TROLLEY FOR ULTRASONIC INVESTIGATION OF RAIL DEFECTS

MODEL FILUS X27W
(with wheel probes)

The Trolley for Ultrasonic Investigation of Rail Defects model FILUS X27W is a hand-pushed trolley, specially designed to check on track the two rails by ultrasonic testing, the trolley is capable of continuous detection of the rail for a number of defects including transversal flaws in the head of the rail (kidney-shaped defects), inspection of gauge and field faces for head checks, longitudinal flaws over the whole height of the rail, star cracks around bolt holes, vertical cracks in welds, porosity and inclusions in thermit welds and corrosion defects at the rail foot. The FILUS X27W uses two wheel probes on each rail rather than traditional sliding probes.

Thanks to on-board electronic and computerized assistance, the detected defects actuate an acoustic and visual warning, the display shows the position of the defects in the rail and the complete inspection is continuously recorded for later analysis.

1. DESCRIPTION AND OPERATION

Rugged, totally self-contained, the FILUS X27W trolley for rail defect investigation is composed of several elements, which can be easily carried to site. The FILUS X27W can be assembled in few minutes by only one operator without tools.

The FILUS X27W is hand-pushed along the track under test, at walking speeds that can be fast on welded track, slow down in welds areas, or moderate on fish-plate jointed track in drilled hole areas, providing a high accuracy of ultrasonic testing.
1. DESCRIPTION AND OPERATION (Cont’d)

The testing operates through ultrasonic wave beams emitted by a series of probes in contact with the running surface of the rail, preliminary wet to obtain an optimum acoustic coupling. The FILUS X27W can control rails which have rail head width between 40 and 80 mm. A device enables the operator to precisely adjust the centring of probes according to the width of the running surface.

Every discontinuity (crack, segregation) detected by a judiciously oriented beam generates a fault echo, which results of an audible warning signal, and this is whichever the probes used. This echo, modified to an electrical signal by the probe and treated by the electronic equipment, can be visualized on the screen, the operator having previously decided which signal he wants. Then the operator can more precisely locate the defect by means of a set of hand probes. Once identified, the signal from each defect can be recorded (along with the data from all the system probes) and, the rail can be precisely marked with paint (see chapter 3 – Accessories and options at extra price).

The Trolley for Rail Fault Ultrasonic Investigation model FILUS X27W is mainly composed of the following elements:

- Two running parts, each including:
  - Two wheel probes swinging in the central part, each wheel containing three probes, prevented from being blocked, with adjustment device allowing the operator to centre the probes in the longitudinal axis of the rail. The wheel position is adjusted according to the width of the rail head to be inspected.
  - For testing to -40°C optional sliding probes can be readily exchanged with the wheel probes (see chapter 3 – Accessories and options at extra price).
  - Two water nozzles for the acoustic coupling liquid (water);
  - An insulated roller, to guide the probes on the rail;
  - A handle to assist the probes over switches.
  - A distance encoder, fitted to one wheel to automatically record the position data.

- An aluminium frame in aluminium which includes:
  - One working plate on which is placed the control electronics and interfaces;
  - Two tanks for acoustic coupling liquid located on each side of the trolley. A valve which is ergonomically placed to the operator’s hand, allows adjusting the flow and stop during idle time.
  - Four lifting handles with ergonomic rubber handles to enable the FILUS X27W to be lifted on and off track;
  - Two metallic storage boxes used to store the manual probes, spare parts, additional tools for the complete ultrasonic inspection of the track and battery;

- One pushing arm which includes:
  - Two ergonomic rubber handles, protecting the operator’s hands;
  - The mounting for the display electronics, the display can be inclined so the screen will always face the operator with an optimum visibility, when pushing the trolley or when running manual tests;
  - A special control box to select Bolt Hole Inspection mode for a more sensitive inspection of the area around bolt holes specifically to identify star cracks;
  - A brake to ensure that the trolley does not “run away” on the track;
1. DESCRIPTION AND OPERATION (Cont’d)

- **The electronic, computer and electric equipment** including:
  - *The “ultrasonic electronic”* which is composed of the following different components:
    - One **electronic box**, lightweight, portable and impact resistant, that encloses the electronic ultrasonic electronics. On this box are mounted:
      - a - Multichannel plugs for connections to the probes;
      - b - Multichannel plug for connection to the interface box “oscilloscope”.
    - A second **electronic box** (computer display) is mounted on the handle comprising:
      - a - An LCD display of the ultrasonic data in A-scan, B-scan or Schematic style for the defect indication;
      - b - A number of buttons to change the display function on the screen;
        - i) A-scan mode;
        - ii) B-scan mode;
        - iii) Manual mode;
        - iv) Distance change;
        - v) Auto adjust for rail height change.
      - c - A display for the distance;
      - d - Two multichannel connectors from the probe electronics;
      - e - Memory card holder for data storage.

- The electric power supply including an **integrated rechargeable battery** (with its own specific space on the trolley) and one **external battery charger**.

The FILUS X27W is supplied with a test rail simulating typical defects used for gauging and the adjustment of the device.

The FILUS X27W is delivered with a PC software for the analysis, comparison of data generated by the FILUS X27W.

The following table details the defects that can be detected with the FILUS X27W (end of document).

The FILUS X27W is supplied with (not exhaustive list) with:
- Its calibration rail for device testing;
- Its earphones;
- One set of small tools (rule, screwdriver, spatula, magnifying glass, etc.);
- One set of manual probes;
- One set of cables;
- Its battery and its charger;
2. TECHNICAL DATA

- Probes:
  Number (7 per rail – in the longitudinal plan of the rail):
  
<table>
<thead>
<tr>
<th>Description</th>
<th>Total number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical probe at 0°:</td>
<td>2 (1 per rail)</td>
</tr>
<tr>
<td>Oblique probes at 70°:</td>
<td>4 (2 per rail)</td>
</tr>
<tr>
<td>Oblique probes at 58/34°:</td>
<td>4 (2 per rail)</td>
</tr>
<tr>
<td>Oblique probes at ±42°:</td>
<td>4 (2 per rail)</td>
</tr>
</tbody>
</table>

- Emission:
  Pulse repetition frequency preset at: 800 Hz
  Frequency of ultrasounds:
    - all probes: 2.5 MHz
  Time base: In time or distance

- Reception:
  Amplification: from 0 to 64 dB

- Ultrasonic testing instrument:
  Ultrasonic electronic card:
    Total number: 2 (1 per rail)
    Electronic signal processing: 2 (1 per rail)

- Acoustic coupling liquid:
  Water (at low temperatures it is recommended to add antifreeze, at very low temperature alcohol can be used)

- Liquid tank:
  Number: 2 (1 per rail)
  Capacity: ≈ 12 Litre per tank

- Fault detection signal:
  Number of tones: 4
  - Automatic and manual Probe Channel 0: 500 Hz Continuous « low range »
  - Automatic and manual Probe Channel 1: 500 Hz Intermittent « low range »
  - Automatic Probe Channels 2-9: 1 000 Hz Continuous « mid range »
  - Manual Probe Channels 2-6: 2 000 Hz Continuous « high range »
  - Stereo Function: Left and right for left/right rails

- Echo visualization:
  Screen Size: 10.4 Inch Touch screen display
  Screen display modes: 3 A-scan, B-scan, Schematic

- Display and storage of recordings:
  Type: Hard Drive
  Typical disk space available: 6 Gbyte
2. TECHNICAL DATA (Cont’d)

- Analysis:
  - A-scan: Real time analysis
  - B-scan: All data greater than 6dB below sensitivity limit is automatically stored
  - Manual data: 10 Channels per rail saved

- Rechargeable internal battery:
  - Type: sealed lead acid accumulator
  - Voltage: 12 V
  - Minimum autonomy: >16 hours trolley usage

- Testing speed:
  - Maximum testing speed: 7 Kph
  - Recommended testing speed: 4 Kph

- Operating temperature: from 0°C to +50°C
- Humidity: up to 95% (non condensing)
- Gauge: 1 435 mm (other configuration available on request)

- Dimensions (depending on gauge and probes configuration):
  - Length in operating position: ≈ 1 320 mm
  - Length in transit position: ≈ 480 mm
  - Width: ≈ 1 840 mm
  - Height: ≈ 980 mm

- Total mass in operating regime: ≈ 42 kg for 1 435 mm track without water (depending on the quantity of water contained in the two tanks)

3. ACCESSORIES AND OPTIONS (at extra price)

- Auxiliary batteries
  Same characteristics than those described in the second chapter

- Sliding probes
  Alternate probe set for low temperature operation

4. CONSUMABLES (at extra price)

- Paint spray (delivered by box of six cans of 750 ml)

We reserve the right to modify any equipment specification of the present offer to take into account the latest technical improvements and working conditions at the date of manufacturing. Pictures and drawings may include some options and are not contractual.
### 5. LIST OF DEFECTS

<table>
<thead>
<tr>
<th>Kind of defect</th>
<th>Cause of defect</th>
<th>UIC Defect code</th>
<th>Defect location</th>
<th>Defect parameters</th>
<th>Defect image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse cracks in rail head</td>
<td>Develops from an original internal defect inside the rail head, an</td>
<td>111</td>
<td>At joint</td>
<td>&quot;kidney-shaped&quot; or tache ovale defect diameter not less than 12mm.</td>
<td><img src="image1.png" alt="Image 1" /></td>
</tr>
<tr>
<td></td>
<td>internal horizontal crack, or very occasionally deep shelling of the</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>gauge corner.</td>
<td>211</td>
<td>Beyond joint</td>
<td></td>
<td><img src="image2.png" alt="Image 2" /></td>
</tr>
<tr>
<td>Transverse cracks in rail head</td>
<td>Develops from an internal defect in the head of the weld</td>
<td>411.1</td>
<td>Flash butt Welding Zone</td>
<td></td>
<td><img src="image3.png" alt="Image 3" /></td>
</tr>
<tr>
<td></td>
<td>Develops along a plane near a normal cross-section of the profile</td>
<td>421</td>
<td>Thermit Welding Zone</td>
<td></td>
<td><img src="image4.png" alt="Image 4" /></td>
</tr>
<tr>
<td>Cracks at the periphery of the</td>
<td></td>
<td>431</td>
<td>Electric arc welding position</td>
<td>&quot;kidney-shaped&quot; or tache ovale defect depth more than 8mm</td>
<td><img src="image5.png" alt="Image 5" /></td>
</tr>
<tr>
<td>welding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transverse cracks in rail head</td>
<td>Transverse fatigue crack across the resurfaced part of a railhead</td>
<td>471</td>
<td>Welding or resurfacing position</td>
<td></td>
<td><img src="image6.png" alt="Image 6" /></td>
</tr>
<tr>
<td>Transverse cracking under</td>
<td></td>
<td>481</td>
<td>At right angles with an</td>
<td></td>
<td><img src="image7.png" alt="Image 7" /></td>
</tr>
<tr>
<td>electrical connection</td>
<td></td>
<td></td>
<td>electrical connection for</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>return current</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 5. LIST OF DEFECTS (Cont’d)

<table>
<thead>
<tr>
<th>Kind of defect</th>
<th>Cause of defect</th>
<th>UIC Defect code</th>
<th>Defect location</th>
<th>Defect parameters</th>
<th>Defect image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Rail head delaminations</td>
<td>Manufacturing defect</td>
<td>112</td>
<td>Above the rail web, at rail end</td>
<td>Defect depth &gt;8mm, defect length &gt;10mm</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>212</td>
<td>Above the rail web, away from rail end</td>
<td></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>Vertical rail head delaminations</td>
<td>Manufacturing defect</td>
<td>113</td>
<td>In rail head, ±5mm of vertical rail axis, at rail end</td>
<td>Defect depth &gt;10mm, defect length &gt;10mm</td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>213</td>
<td>In rail head, ±5mm of vertical rail axis, away from rail end</td>
<td></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>Vertical Rail Web delaminations</td>
<td>Manufacturing defect</td>
<td>133</td>
<td>In rail web, ±5mm of vertical rail axis, at rail end</td>
<td></td>
<td><img src="image5.png" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>233</td>
<td>In rail web, ±5mm of vertical rail axis, away from rail end</td>
<td></td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
<tr>
<td>Horizontal cracking at head-to-web transitions</td>
<td>Manufacturing defect</td>
<td>1321</td>
<td>Head/web interface at rail end</td>
<td>Defect length &gt;10mm</td>
<td><img src="image7.png" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2321</td>
<td>Head/web interface away from rail end</td>
<td></td>
<td><img src="image8.png" alt="Image" /></td>
</tr>
<tr>
<td>Horizontal cracking at web-to-foot transitions</td>
<td>Manufacturing defect</td>
<td>1322</td>
<td>Web/foot interface at rail end</td>
<td>Defect length &gt;10mm</td>
<td><img src="image9.png" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2322</td>
<td>Web/foot interface away from rail end</td>
<td></td>
<td><img src="image10.png" alt="Image" /></td>
</tr>
</tbody>
</table>
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<table>
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<tr>
<th>Kind of defect</th>
<th>Cause of defect</th>
<th>UIC Defect code</th>
<th>Defect location</th>
<th>Defect parameters</th>
<th>Defect image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial crack in the web or “Star Crack”</td>
<td>Defect due to traffic loads on a poorly drilled or finished hole</td>
<td>135</td>
<td>Originating at a bolt hole and radiating at approximately 40-45°</td>
<td>Length &gt;5mm if across all of web, or &gt;10mm at one side of the web</td>
<td><img src="image1" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>235</td>
<td>Originating at a non-bolt hole and radiating at approximately 40-45°</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>236</td>
<td>Diagonal cracking away from any hole</td>
<td></td>
<td><img src="image2" alt="Image" /></td>
</tr>
<tr>
<td>Vertical transverse cracks in the rail foot</td>
<td>Start at corrosion site or damage sites on the rail foot</td>
<td>154</td>
<td>Within ±5mm of rail centerline at rail end</td>
<td>Length &gt;10mm, depth &gt;10mm from rail foot</td>
<td><img src="image3" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>254</td>
<td>Within ±5mm of rail centerline other than at rail end</td>
<td></td>
<td><img src="image4" alt="Image" /></td>
</tr>
<tr>
<td>Transverse breaks without apparent origin</td>
<td></td>
<td>100</td>
<td>At rail end</td>
<td></td>
<td><img src="image5" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td>200</td>
<td>Elsewhere in the rail</td>
<td></td>
<td><img src="image6" alt="Image" /></td>
</tr>
<tr>
<td>Full section breaks</td>
<td>Starts at site of bruising or impact damage from a defective wheel, defect</td>
<td>301</td>
<td></td>
<td></td>
<td><img src="image7" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>growth due to traffic load</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Start at a site of faulty machining or track drilling, defect growth due to</td>
<td>302</td>
<td></td>
<td></td>
<td><img src="image8" alt="Image" /></td>
</tr>
<tr>
<td></td>
<td>traffic load</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>