WELCOME

Pressure Systems Installations: Significant Technical Challenges in a Difficult Commercial Climate

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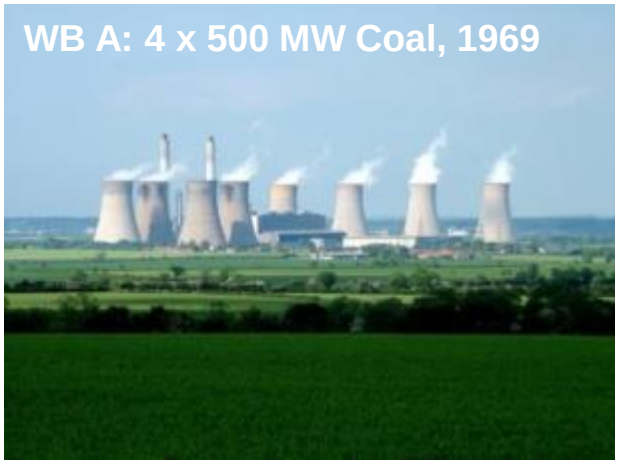
Agenda

- Regulation and Commercial Context
- Engineering Challenges
- Opportunities for Monitoring of Pressure Systems, use of Sensors….and Data



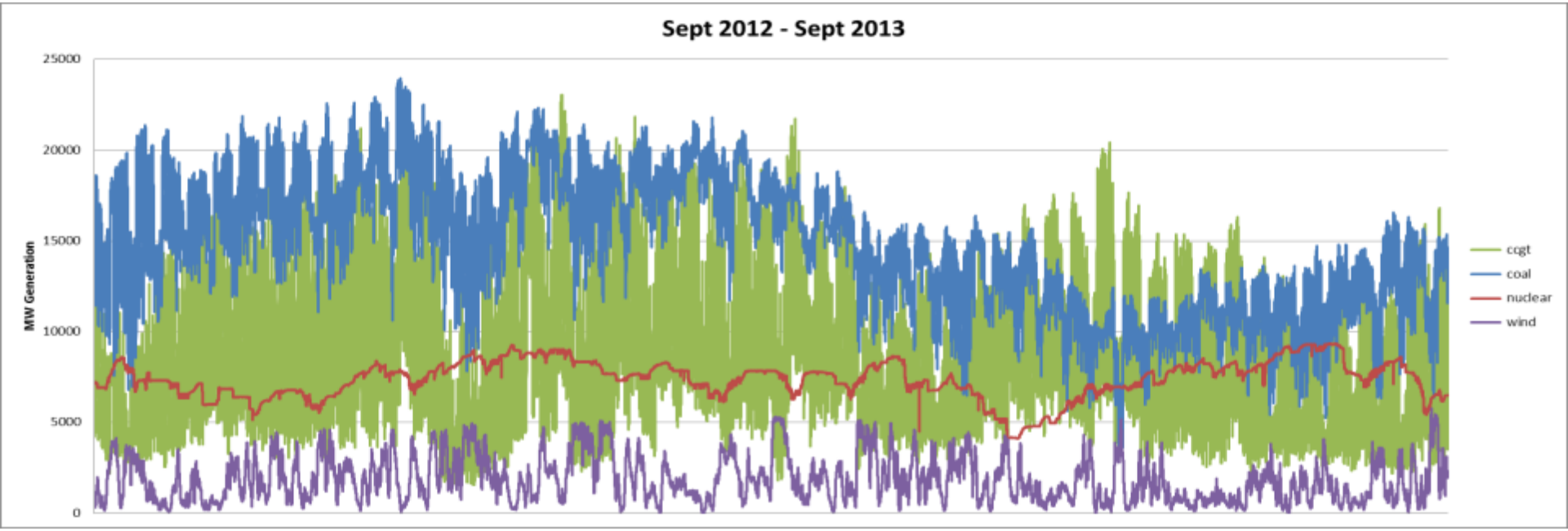
Regulatory/Commercial Context

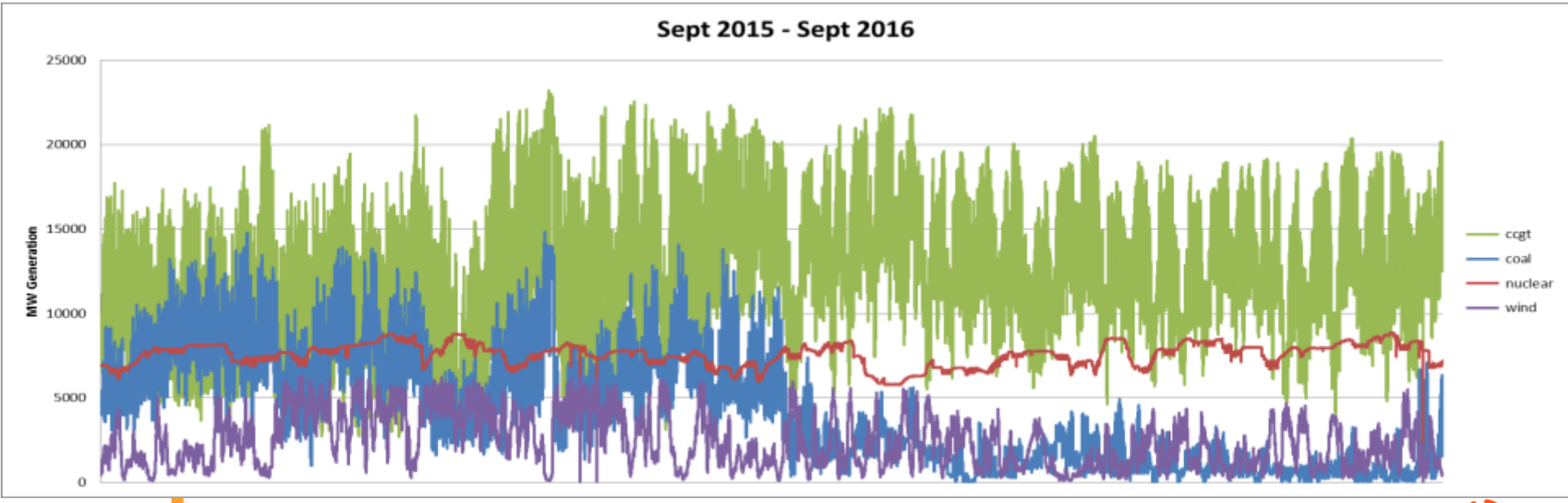
Closure of existing Coal fired plants in the UK due to various reasons:

- IED emissions regulations, Carbon Tax and CO_2 Emissions National Target,
- Cost of operating and maintaining an ageing Coal fleet with a limited commercial life ahead, especially under flexible load conditions,
- Preference for CCGT generation over Coal at lower emissions,
- Increasing Wind Generation.

Look Ahead:

- Introduction of the Capacity Market, individual Unit bid prices. Emphasises the importance of plant reliability, pressing need to be on load as requested to capture market price,
- Planned closure of all Coal generation by 2025 at latest,
- Reducing investment in operating Coal Units, run down of existing Coal stocks,
- CCGT Units operating flexibly (high Unit starts) ,
- Station revenue is now much lower



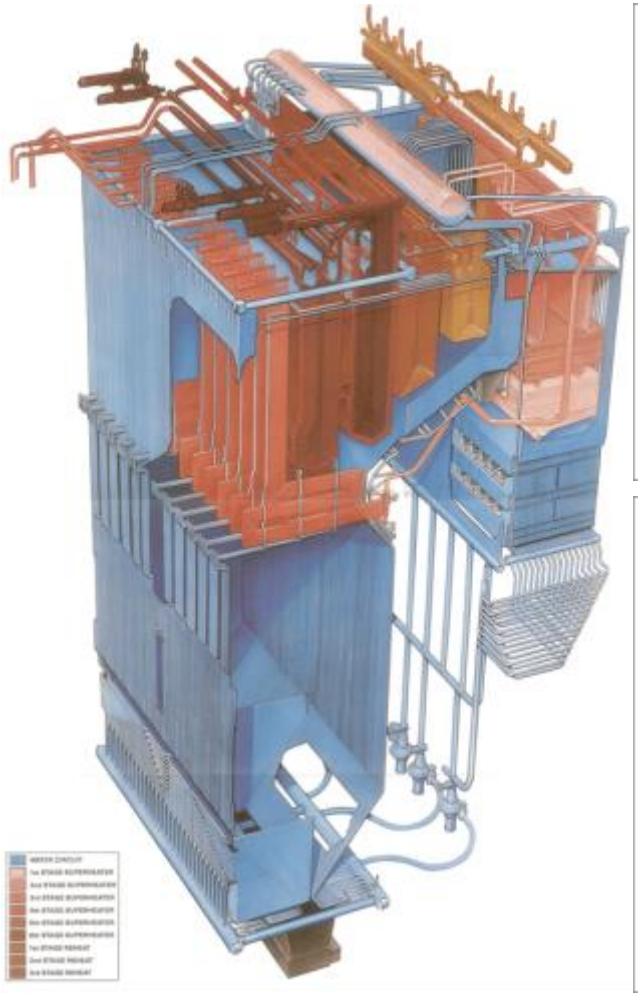


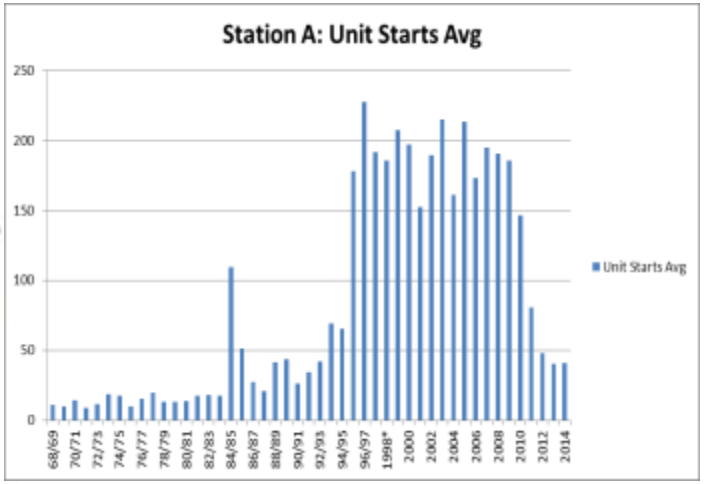
Source：http://www.gridwatch.templar.co.uk/

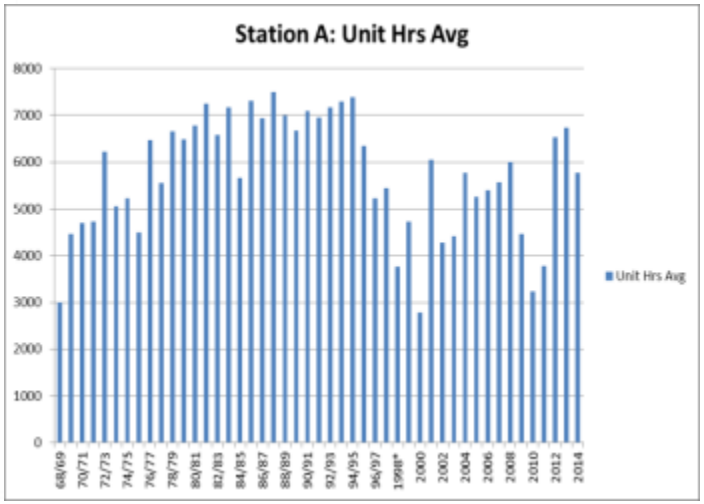
Engineering Challenges
(Understanding the behaviour of ageing materials in-service)

Coal Units

Forward Operation of ageing Units until Closure: High number of annual Unit starts (150/200) and relatively low operating hours (1500/2000)







Challenges
Life expiry (behaviour) of ageing materials

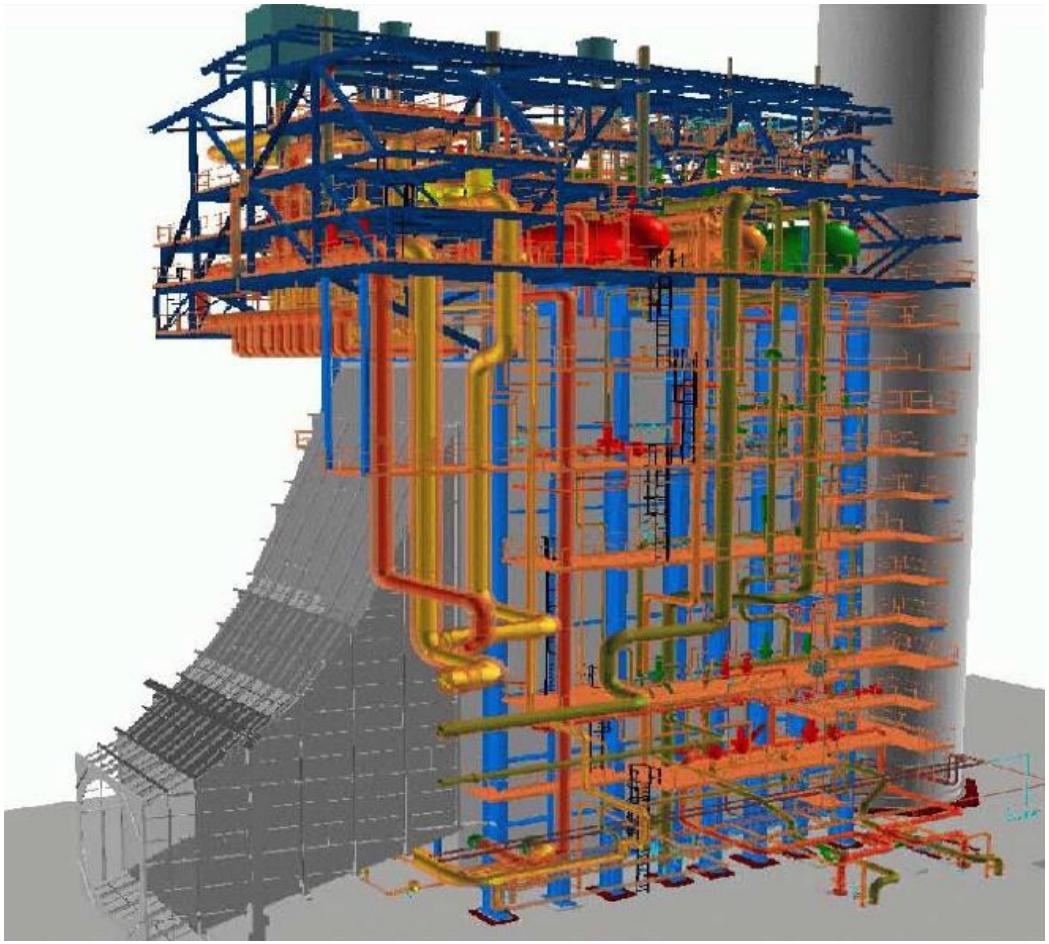
Creep Rupture
Creep-Fatigue interaction
Thermal Fatigue
Corrosion
Corrosion-Fatigue
Erosion/Thinning
Flow accelerated corrosion

Locations

Pipework, Welds
Steam Chest, Headers, Valves
Turbine Casings….

CCGT Units

WB B: Unit typical operation to date: 15,000hrs and ~ 750 starts
Use of relatively advanced steels (P91) in Superheat sections of the Heat Recovery Steam Generator (HRSG)
Forward Operation: Anticipate continuation of high number of Unit starts



Challenges
(Similar to Coal, but noting the following)

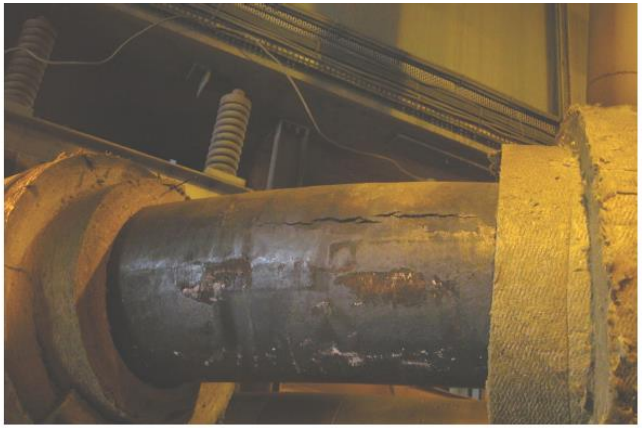
Advanced steel (P91) is very sensitive to composition, site installation process, adverse operating conditions. P91 is difficult to inspect, assess and repair

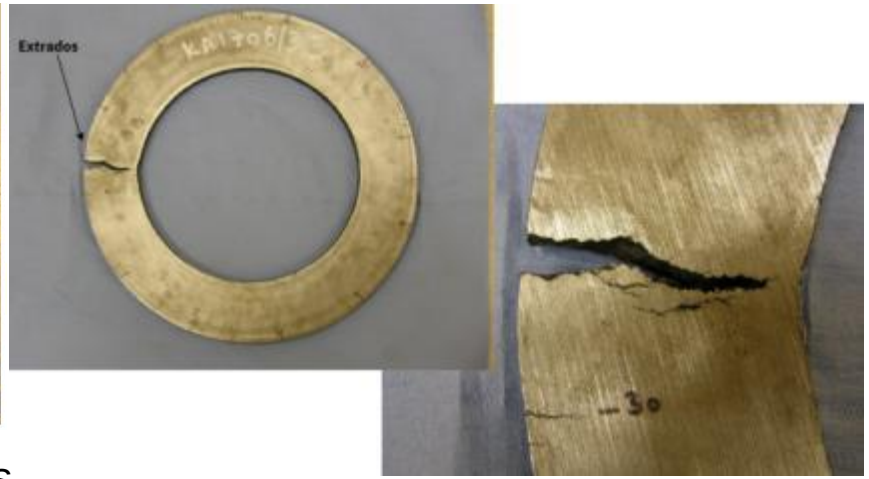
Locations

Access to pressure system components is much restricted (by design)

Life expiry (behaviour) of relatively young materials!

Some Examples of in-service Degradation

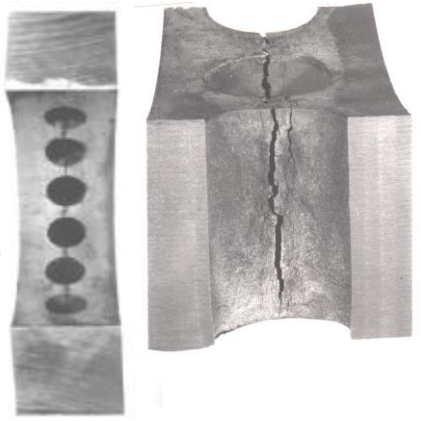


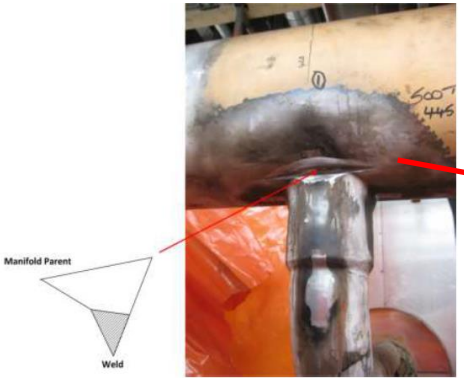


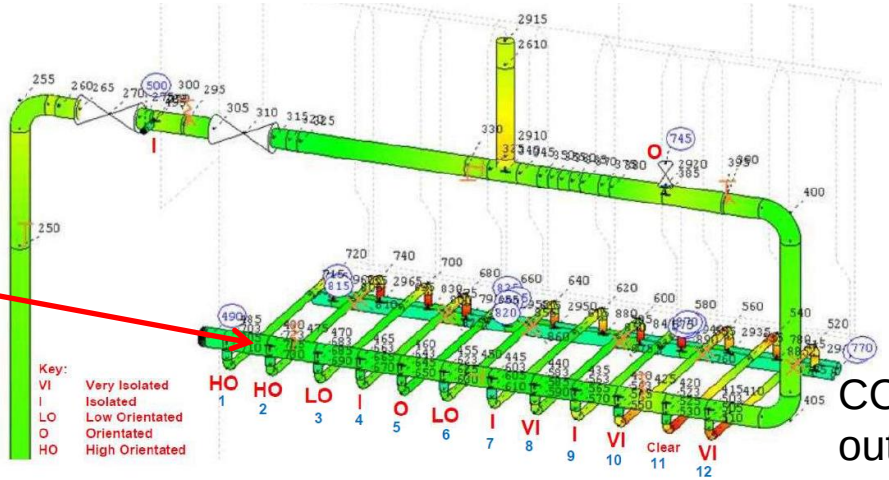
Main Steam line (CMV)

Boiler Tubes

Header ligament cracking







CCGT – P91 outlet manifold

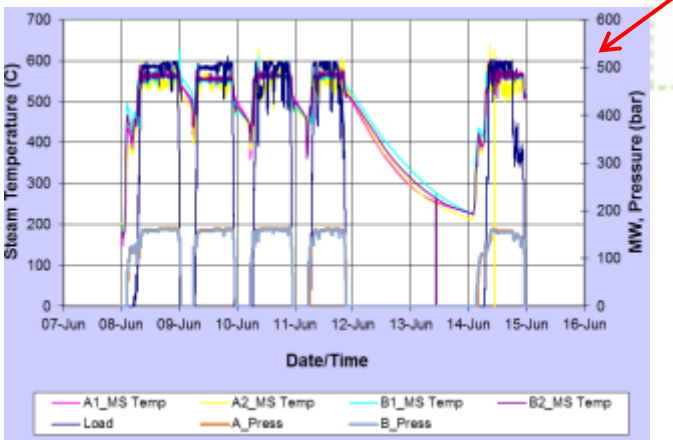
How do we Currently Manage the Integrity of Pressure Systems?

4-yearly statutory inspection (2-yearly interim outage for 'monitors')

Ticket to operate obtained; only for the next 4-year period

Very limited data integration to support longer term life prediction

Data Silos



Plant Operation
- Maintain Safety
- Maximise Availability
- Optimise Inspection, Repair, Replacement Cost

Update Inspection Schedule, Remedials, Monitors

Business Perspective
- Risk Appetite
- Regulations
- Market Conditions

Residual (Operable) Life

On-Load Condition Assessment
Creep and Creep-Fatigue Damage

Evaluate Life Consumption

Miniature Specimen Testing
Assess remaining life of ageing material

On-Load
Plant Operational Data (Temperature and Pressure), Strain (Active), Pipe Hanger Surveys

Outage Data Review and Return to Service

Off-Load (Outage)
NDT (Macro Defects, Geometry), Hardness, Creep Replication, Pipe Hanger Surveys, Strain (Passive), Material Composition

Experiential Knowledge

Maintaining Safe Operation is Priority

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Some Opportunities for Monitoring of Pressure Systems, use of Sensors ….and Data Thereafter

1. Onload and Offload Data Interpretation and Analysis
2. Outage Inspection
3. Assisting the Operator to Manage Risk

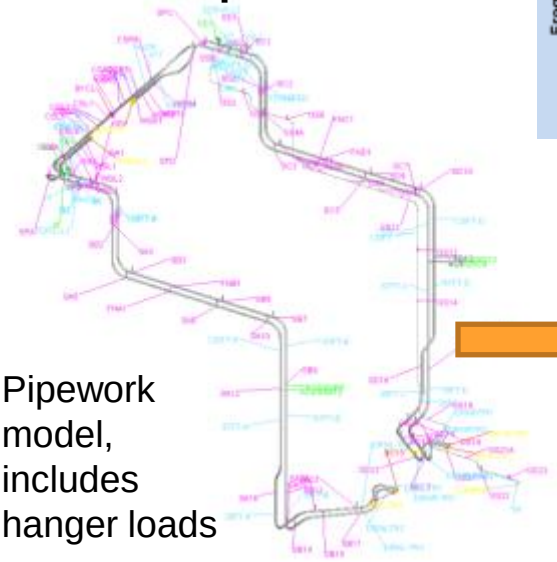
Some Examples of Related Research to Address the Challenges

Onload and Offload Data Interpretation and Analysis

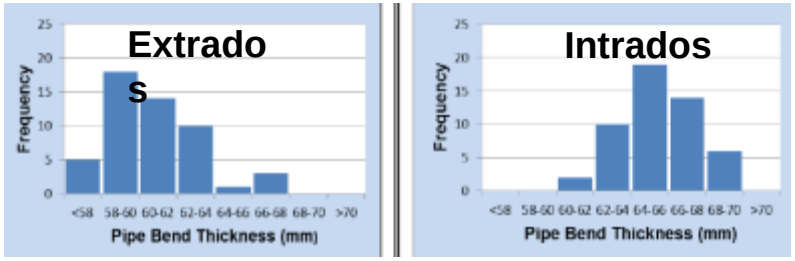
- Vast amounts of material condition data is captured during outages: By no means fully utilised to support condition assessment (Sits in Silos)
- Very traditional process: Inspect, produce report, secure ticket to run for the next 4 years

Opportunity: Data fusion and analysis, use of material lifing models that directly accept/use measurements from online sensors and/or from outage inspections. Enable the operator to a) Improve operation, b) Optimise the scope of future inspections, c) Predict the change in condition…inspect…..update lifing model

Example: Main Steam Bend Creep



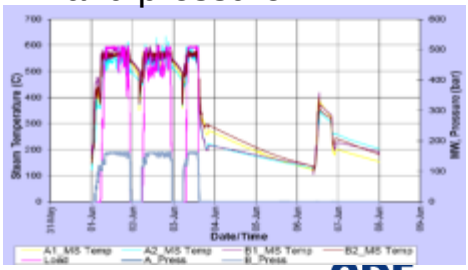
Pipework model, includes hanger loads



Outage Bend NDT wall thickness

Automate bend modelling and creep life assessment

Onload temperature and pressure



J.P Rouse et al, 'Steady-state creep peak rupture stresses in 90 power plant pipe bends with manufacture induced cross-section dimension variations', Int Jnl Pressure Vessels and Piping, 2013

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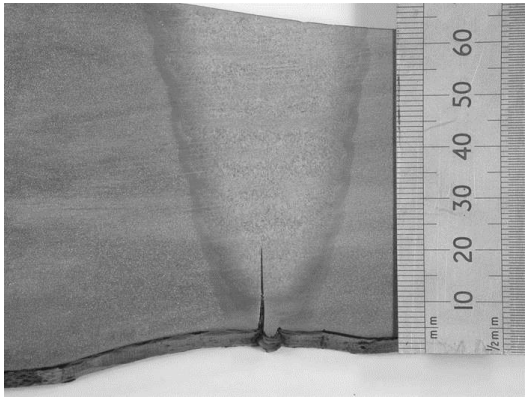
Outage Inspection

- Inspections are used to ‘determine the condition of the asset’; Preferable if they were primarily used to ‘confirm the predicted condition of the asset’ as part of a more forward looking assessment process,
- On-load measurements of defect propagation rate, with permanently installed sensors, would be of great benefit for Safety Cases on high temperature systems; allowing continued safe operation whilst repairs/replacements can be arranged.
- Site metallurgical data capture (replicas, hardness), significant cost as plant ages, interpretation with respect to life prediction could be greatly improved

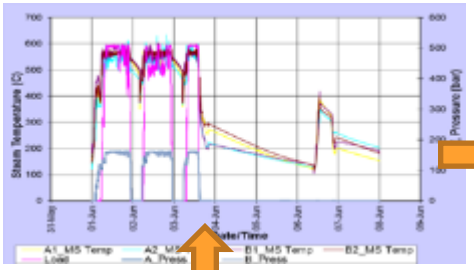
Opportunity: Permanently installed sensors to measure damage accumulation rate on key systems/components. Use of small specimen sampling techniques to assess material behaviour

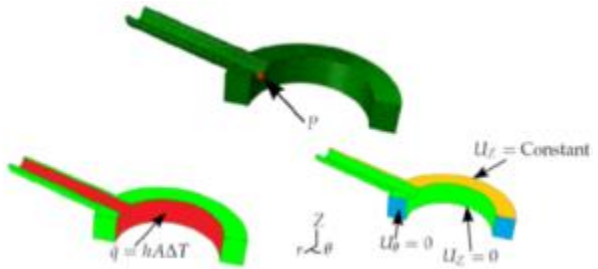
Main Steam pipe weld with thermal fatigue induced bore crack

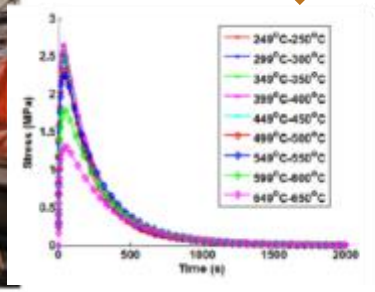


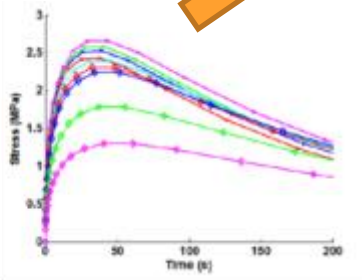
Online creep damage sensor (ACPD) installed at West Burton; Ref Imperial College

Header Monitoring







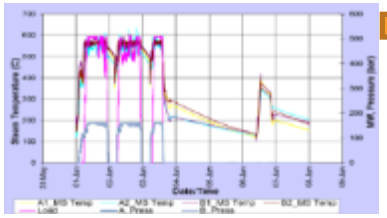


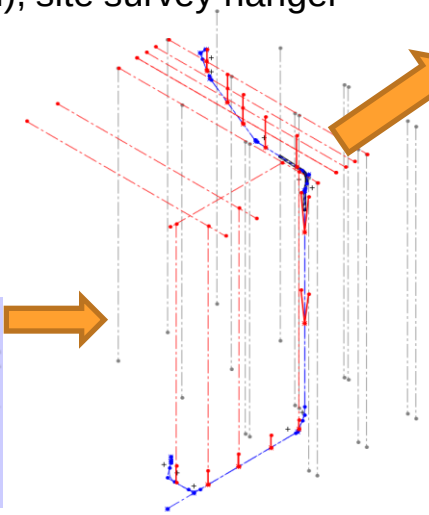
Neural network; range of header geometries

Develop Operator Interface

EPSRC Flex-E-Plant (EP/K005095/1)

Full pipeline models (West Burton), site survey hanger loads

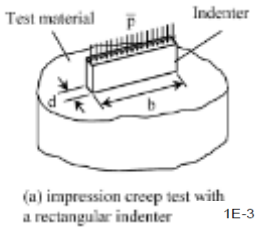




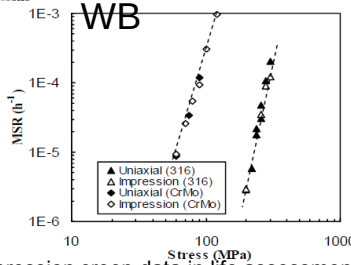
ABAQUS model, with range of Creep models

Develop Operator interface – site data input, Automated analysis

Small specimen testing (impression creep), through thickness vs. replication



Ties in with ACPD online creep tests, WB



W. Sun et al, 'Application of impression creep data in life assessment of power plant materials at high temperatures', Proc IMechE Vol. 222 Part L: J. Design and Applications, 2008

Assisting The Operator to Manage Risk

Opportunity	Benefit
Provide the plant operators with frequent (timely) and easy to understand information related to the condition of the plant	Enables proactive changes to plant operation to reduce the rate of damage accumulation
Improve risk assessment/reporting; ensure full use of operational/outage intelligence	Reduce operational maintenance costs, maintain safety, optimise capital spend
Provide the operator with the ability to use all the operational/outage intelligence and respond to changes in Regulation and/or Market conditions	Optimises through life cost of plant operation, ensures the plant is commercially viable

More informed Risk Management will save £M's on operational and capital costs; in these challenging times it is essential that this is pursued.

Noting that Safe Operation must be Maintained

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THANK YOU

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