NDT Lessons Learned

NDT For the Nuclear Industry Seminar

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At a glance

- **50,000** Employees
- **18,245** Engineers
- **750** Apprentices
- **50** Countries

**Civil Aerospace**

- 35 types of commercial aircraft powered by Rolls-Royce engines
- 13,000 engines in service around the world
- 24,600 employees

**Defence**

- Over 150 Customers in over 100 countries
- 16,000 engines in service around the world
- 9,800 employees

**Power Systems**

- >1,200 Development, service production, and dealership locations
- >20,000 Reciprocating engines sold per year
- 11,400 employees

50,000 Employees
18,245 Engineers
750 Apprentices
50 Countries
Inchinnan Facility

- 50,000m² factory, opened in 2004
- Moved East Kilbride facility here in 2016
- Aerofoils Centre of Excellence, shafts, turbine blades (new manufacture)
- Repair & Overhaul
- Forging operation
- 750 staff
Process Management
In-Service or “unique” NDT Validation Procedure

- Slow down “panic week”
<table>
<thead>
<tr>
<th>Project Information</th>
<th>Information/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Title + Red Top/SAR number if applicable</td>
<td></td>
</tr>
<tr>
<td>Names and contact details of key project individuals:</td>
<td></td>
</tr>
<tr>
<td>- IPT Leader</td>
<td></td>
</tr>
<tr>
<td>- Chief Service Engineer</td>
<td></td>
</tr>
<tr>
<td>Date for first meeting arranged with NDE Project Owner</td>
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<table>
<thead>
<tr>
<th>SAP Network and Activity Numbers</th>
<th>Information/Comments</th>
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<tbody>
<tr>
<td>Hours and Primary Cost numbers raised for initial NDE involvement. Details for Materials NDE Function are:</td>
<td></td>
</tr>
<tr>
<td>- Work Centre</td>
<td></td>
</tr>
<tr>
<td>- Plant Number</td>
<td></td>
</tr>
<tr>
<td>- Resource Manager</td>
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<tr>
<td>- Required Completion Date</td>
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<table>
<thead>
<tr>
<th>Component Information</th>
<th>Information/Comments</th>
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<tbody>
<tr>
<td>Confirm Design Authority</td>
<td></td>
</tr>
<tr>
<td>Part Name</td>
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<td>Part Number</td>
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<tr>
<td>Category</td>
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<table>
<thead>
<tr>
<th>Defect Information</th>
<th>Information/Comments</th>
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<tbody>
<tr>
<td>Type of defect (including surface or sub-surface)</td>
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</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td></td>
</tr>
<tr>
<td>Orientation</td>
<td></td>
</tr>
<tr>
<td>Surface roughness</td>
<td></td>
</tr>
<tr>
<td>Description of potential non-relevant false-cells (e.g. mechanical surface damage for ET; porosity, inclusions, and for-side damage for UT)</td>
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</table>

<table>
<thead>
<tr>
<th>Inspection Requirements</th>
<th>Information/Comments</th>
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<tr>
<td>Is the Inspection to be carried out at Manufacture, at Overhaul or On-Wing (anticipated locations)</td>
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<tr>
<td>Number of Inspection kits required</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Drawings</th>
<th>Information/Comments</th>
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<tbody>
<tr>
<td>Latest issue of Electronic drawings/3D models of the part and assembly (relevant)</td>
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</tr>
<tr>
<td>Agreement to send to external suppliers with Non-Disclosure Agreement in place</td>
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</table>

<table>
<thead>
<tr>
<th>Hardware</th>
<th>Information/Comments</th>
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</thead>
<tbody>
<tr>
<td>Components of same Part Number available for manufacture of bench trial test pieces</td>
<td></td>
</tr>
<tr>
<td>Access to components for future test pieces in kits</td>
<td></td>
</tr>
<tr>
<td>Agreement to send to external suppliers with Non-Disclosure Agreement in place</td>
<td></td>
</tr>
</tbody>
</table>

Identify who can define the problem and timeline
Get a budget
Check what engine marks are needed.
Cracks have 3 dimensions

Needed for purchasing... so we do in-house or outsource?
Plenty of CAD designers, but not a lot of NDE
Where is a practice engine?
Interpretation of User Requirements


Writing Purchase Specifications

Detailed SoR for purchasing NDE items.

Please engage with NDE Laboratory to get feedback on the “best” suppliers.

1. COMPONENTS

1. SCOPE

To be limited to the engine.

Method to be Eddy Current Inspection.

Inspection to be in accordance with RPS705 - Eddy Current Inspection.

Inspection to be limited to the defined inspection areas.

2. Definition of Inspection Areas

Inspection Area: Mount Lug Run-Outs

Orange lines indicate inspection areas.

Figure 1 – Inspection Areas

3. SURFACE CONDITION REQUIREMENTS

All inspection areas must be free from dirt, grease, burrs and debris.

There must be no coatings applied to the material under test.

Tests will indicate whether the surface finish is appropriate for eddy current inspection. This should include testing examples of the components with a surface finish towards the upper tolerance limit as specified by the component drawings.

Figure 2 – Inspection Zones on Mount Lug Run-Outs

Figure 3 – Inspection Zone on Corner

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Key Point:

- Involve the NDT team and conduct “value stream mapping” and “swimlane” type exercises to identify delays.
- Every lesson learned – ensure they are incorporated in your processes so history does not repeat itself.
- Ensure the customer signs off requirements capture to save later disagreements.
The problem

Ref: Australian Transport Safety Bureau
NDT Toolbox Concept

- Record things that are currently impossible to do with NDT, or the team are too busy to work on at the moment.
- Feed the impossible ideas to the University & Catapult network when they need collaborative projects to work on.
- For the more realistic projects, assign to Apprentices.
Key Learning

• “Things are only impossible until they are not”
Dye Penetrant

Case courtesy Jon Biddulph & Dawei Yan
Introduction

- An engine test rig disc was subject to FPI and 4 crack indications found.
- The disc was shipped to Failure Investigation at Elton Road for further analysis but only one large crack (4.5mm) could be found with FPI.
- Disc sent away for thorough clean and repeat FPI. Only the large crack could be found.
- Investigations revealed the investigator had applied replicating media (Microset 101FF) to find the three small crack indications.
- Microset leaves a surface residue that repels FPI.
- Certain products, e.g. coolants, cleaning solutions etc. that contain silicates/silicon based compounds may leave residues on components that cause fluorescent penetrant to separate on the component surface. FPI Process Spec RRP58003 recognises the potential for this and the actions to be taken.
- When applying the microset over a known crack and cleaning with Ardrox 204 rubber digester, the residue was removed but the crack was still undetectable by FPI and therein lies the safety concern.
Safety Concern: Justification to not raise Red Top

- Record things that are currently impossible to do with NDT, or the team are too busy to work on at the moment.
- Feed the impossible ideas to the University & Catapult network when they need collaborative projects to work on.
- For the more realistic projects, assign to Apprentices.
Safety Concern: Closure Strategy

- Instruct the following:
- All replicasting to be done after FPI.
- If it is deemed necessary to replicast prior to the standard FPI operation, then the area to which the moulding compound has been applied must be subject to a swab, or full etch to ensure the complete removal of any silicon residue (This may also require an oven dry sequence, dependent on the stage of manufacture).
- Where replicast is used for measurement purposes, and is deemed necessary prior to the standard FPI operation, the area in question must have FPI performed on the surface prior to the application of any moulding compound.
- Brief the FPI inspectors to be extra vigilant for evidence of the lack of adhesion of the Penetrant fluid in the area to which replicast was applied.
Eddy Currents

Case courtesy Mick Ticehurst
Eddy Current Inspection of Pipes

Pipe

OD Crack

Hub material

Weld

Hub material

Pipe

ID Crack
Eddy Current Inspection of Pipes

- Defect free
- Defect present
- Poor surface “noise”
Eddy Current Inspection of Pipes

Good surface finish (as per our laboratory samples) @ 50µm

Above shows “poor” surface finish (as per new samples)
Calibration Block Wear

- This lead to the conclusion that by using worn standards the sensitivity of the inspection would be higher leading to increased number of rejected components due to the noise level of the surface being inspected.
Key Learning

• Consult the drawing for uRa values and ensure test pieces reflect this.
• Fix – Updated “Intelligent Launch” checklist to capture additional material properties.
C-Scan Ultrasonic Tanks
Fanblade Inspection Tanks
Fanblade Inspection Tanks

Poka-yoke!
Fanblade Inspection Tanks

Poka-yoke!
Key Learning

• You can’t fit a circle in a square peg
Purchasing
Purchasing Rules
Key Purchasing rules

- Evergreen maintenance contracts & warranty
- Service Level Agreements for repair times
- Sources of compressed air, 415V supplies etc and HSE rules
- Extraction system design (LEVs)
- Stock up on consumables
- Data – avoid propriety file formats…… BINDT needs to influence Industry 4.0
- Work with the IT Department in advance and site management/HSE
- Gated payments
Key Learning

- Build a win-wing relationship with suppliers
Chris Stevenson’s Lessons Learned
Misc. Key Lessons Learned

• Always dual source during company emergencies.
• NDE staff are in short supply; someone else can run project plans, purchase probes and complete technical drawings.
• If you rely on other teams in a company, e.g. purchasing, drawing office, publications department, ensure you know who their manager is!
• Write in simplified technical English. No subcutaneous defects.
• If you have a tricky written procedure, consider making a video…. If you need to conduct 1:1 training, this can be very expensive for a global organisation.
• Always follow the validation procedure - don’t cut corners
Conclusion

• Stick to the validation procedure.
• Update the validation procedure with lessons learned.