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# Case Study: In-line Inspection of Buried Large Bore Pipework at Dalmeny Tank Farm

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Mechanical Engineer

06/11/2023

# About me

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Date	Role
2014-2019	Studied and Graduated with a MEng in Mechanical Engineering from the University of Strathclyde
2019	Joined the INEOS Grangemouth Graduate Scheme
2019-2022	Dalmeny Tank Farm/ Hound Point Asset Care Engineer
2022- Present	LPG Rotating Equipment & Maintenance Engineer  Elected as a Chartered Member of the IMechE

# Agenda

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- Who are INEOS and what do we do?
- Background on Forties Pipeline System
- Case Study: In-line Inspection Strategy for Buried Pipework at Dalmeny Tank Farm
- Summary
- INEOS Career Opportunities

# Who are INEOS and what do we do?

-  **\$65bn** sales
-  **25,000** employees
-  **36** businesses
-  **66m tonnes** of chemical capacity
-  **17m tonnes** of products pa
-  **10m barrels** of oil pa

**183**  
sites worldwide

**29** Countries

**87** sites  
in Europe

**38** sites  
in Asia

**58** sites  
in Americas



# INEOS Grangemouth

## Refinery

- Diesel and petrol (75% Scotland, 10% Northern Ireland) .
- Aviation fuel (95% Scotland).
- Heating fuels and fuel oil.

## Petrochemicals

- 1.4m tonnes production capacity pa.
- Ethylene, ethanol, polyethylene, polypropylene.

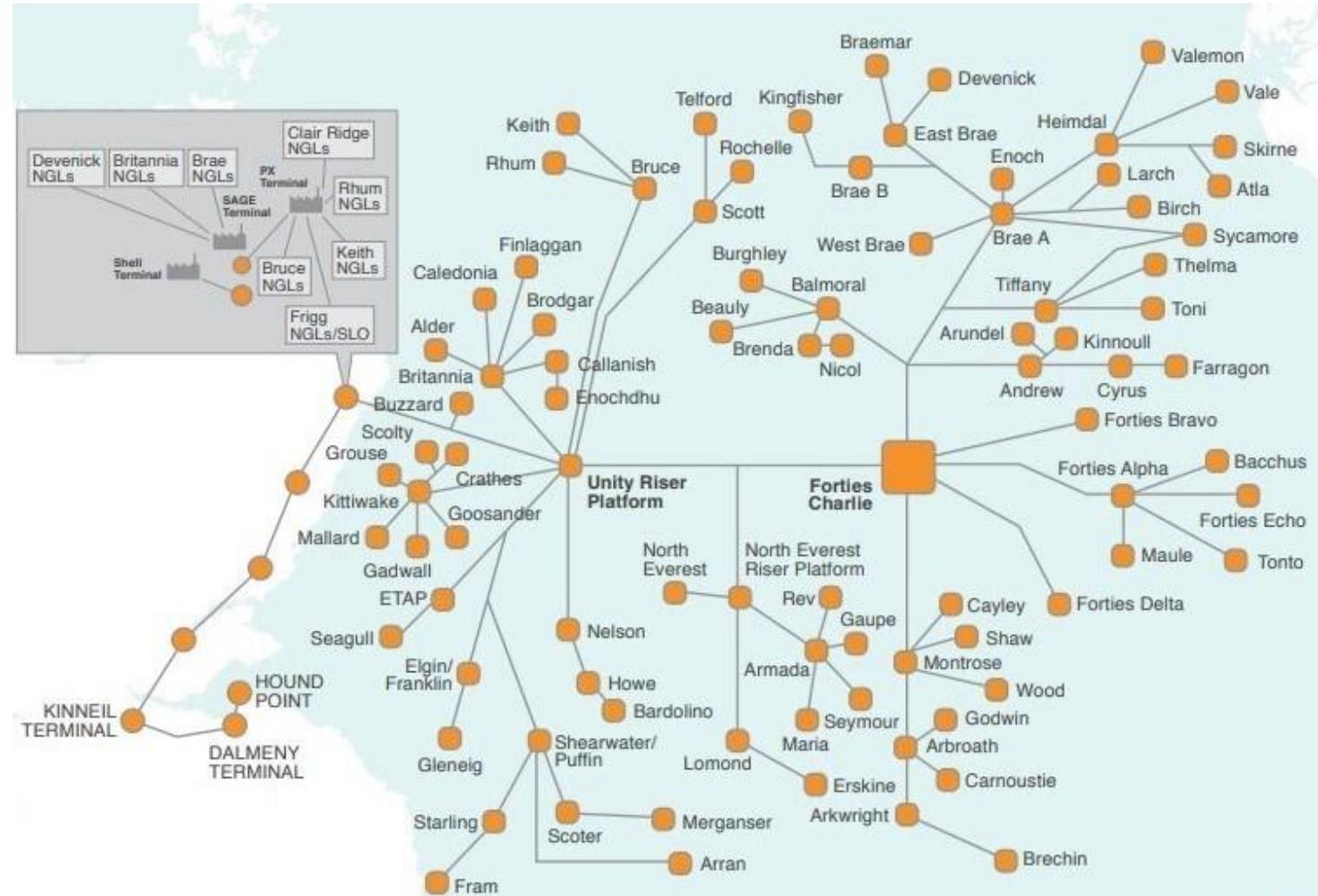
## Forties Pipeline System (Kinneil)

- Transports oil from North Sea fields (40% of North Sea production).



# Forties Pipeline System

- Forties Pipeline System (FPS) is a major pipeline system established in 1975 spanning over 400km.
- Transports approx. 250k bpd from the North Sea to Grangemouth.
- Approximately 40% of UK oil and gas is transported through FPS.
- Acquired by INEOS from BP in 2017.



# FPS Export Assets

## Dalmeny/ Hound Point (DHP)

- Stores 2.4 Million barrels of stabilised crude oil across four tanks.
- Crude is exported to ships via Hound Point Loading Platform.

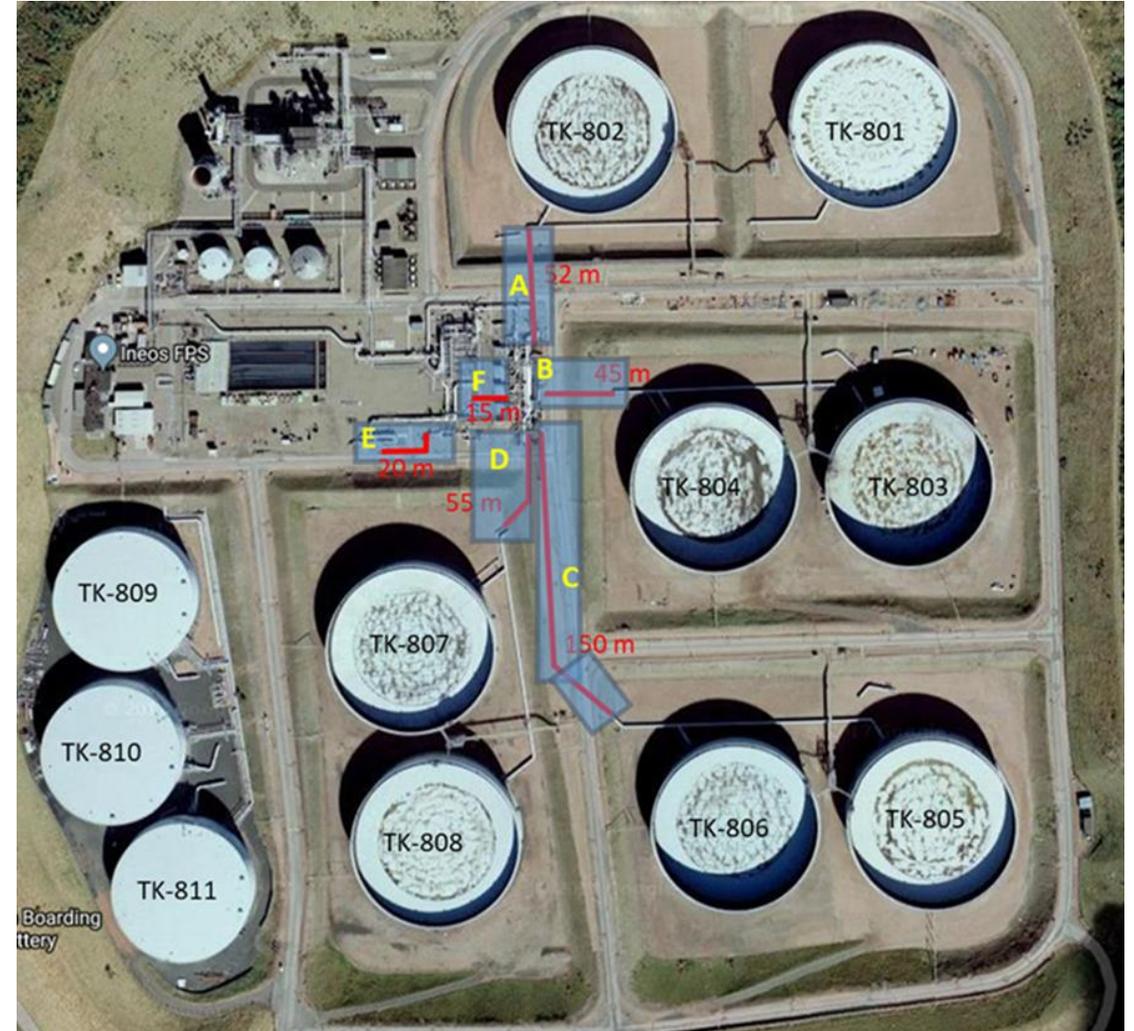


## Liquefied Petroleum Gas (LPG)

- Stores 17,000 tonnes of Propane and Butane.
- LPG is cooled at refrigerant plant and stored in low temperature tanks.
- LPG is exported to other INEOS sites and to external customers.

# Problem Opportunity- Inspection of Tank 801/2 & 807/8 Fill Lines

- As part of Dalmeny 2040 tankage strategy, 48" fill lines to tanks 801/802 and 807/808 required inspection for endorsement.
- These lines are buried under critical site roads.
- To inspect lines externally would require excavation at a significant cost and disruption to site.
- Total cost for excavating approx. £1.5m per line.
- To instate new pipework above ground from tanks to MOL sump would require cost of approx. £10m per line.
- Opportunity to inspect pipework internally via in-line inspection tool at a reduced cost.



Tank 802 & 808 fill lines labelled A & D respectively

# The Pressure Systems Safety Regulations

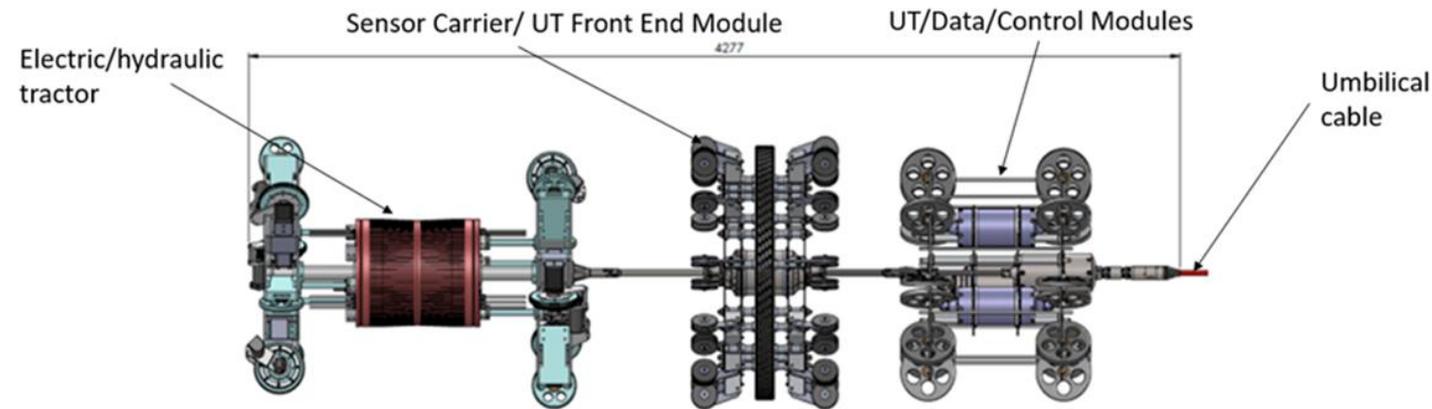
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- Originally published in 2000, aim is to prevent serious injury from the hazard of stored energy as a result of the failure of a pressure system or one of its component parts.
- Applies to relevant fluids, including all process piping at Dalmeny Tank Farm.
- Dictates requirement for a Written Scheme of Examination (WSE) and statutory inspection of equipment.
- User/ owner responsible for ensuring equipment is fit for purpose.
- Both company and YOU as an individual can be prosecuted by the HSE for breaching these regulations.



# Rosen Norway 48" Tethered Crawler Inspection Tool

- Vendor selection process undertaken in 2020 to select suitable ILI tool with contract being awarded to KTN.
- Self propelled tool consisting of three modules.
- Captures full circumferential data of pipe via UT sensors.
- Powered via umbilical cable connected to motorised winch.



# Preparatory Work

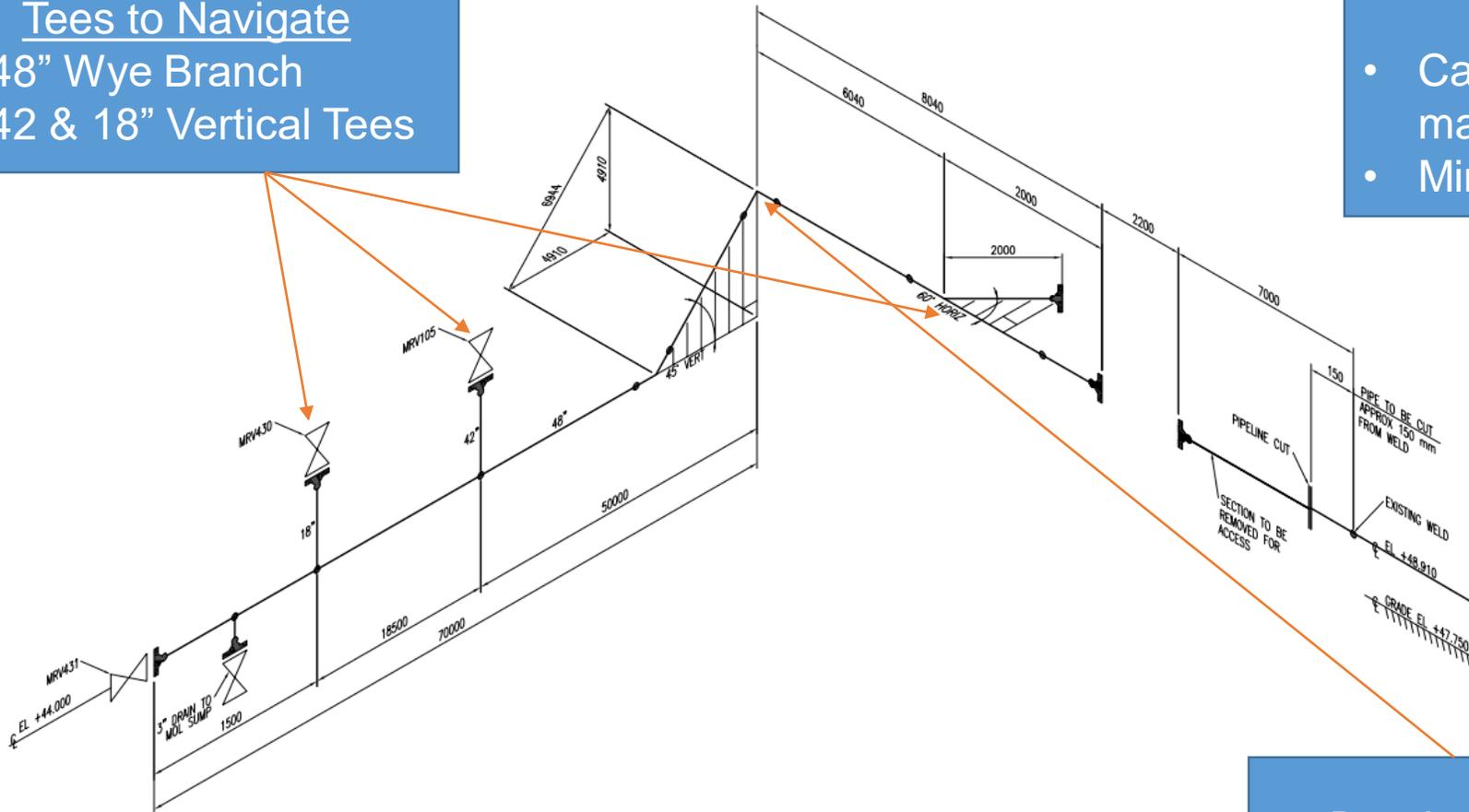
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- Analysis of pipework; diameter tolerances, bend radius, tees.
- Methodology for cleaning; chemical clean vs water flushing/jetting.
- Management of Change Paperwork and Risk Assessment.
- Field Assessment Trial.
- Permits, constructability, communication.

# Bends & Tees

## Tees to Navigate

- 48" Wye Branch
- 42 & 18" Vertical Tees



## Minimum ID

- Calculated from pipe material specification
- Min ID = 1166mm

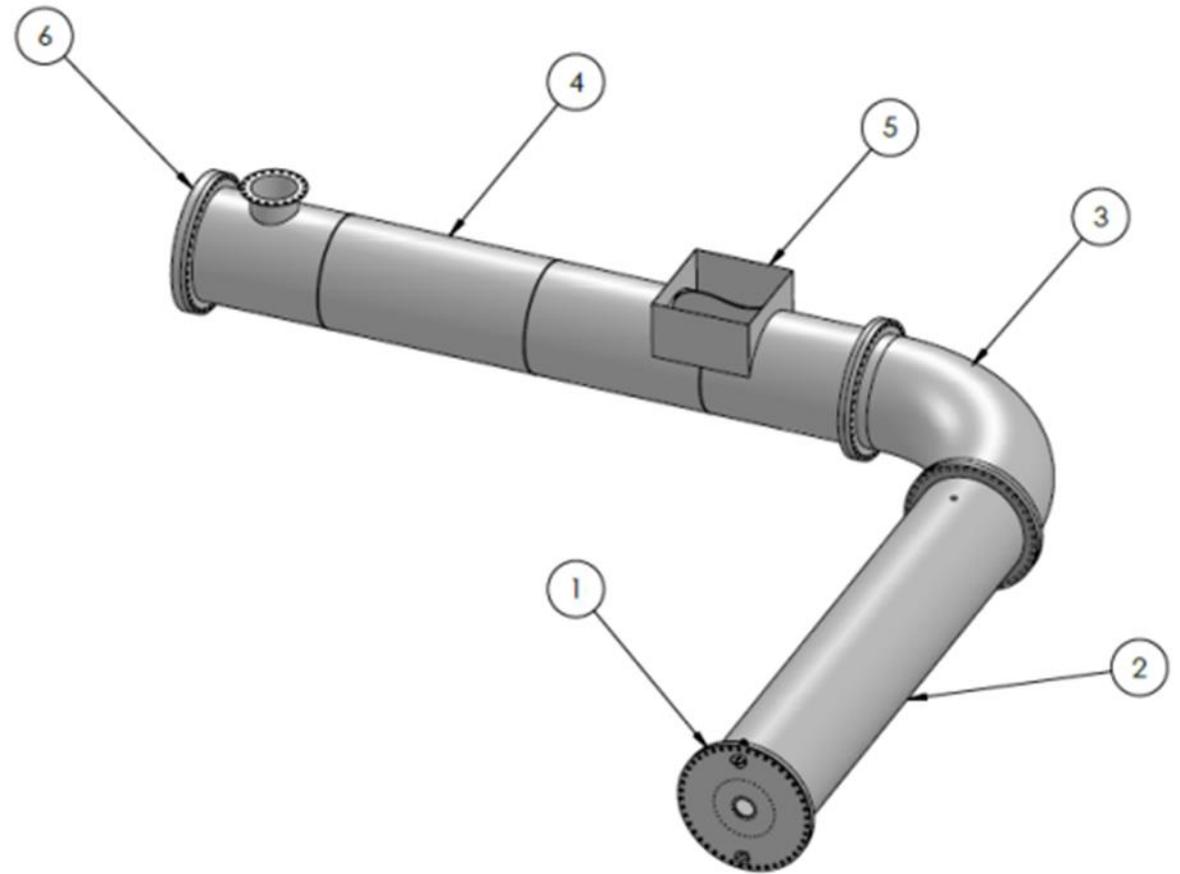
## Bend to Navigate

- 1.5D min radius

# Field Assessment Trial

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- Conducted at KTN's facility in Norway.
- Detailed testing procedure agreed between KTN & INEOS to verify tool can navigate relevant features.
- Results recorded and sent to INEOS remotely (Covid-19).



# What happens when things go wrong?

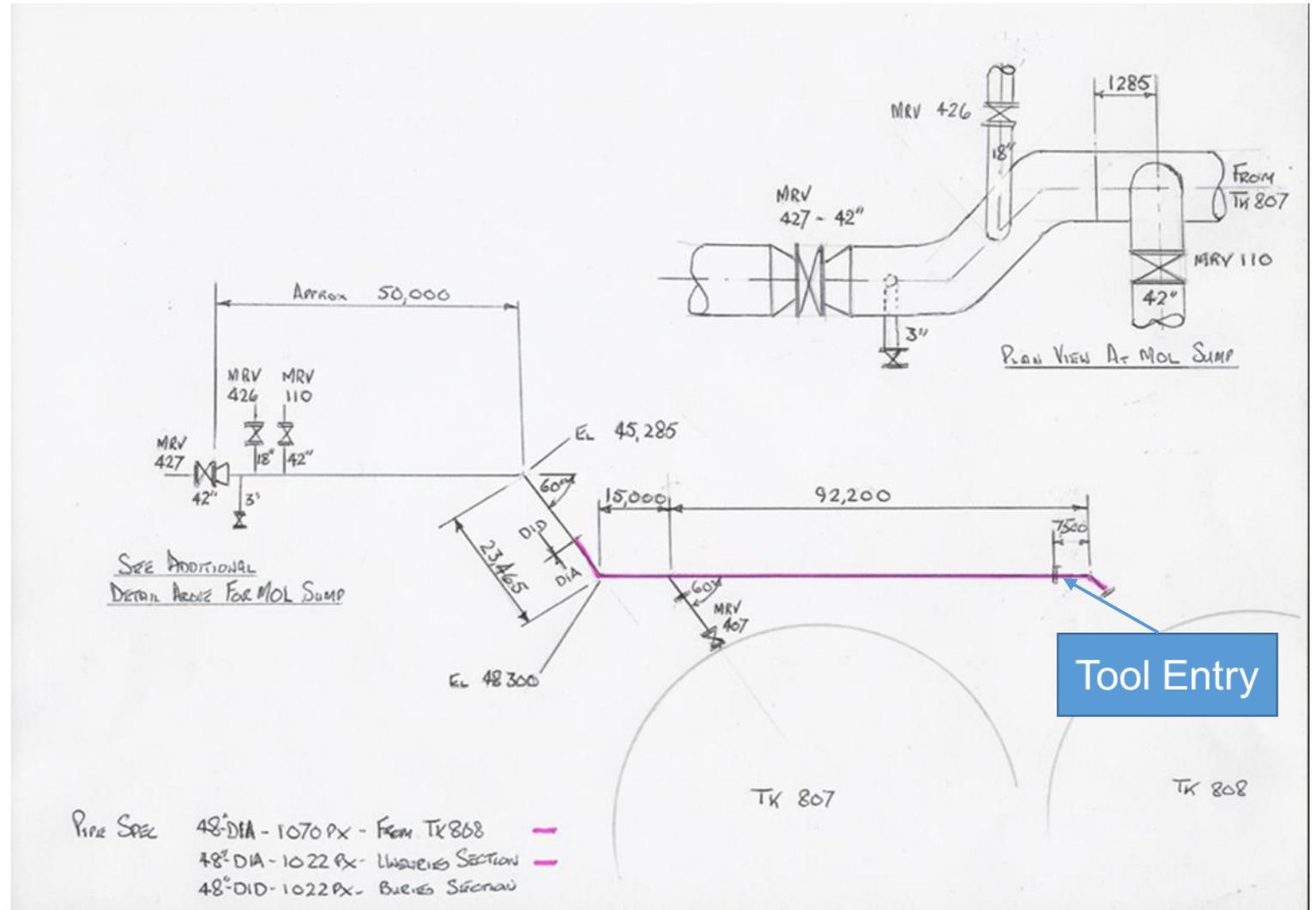
- Tool could not navigate wye branch during FAT for T802 line.
- Spring loaded wheels caught at offtake.



- Last minute engineered solution required for project to commence.

# Applying lessons learned to Tank 807/808 line

- Tool launch for T807/808 fill line was approx. 90m from wye branch.
- Metal sleeve therefore could not be implemented to bypass branch.
- Requirement stated to KTN and FAT carried out three months before site execution to provide contingency.
- Tool engineered to differentially lock wheels when passing wye branch. Increased torque applied to wheels contacting wall.
- Tool length increased from 4m to 6m.



# Cleaning of Pipework

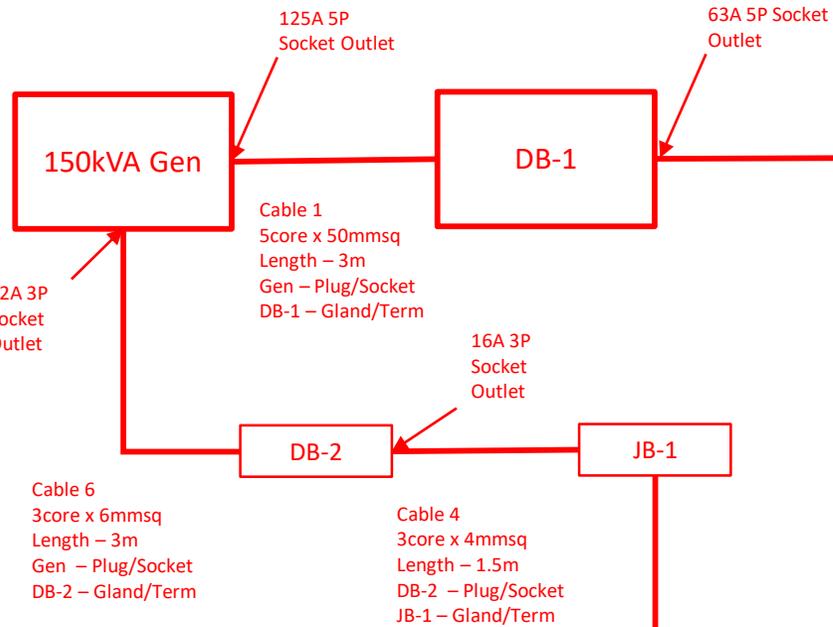
- Utilised Pipetech's Aquamilling System to internally clean the pipework.
- Removed debris and residue from the pipe wall which would impede the tool sensors.



- Relevant permits and controls in place regarding high pressure application.
- Hoses fed into pipe via Entry Point Alignment Tool (EPAT) and discharge water monitored for cleanliness.

# Power System

## Perimeter Road (Non Haz Area)



### Generator Settings

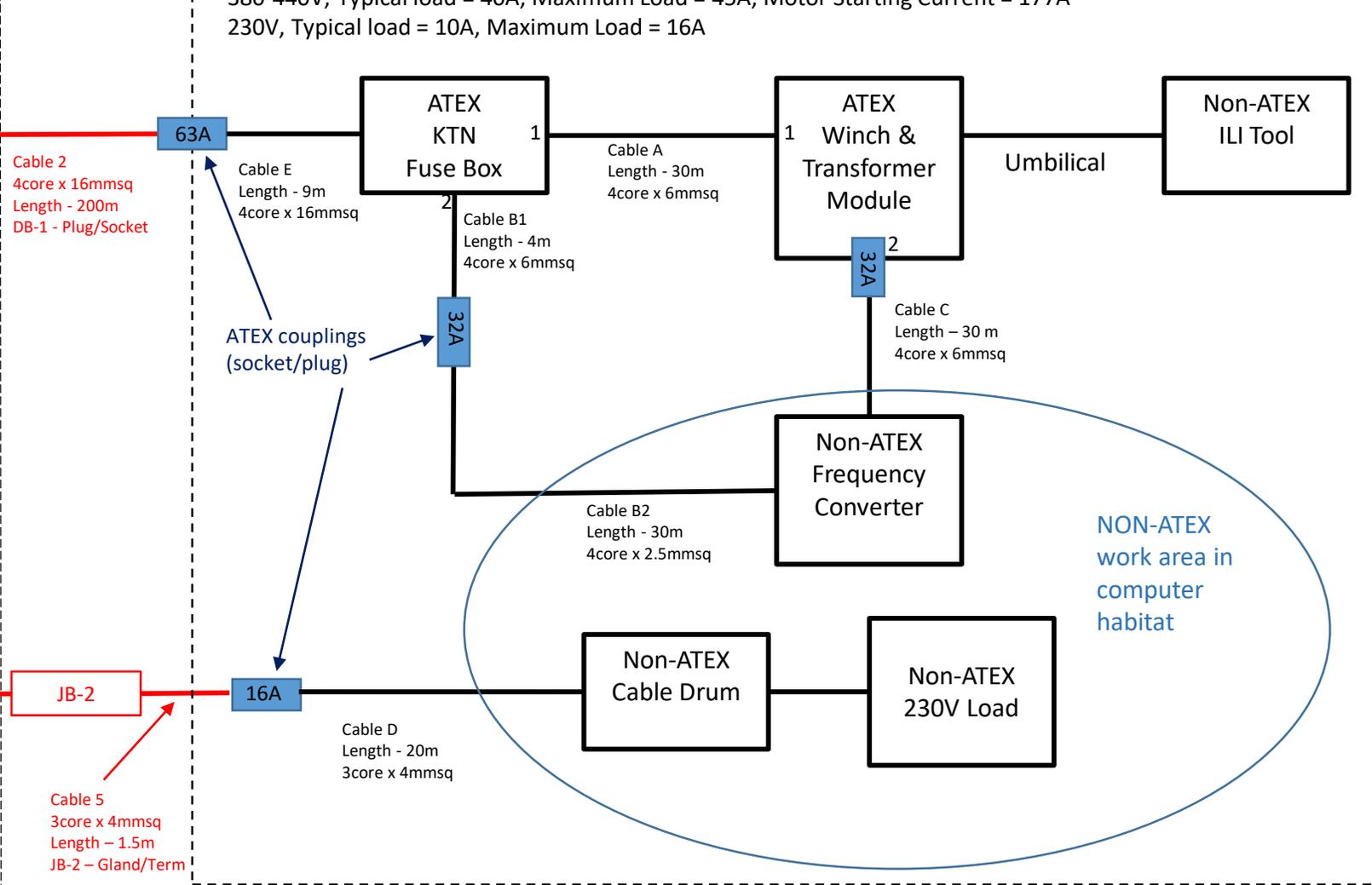
- Voltage - 415V  
Frequency - 50Hz  
MCCB (Schneider Electric NSX250F)
- Long Time Protection Pick Up  
I<sub>o</sub> - 100A
  - Long Time Protection Fine Adjustment  
I<sub>r</sub> - 0.9
  - Short Time Protection Pick Up  
I<sub>sd</sub> - 3

### Earth Leakage Relay (Socomec M40)

- I<sub>Δn</sub> - 1A
- Delay - 0.06s

## Tank Bund (Zone 2 Area)

KTN Supplied Equipment  
380-440V, Typical load = 40A, Maximum Load = 45A, Motor Starting Current = 177A  
230V, Typical load = 10A, Maximum Load = 16A



# Set-up of Equipment for ILI

- Mobilised equipment to site.
- Performed relevant checks and certification.



- Tool inserted into pipe and stuffing box flange fitted.
- Pipework water filled; ATEX & UT couplant.

# Execution of In-Line Inspection

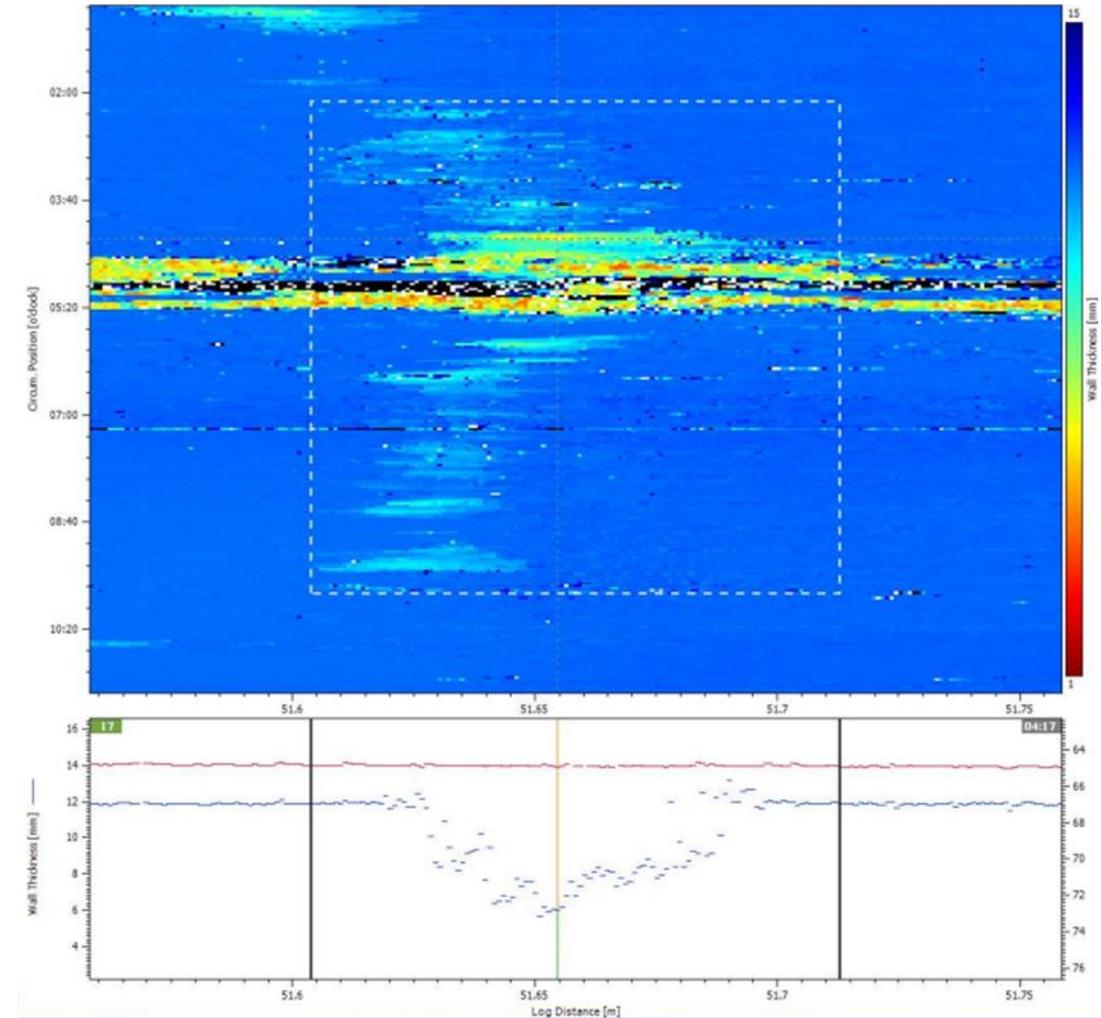
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- Tool authorised for use and powered-up.
- Constant data stream to computer habitat. Monitor for tool location.
- Applied communication skills to work alongside non-native English speaking technicians.



# Data Results

- Tank 802's fill line inspected in October 2020 and tank 808's in June 2021 during full system outage.
- Applied learnings from tank 802 inspection to tank 808. Project delivered ahead of schedule.
- IIs successfully captured 98% of pipework requiring inspection and retrieved required data to assess lines.
- One area of significant corrosion detected on 802 fill line.



# Fitness for Purpose Assessment

- Area of external corrosion detected on 12 o'clock position of 802 line.
- Corrosion occurred at interface between buried/unburied section.
- Min wall thickness: 5.4mm
- ASME B31.3, Eq 304.1.2 utilised for assessment.



## 304.1.2 Straight Pipe Under Internal Pressure

(a) For  $t < D/6$ , the internal pressure design thickness for straight pipe shall be not less than that calculated in accordance with either eq. (3a) or eq. (3b)

$$t = \frac{PD}{2(SEW + PY)} \quad (3a)$$

# ASME B31.3 Calculation

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D, outer diameter = 1219.2mm

P, design pressure = 0.91MPa

W, weld factor Table 302.3.4 as 1

Y, coefficient from Table 304.1.1 as 0.4

E, quality factor from Table A-1B as 1

S, maximum allowable stress from Table A-1M as 138MPa

$$t = \frac{0.91 * 1219.2}{2(138 * 1 * 1) + 2(0.91 * 0.4)} = 4mm$$

Existing wt 5.4mm > 4mm so pipework is safe to operate. Consider composite wrap repair to mitigate further external corrosion.

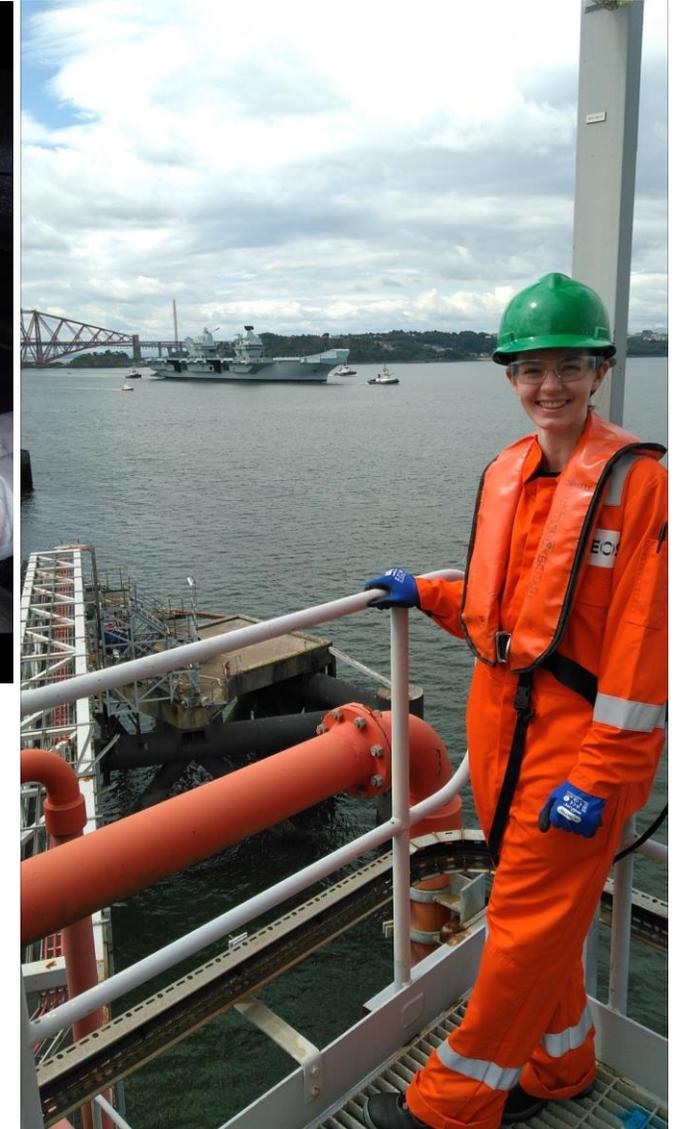
# Summary

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- Implemented an unorthodox, sustainable and cost efficient methodology for inspecting critical buried pipework at Dalmeny Tank Farm.
- The overall cost between both projects was approx. £650k vs over £3M to excavate.
- Field Assessment Trials should always allow a suitable time period to perform amendments.
- Quality of inspection data dictated by cleanliness of pipe.

# Summer Internships

- 8-12 week paid placement for 3<sup>rd</sup>/4<sup>th</sup> year students
- Based within an asset team & given real responsibility/ projects
- Hands-on experience
- Applications open around March 2024



# Engineering Graduate Programme

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- 4 year programme based in Grangemouth, Scotland
- Starting salary of £36,000
- IMechE accredited Monitored Professional Development Scheme (MPDS) towards Chartership
- Rotations across different sites
- Once in a lifetime opportunity to visit Namibia and complete the In-Nam Challenge
- Commercial graduate programme also available for STEM students
- Applications currently open for 2024 graduates



# Questions?

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