RT-VT & PAUT results on AUP weld coupons for LMQXFA cold mass

Contributions form NDT team in EN/MME/MM
Gonzalo Arnau
Alexandre Porret (RT, VT)
Simon Bonnin (PAUT)
Summary

- RT & VT results
- PAUT procedure used on CERN MQXF longi welds
- PAUT inspection of LMQXFA weld coupons
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**ISO 6520-1 reference for identified defects (imperfection designation):**
- 2011 (Gas Pore)
- 2014 (Linear porosity)
- 401 (Lack of fusion)
- 5011 (Continuous undercut)
- 5012 (Intermittent undercut)
- 5014 (Inter-run undercut)
- 602 (Spatter)

**ISO 5817 level B (VT) and ISO 10675-1 level 1 (RT):**
- A = Acceptable
- NA = Not Acceptable following ISO 5817 level B (VT) and ISO 10675-1 level 1 (RT)
PAUT procedure used on CERN MQXF longi welds
Equipment

PAUT device: Omniscan MX2

Probes tried:

- **Probe A27**
  - Dual matrix array
  - 4MHz, compression wave
  - 64 elements x 2
  - 2 wedges tested

- **Probe A25**
  - Dual linear array
  - 5MHz, compression wave
  - 32 elements

- **Probe A15**
  - Dual linear array
  - 3.5MHz, shear wave
  - 16 elements

Set up software: NDT Setup Builder

Post treatment Software: Omni PC
Reference blocks extracted from real MQXF cold mass welds

Sample 1

1A
SDH Ø2.0mm, 25mm length Center line, bottom

1B
notch 2.0x2.0mm, 25mm length chamfer, top

1C
SDH Ø2.0mm, 25mm length Center line, top

Sample 2

2A
SDH Ø2.0mm, 25mm length Center line, middle

2B
notch 2.0x2.0mm, 25mm length Center line, bottom

Sample 3

3A
SDH Ø2.0mm, 25mm length chamfer line, top

3B
notch 2.0x2.0mm, 25mm length Center line, top

3C
SDH Ø2.0mm, 25mm length chamfer line, bottom
Analysis software: OMNI PC

A-Scan

S-Scan

Encoding scan along the weld

B-Scan
UT Signature of artificial defects in reference block in S-Scans

Without defect

Notch

SDH centered line

Table 2 — Description of testing levels

<table>
<thead>
<tr>
<th>Mode</th>
<th>Testing levels</th>
<th>Example of sketches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed angles at fixed probe position to weld (time scan)</td>
<td>Two sides</td>
<td>Not suitable as single technique</td>
</tr>
<tr>
<td>Fixed angles with center scanning</td>
<td>One side</td>
<td>One side</td>
</tr>
<tr>
<td>E-scan at fixed probe position (time scan)</td>
<td>One side</td>
<td>Two sides with two angles</td>
</tr>
<tr>
<td>F-scan at fixed probe position to weld (time scan)</td>
<td>One side</td>
<td>Two sides or two probe positions</td>
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Top, front

Bottom

EN ISO 13588
B-Scan of Reference Blocks

All indications are detectable, except notch centered on the surface

3B : Not detectable
Gain setting / evaluation level

Non-destructive testing of welds —
Phased array ultrasonic testing (PAUT) —
Acceptance levels (ISO 19285:2017)

On the reference blocks, the gain to have all the indications at 90% SH is around 33.5 dB

Scans performed at 43.5 dB

Figure A.1 — Levels for techniques 1 and 3 for thicknesses 6 mm to 15 mm — Acceptance level 2

ISO 5817 Quality Level C

ISO 5817 Quality Level B
### Example of real MQXF cold mass weld extremity

<table>
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<tr>
<th>Angle 60</th>
<th>Angle 62</th>
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<tr>
<td>X = 0 mm – 24 mm</td>
<td>X = 238 mm – 269 mm</td>
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<tr>
<td>X = 572 mm – 618 mm</td>
<td>X = 665 mm – 750 mm</td>
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Example of real MQXF cold mass weld extremity. Analysis of PAUT indications

→ **Good correspondence** of PAUT indications with RT indication and with weld imperfections revealed by cross-sections
PAUT inspection of LMQXFA weld coupons
### 2. Control parameters

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Conformity: A = Acceptable, NA = Not Acceptable following ISO 10675-1 Level 1

- **5011 = continuous undercut**
- **Lack of fusion on surface, Not visible with PAUT**
PAUT Inspection

Scan using a block to keep same distance between wedge and weld = 4mm

All the samples have been scanned with the same settings MQXF welds. Gain at 43.5 dB
B-Scan - Sample W1

RT results
Nothing to report

PAUT results
Nothing to report
B-Scan - Sample W2

Angle 63
Nothing to report

Angle 76
Nothing to report
B-Scan - Sample W3

**RT results**
- 5011

**PAUT results**
- Indications type porosity or 5011
  - amplitude < 90%SH
  - acceptable classe B and C
- Indication type LOF
  - amplitude < 90%SH
  - acceptable classe B and C
B-Scan - Sample W4

RT results
5011
401 (LOF) at 290 mm

PAUT results
Indication at 290 mm:
Signal at 43.5dB
Signal at 39.5dB
under 90% SH acceptable level B & C
B-Scan - Sample W5

RT results
Nothing to report

PAUT results
Indications acceptable

Angle 64

Angle 61
B-Scan - Sample W6

Angle 63

RT results
5011

PAUT results
Indications acceptable

Angle 61
B-Scan Sample W7

**RT results**

Nothing to report

**PAUT results**

Nothing to report

Lack of fusion?
B-Scan - Sample W8

Angle 62

RT results
Nothing to report

PAUT results
Indications acceptable

Lack of fusion?

Angle 65