Eddy Current As Alternate Method for Inspection of Welded Joints

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Product Support Leaders
GE Inspection Technologies
Inspection of welded joints for surface breaking cracks is required in most land based and off-shore petro-chemical facilities.

Surface breaking cracks can lead to catastrophic failure if undetected and not repaired.
### Traditional Weld Inspection Methods

**Liquid Penetrant and Magnetic Particle**

<table>
<thead>
<tr>
<th><strong>Advantages</strong></th>
<th><strong>Dis-Advantages</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reasonable cost</td>
<td>• Coating must be removed prior to inspection then re-applied</td>
</tr>
<tr>
<td>• Portable</td>
<td>• Disposal of chemicals</td>
</tr>
<tr>
<td>• Minimal inspector training</td>
<td>• Time consuming</td>
</tr>
<tr>
<td>• Easy Interpretation of data</td>
<td>• Scaffolding often required</td>
</tr>
<tr>
<td></td>
<td>• No digital documentation of indications</td>
</tr>
</tbody>
</table>
EN 1711 (Mar 2000)
Eddy Current Examination of Welds by Complex Plane Analysis
Recently Converted to ISO/DIN 17634 Standard

Other Approvals
- Lloyds Register
- DNV (Det Norske Veritas)
- Bureau Veritas
1 Scope

This standard defines eddy current examination techniques for detection of surface breaking and near surface planar imperfections, mainly in ferritic materials (weld material, heat affected zones, parent materials).

This eddy current technique can also be applied to other metallic construction materials (e.g. stainless steels) if required by the design specification.

The techniques can be applied to coated and uncoated objects during fabrication and in service, onshore and offshore.

The examination can be carried out on all accessible surfaces and on welds of almost any configuration.

Usually, it can be applied in the as-welded condition. However, a very rough surface can prevent an efficient examination.

Unless otherwise specified for specific points in this standard, the general principles of prEN 12084:1995 apply.
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<table>
<thead>
<tr>
<th>Time</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post Clean Repainting</td>
<td></td>
</tr>
<tr>
<td>Inspection</td>
<td></td>
</tr>
<tr>
<td>Developer Application &amp; Dwell</td>
<td></td>
</tr>
<tr>
<td>Penetrant Application &amp; Dwell</td>
<td></td>
</tr>
<tr>
<td>Paint Stripping &amp; Cleaning</td>
<td></td>
</tr>
</tbody>
</table>
### LP Inspection Time

<table>
<thead>
<tr>
<th>Step</th>
<th>Time (2.5 to 3:1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post Clean Repainting</td>
<td></td>
</tr>
<tr>
<td>Inspection</td>
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<td></td>
</tr>
</tbody>
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### Eddy Current Inspection Time

- 2.5 to 3:1 LP to EC

### Diagram

- Surface Prep
- Inspection
- Development Application & Dwell
- Penetrant Application & Dwell
- Paint Stripping & Cleaning
- Post Clean Repainting
- Inspection
<table>
<thead>
<tr>
<th></th>
<th>LP/MP Cost</th>
<th>EC Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certified Inspector</td>
<td>$</td>
<td>$$$</td>
</tr>
<tr>
<td>Consumables</td>
<td>$$$</td>
<td>None</td>
</tr>
<tr>
<td>Capital Equipment</td>
<td>$</td>
<td>$$$$$</td>
</tr>
<tr>
<td>Compliant Disposal of Consumables</td>
<td>$$$$$</td>
<td>None</td>
</tr>
</tbody>
</table>
# LP Versus EC

## Inspection Cost Comparison

<table>
<thead>
<tr>
<th>Penetrant Inspection - 6 off Joints</th>
<th>Time Taken (mins)</th>
<th>Time/Cost</th>
<th>Typical Timings/Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint removal</td>
<td>40</td>
<td>mins</td>
<td>40 mins</td>
</tr>
<tr>
<td>Inspection pre-clean</td>
<td>18</td>
<td>mins</td>
<td>18 mins</td>
</tr>
<tr>
<td>Penetrant Application</td>
<td>12</td>
<td>mins</td>
<td>12 mins</td>
</tr>
<tr>
<td>Penetrant Dwell</td>
<td>20</td>
<td>mins</td>
<td>20 mins</td>
</tr>
<tr>
<td>Excess Penetrant Removal</td>
<td>18</td>
<td>mins</td>
<td>18 mins</td>
</tr>
<tr>
<td>Developer Application</td>
<td>6</td>
<td>mins</td>
<td>6 mins</td>
</tr>
<tr>
<td>Developer Dwell</td>
<td>10</td>
<td>mins</td>
<td>10 mins</td>
</tr>
<tr>
<td>Evaluation</td>
<td>18</td>
<td>mins</td>
<td>18 mins</td>
</tr>
<tr>
<td>Post-clean</td>
<td>18</td>
<td>mins</td>
<td>18 mins</td>
</tr>
<tr>
<td>Repainting</td>
<td>20</td>
<td>mins</td>
<td>20 mins</td>
</tr>
<tr>
<td>Total Time Taken</td>
<td>3.0 hours</td>
<td>hours</td>
<td>3 hours</td>
</tr>
<tr>
<td>Man Hour Rate</td>
<td>$24</td>
<td>US$</td>
<td></td>
</tr>
<tr>
<td>Total Man Hour Costs</td>
<td>$72</td>
<td>US$</td>
<td></td>
</tr>
<tr>
<td>Consumables, including scaffolding costs if applicable</td>
<td>$60</td>
<td>US$</td>
<td>Min $10/joint</td>
</tr>
<tr>
<td>Total Inspection Cost</td>
<td>$132</td>
<td>US$</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EC Weld Inspection - 6 off Joints</th>
<th>Time Taken</th>
<th>Time/Cost</th>
<th>Typical Timings/Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Prep</td>
<td>0.25 hours</td>
<td>15 mins = 0.25 hrs</td>
<td></td>
</tr>
<tr>
<td>EC Inspection</td>
<td>1 hours</td>
<td>1 hour</td>
<td></td>
</tr>
<tr>
<td>Man Hour Rate</td>
<td>$60</td>
<td>US$</td>
<td></td>
</tr>
<tr>
<td>Total Inspection Cost</td>
<td>$75</td>
<td>US$</td>
<td></td>
</tr>
<tr>
<td>SAVING US$</td>
<td>$57</td>
<td>US$</td>
<td></td>
</tr>
<tr>
<td>TIME SAVING</td>
<td>2 hours</td>
<td></td>
<td></td>
</tr>
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</table>
LP Versus EC
Inspection Cost Comparison

Hyperlink to .xls
Middle East 250,000 Barrel Per Day Refinery
LP Inspection Costs During Shutdown
~ 10,000 Weld Joints for Cracks

• 500 cans of penetrant aerosols ~ $6,500

• Total Inspection Time: ~5,000 hrs.
  • ~2,100 hrs. for LP
  • ~2,900 hrs. for pre and post Inspection tasks
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LP Inspection Costs During Shutdown
~ 10,000 Weld Joints for Cracks

- 500 cans of penetrant aerosols ~ $6,500

- Total Inspection Time: ~5,000 hrs.
  - ~2,100 hrs. for LP
  - ~2,900 hrs. for pre and post Inspection tasks

Eddy Current: ~1,700 hrs. for entire inspection with no consumables
Eddy Current Inspection of Welds

Field proven EC probe designs minimize impact of rough surfaces

Standard
High Wear Ceramic Tip
High Temperature
(425°F/220°C)
Eddy Current Inspection of Welds

Field proven EC probe designs minimize impact of rough surfaces

Standard High Wear Ceramic Tip
High Temperature (425F/220C)

Minimal Lift Off Effect Due to Rough Weld Surface
Eddy Current Inspection of Welds
Guided Workflow Helps Ensure Consistent Inspection and Reduce Error Traps

Weld Calibration

Step 1
Place the number of shims determined from the coating measurement step over the reference standard notches.

Step 2
Perform a "Null/Instrument Balance".

Step 3
Scan probe over 1.0 mm notch and adjust the signal (gain and phase) to be at 100% screen height on the vertical from the balance point.
Digital Documentation of Weld Indications
Collaboration with Remote Experts

Cloud Services

Connected Devices
Web Portal

Real-time access to knowledge from off-site experts
More accurate and efficient inspections
Real-time sharing of inspection data
Digital Gain Control (DGC) to Compensate for Varying Coating Thicknesses

As coating/paint thickness varies across a weld, gain automatically readjusted to ensure inspection sensitivity.
Summary

• Eddy current is an ISO (EN) approved inspection method for welded joints
• Eddy current offers distinct advantages over LP/MPI
  • No consumables to purchase
  • No consumables to dispose of
  • No need to remove coatings prior to inspection
  • Digital record of inspection
• Simple financial analysis can identify break even point for EC inspection compared to LP/MPI
• Guided workflows and remote collaboration can further enhance weld inspections
• Digital Gain Control further improves weld inspection productivity
GE Inspection Technologies
Mentor EM for Weld Inspection