Automation of NDE on RSRM Metal Components

Presented by:
John Hartman, ATK Thiokol Propulsion
Mark Kirby, Westinghouse AMDATA
Automation of NDE on RSRM components

Acknowledgements
The authors would like to acknowledge the following people and organizations for their contributions to this effort

Mike Suits  Marshall Space Flight Center, NASA
Craig Bryson  Marshall Space Flight Center, NASA
Scott Teunis  Progressive Technologies, Inc.
Dave Kay  ATK Thiokol Propulsion
Automation of NDE on RSRM components

- Past NDE on RSRM metal components
- Why change?
- Advantages/Improvements
- Elements of Automated Inductive Inspection System
- Current Status
Past NDE on RSRM metal components

- Historically, nearly all NDE has been visually based
  - Magnetic particle inspection of steel components
  - Liquid penetrant of aluminum components
  - Semi-automated and manual eddy current inspections of select holes and joints

- Goal of inspections: detect surface cracks or discontinuities in both new and refurbished metal components
Past NDE on RSRM metal components

Case Magnetic Particle Inspection Bay
Past NDE on RSRM metal components
Past NDE on RSRM metal components
Past NDE on RSRM metal components

WHY CHANGE?
Why Change?

- Biggest Reason: *Increase Reliability*
- **Reliability**: Assurance that critical sized flaws will not go undetected
- Remove the strong dependency on operator skill and attentiveness
Why Change?

- Safe flight is certified by Proof Test, NDE, or both
- Based on in-house POD study, current magnetic particle inspections do not reliably screen for Critical Flaws in ALL regions
  - Minimum Detectable Flaw Size (90/95) > Critical Flaw Size
- These areas must be certified by proof and/or eddy current
Why Change?

Solution:

Implement an Automated Inductive Inspection System (AIIS) with the capability of reliably detecting critical sized surface flaws.
Advantages of the AIIS

- **Control & Repeatability**
  - Inspections, data acquisition & analysis are programmed
  - Same inspection & analysis each time
  - Detection sensitivity is calibrated
  - Pressure is no longer on the operator & his attentiveness
Advantages of the AlIS

- **Better detection capability**
  - Overall, AllS will find smaller flaws more reliably (at a 90% POD/95% CL)
  - Current sensitivity levels are set at 0.1” and 0.25” long cracks (2:1 length-to-depth ratio)
Advantages of the AllS

- **Data Storage**
  - All data and images are stored
  - This can be useful in developing history for a part and for determining the nature of flaws (manufacturing vs. service)
Advantages of the AllS

- **Reduction of waste streams**
  - No solvents or chemicals to dispose of
  - Reduction or elimination of acid etch
    - Also extends lifetime of aluminum parts
Advantages of the AllS

- Potential reduction of process time for Case Hardware and Aluminum Nozzle Hardware
  - Possible elimination of acid etch process
  - Possible elimination of glass bead
Elements of AllS

5 independent axes
7 axes when inspecting various holes
Elements of AILS

Close up of wrist

A-axis

B-axis
Elements of ALLS

- Turntable is on rails, extends into high bay for loading and offloading of components
- Components are mounted on adjustable chocks
Elements of AILS

- Each component incorporates multiple "probe sleds" used to inspect different part geometries
- All sleds slide onto wrist using dovetail joint
Elements of AllS

Various Sleds
Elements of AllS

- Operator interface: Part Inspection Program (PIP)
  - Operator selects part; then probe sled

```
<table>
<thead>
<tr>
<th>Analysis</th>
<th>Scnd</th>
<th>Alzd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cal Out Block ID Out 0 Deg 47.6&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aft End Up ID Membrane Section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cal In Block ID Out 0 Deg 47.6&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ID Membrane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cal Out Block ID Out 0 Deg 47.6&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aft End Up OD Membrane Section</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cal In Block OD Out 0 Deg 47.5&quot;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aft End Up ID Holes (Ye 'Ole Log Shoe pointing circ).025</td>
</tr>
<tr>
<td>Cal In Block ID Out 0 Deg 47.6&quot;</td>
</tr>
<tr>
<td>ID Holes</td>
</tr>
<tr>
<td>Cal Out Block ID Out 0 Deg 47.6&quot;</td>
</tr>
<tr>
<td>Aft End (Ye 'Ole Log Shoe) 0.75</td>
</tr>
<tr>
<td>Cal In Block ID Out 0 Deg 47.6&quot;</td>
</tr>
</tbody>
</table>
```
Elements of AlIS

- All regions and surfaces inspected with the sled are selected, and the AlIS inspects those surfaces
- Each "region" starts & ends with a calibration scan

<table>
<thead>
<tr>
<th>Inspection</th>
<th>Sled</th>
<th>Sled configuration</th>
<th>Region</th>
<th>Surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100420-01_IDH.sld</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>▶ Aft End Up ID Holes (Ye 'Ole Log Shoe pointing circ).025</td>
<td>Cal In Block ID Out 0 Deg 47.6&quot;</td>
<td>ID Holes</td>
<td>Cal Out Block ID Out 0 Deg 47.6&quot;</td>
<td></td>
</tr>
</tbody>
</table>

Start | Abort
Elements of AILS

Cal standard with notches

Impedance & strip chart display
Elements of AIIS

- Scan surface of interest
Elements of AllS

- PIP keeps track of data acquired and analyzed

Data can be reviewed by clicking on surface. Right-clicking to get auto analysis results.
Elements of AllS

- After all data is acquired, analysis results can be printed out
- All auto analysis findings are reviewed for final evaluation
- C-scan images are also independently reviewed by the operator in a pseudo real-time mode
Elements of AllS

- Part is off-loaded and next part is loaded on
Current Status

• AIIS is now inspecting flight hardware concurrently with the certified NDE process (MT, PT, ET, UT)
• Once all qualification paperwork and approvals are obtained, the majority of the visual and manual inspections (MT, PT, ET) will be deleted
• Select areas that tend to more frequently have cracks will continue to be double inspected (AIIS & MT)
Concluding Statements

- An automated eddy current system has been designed and built, and is being implemented to inspect RSRM (Space Shuttle) metal components.
- The system provides a significant increase in inspection reliability, as well as other benefits such as data storage, chemical waste reduction and reduction in overall process time.