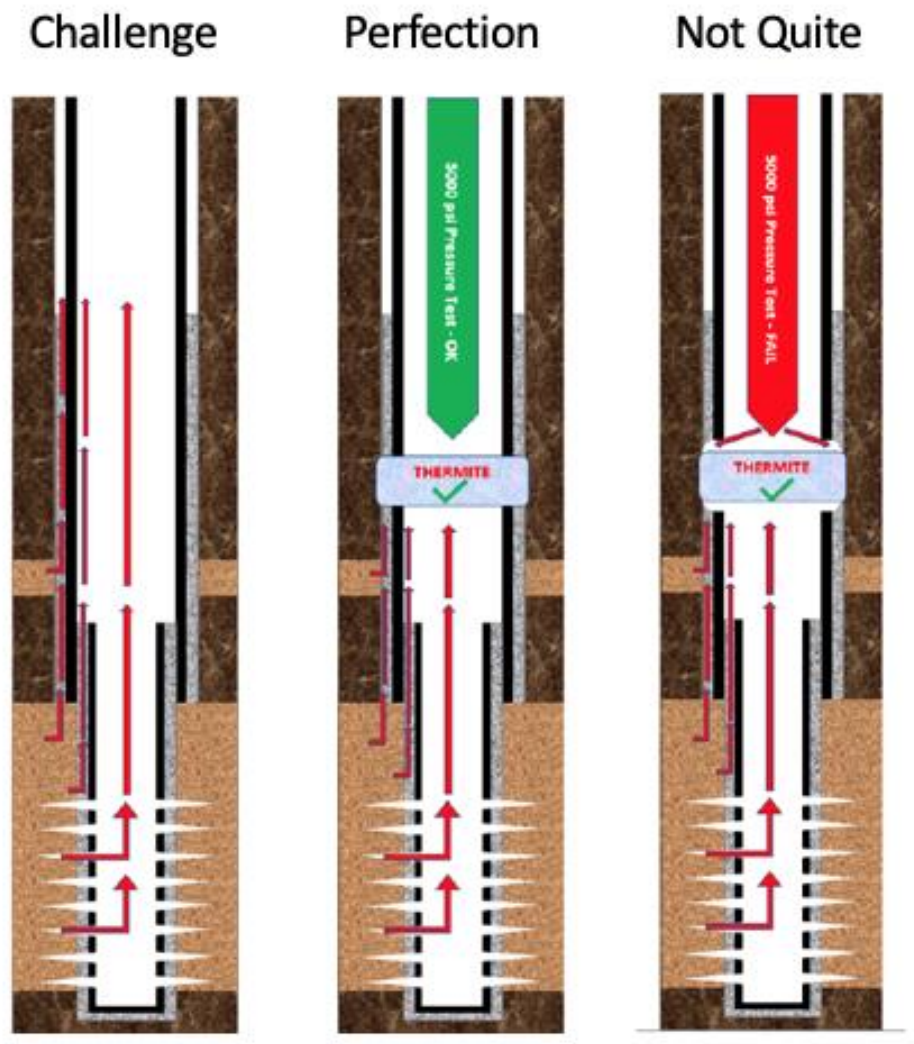
# Thermite Barrier Considerations & Acceptance

New barrier considerations

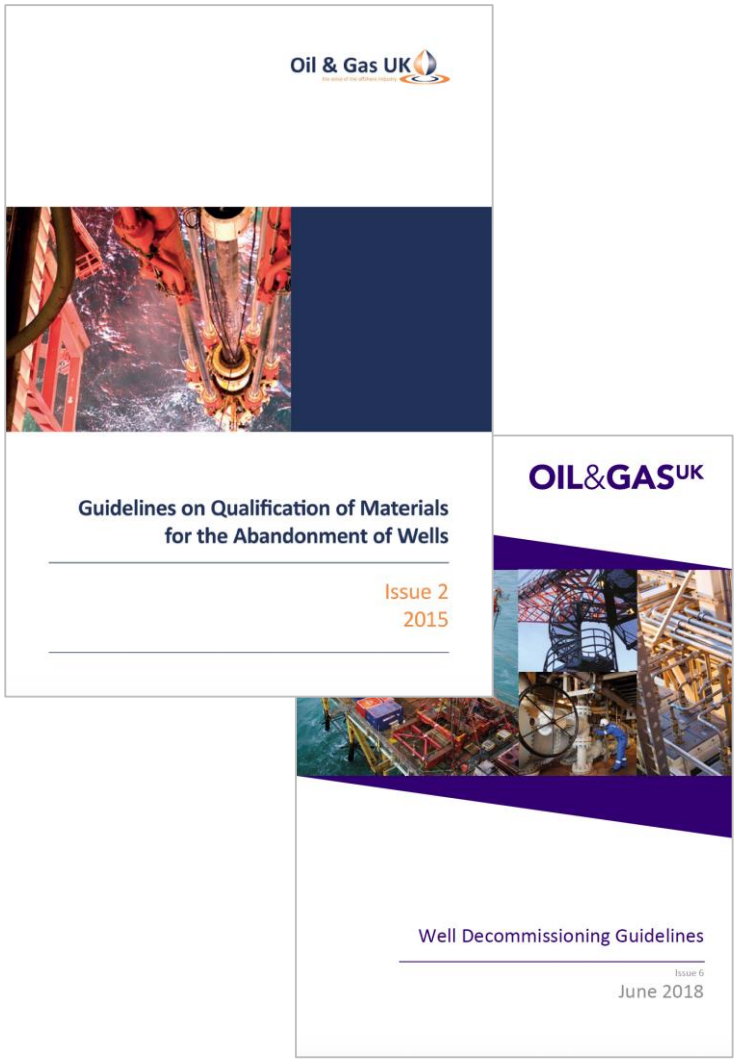
- Volume of barrier material required?
- Confirmation of operational success?
- Degradation – life expectancy?
- Barrier envelope testing methodology?

New barrier acceptance

- Alternative material testing – UK O&G Guidelines
- Barrier method qualification – Test chamber
- Offshore verification



# UKCS - Material Testing, Barrier Qualification & Verification




Qualification of Materials (Issue 2)

- Thermite - Type J 'Modified in-situ materials'
- 3 tests are classed as mandatory –
  - Permeability testing using nitrogen
  - Dry mass – Measurement of shrinkage
  - Creep – Rate determined by application

Well Decommissioning Guidelines (Issue 6)

- NEW alternative materials section
- Number of Permanent Barriers – "…*risk assessment*"
  - *Differential pressure across the the barrier*
  - *Impact of single point failure*
  - *Robustness of barrier placement and verification*

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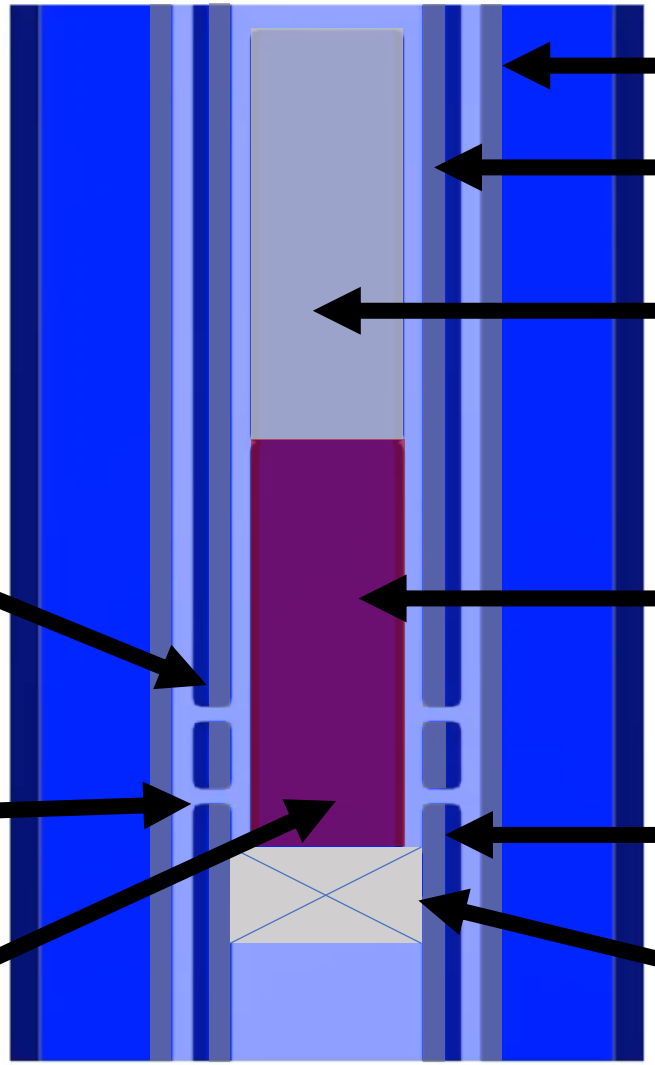
# Workshop Outcomes

| Root Causes of Potential Failure Modes | Mitigation Strategy |
|---|---|
| Inadequate formation selection process for candidate wells | Shale thermal impact testing / well selection criteria guidelines |
| Contamination segregation | Well design criteria and well architecture guidelines |
| Thermite plug corrosive | Corrosive laboratory tests |
| Short plug length | Well selection criteria guidelines |
| Chemical composition of plug | Optimum thermite recipe and contamination sensitivity lab tests |
| Lack of understanding of plug strength | Laboratory testing for mechanical properties |
| Total amount of energy supplied over a given timeline insufficient to create a barrier by melting casing and caprock | Development of a thermal simulation model |
| Lack of understanding of barrier composition at sealing interface | Full scale testing in pressure vessel |

# 1. Thermal Simulation Model

Accept Wellbore Data to

Predict Probability of Success



7” Casing

5” Tubing

Alloy Melt - Temp ~140°C

Alloy melts to form tubing and annulus gas tight barrier

Thermite Peak Temp 2500°C

Thermite forms structural Platform in the annulus

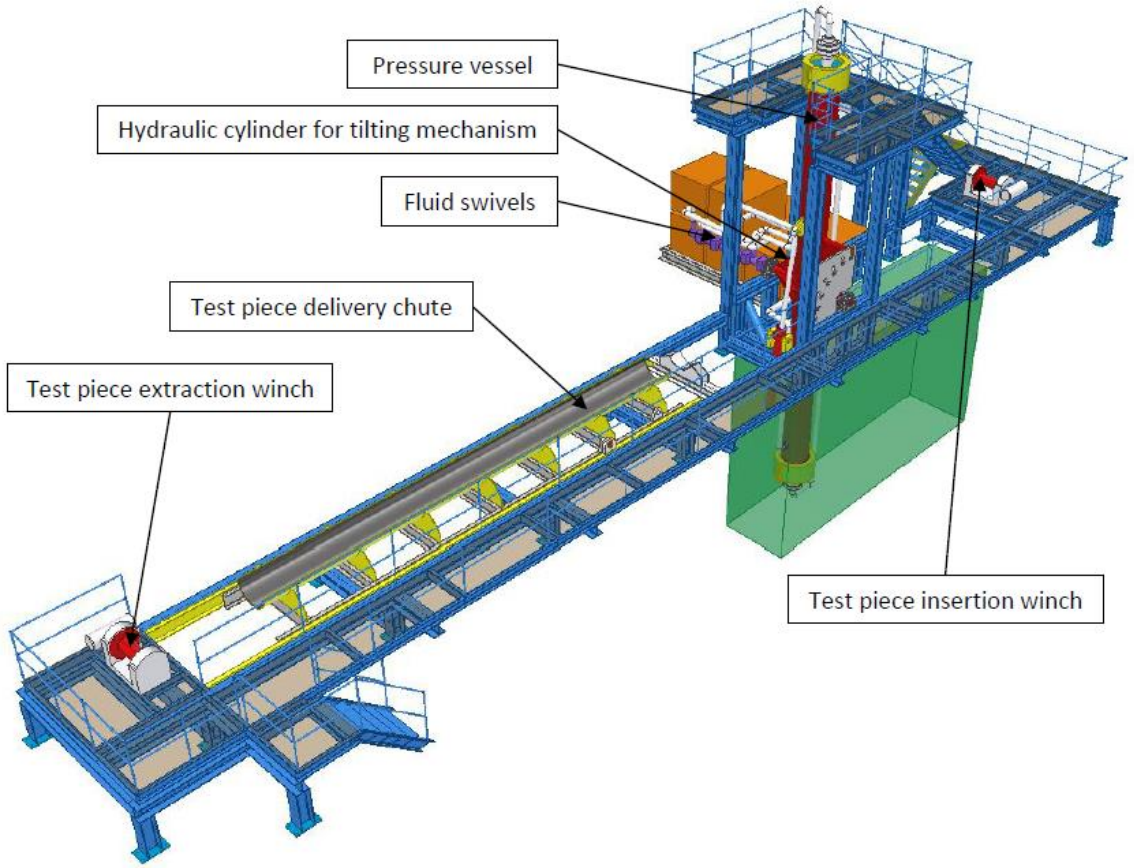
Thermite Changes Phase Solid to Liquid

Thermite Reaction Initiation (Bottom Up)

Tubing Retainer

# 2. Full Scale Testing in Pressure Vessel

## Independent P&A Qualification Test Chamber




- Independent ‘alternative material’ P&A barrier qualification test facility
- Configurable to enable testing of all cement alternatives; resins, polymers, alloys, thermite etc.
- Mimic downhole conditions
- Industry stakeholder engagement
  - Questionnaire
  - Specification Definition

# Action Required Now

- Limited Collaboration (IP related issues?)
  - Op Co & Service Co test results not shared

- OGTC - ‘Alternative Barrier Collaboration Group’
  Thermite, Alloy, Resin, Polymer, Expanding Cements…

1. CFD Modelling - to ‘define the limits’ of each technology
2. Material Testing – e.g. Bismuth alloy – as per UK O&G Test Guidelines
3. Barrier Qualification (ISO 14310 V6 – Op Co collaborate to define test criteria)
4. Verification – Field Trials – Wireless Gauge to accelerate acceptance

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# Questions?