Ultrasonic Detection of Wet Hydrogen Damage

BACKGROUND:

Wet hydrogen damage is categorized as base material damage, which leads to blistering and Step-Wise Cracking. Alternatively, the damage can occur in the heat-affected zone of the weld in which case SOHIC (Stress Oriented Hydrogen Induced Cracking) can occur.

TECHNIQUE:

Either type of damage can be detected when a vessel is in service by using an automated ultrasonic technique. In the early stages of damage, a compression test will be adequate for the base material inspection. However, in the later stages of damage, the base material and the weld inspection require the use of both compression and shear wave ultrasonics.
The stages of base material damage are:

1. Specular: A condition where the compression probe receives a large number of small single pixel reflectors. This can indicate the onset of Hydrogen damage. The individual small areas are not joined to form a laminar blister.

2. Laminar: This stage of damage generated an area or multiple areas of laminations, often at different depths, but generally towards the center of the thickness. The back echo from the full thickness has high amplitude. No shear indications are noted at this stage.

3. Blister: At this stage the lamination faces are open and the back echo is reduced. Often a ghost echo from a second reflection of the ligament thickness is visible within the test zone.

4. Step-wise Cracking: The blisters are joined by cracks, visible by the changes in step thickness from the compression probes and signals from the shear probes.

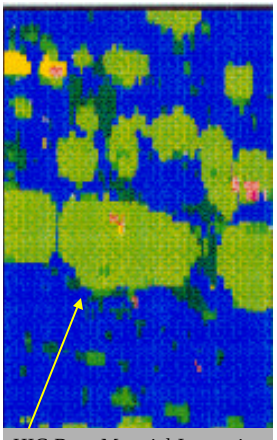


Figure 1 – Base Material Inspection Blistering

When the reflections from the blisters reach the stage shown in figure 1 above, additional shear inspection is required to determine if Step-Wise cracking is present.

Earlier stages show no loss of “back-wall echo” as seen in figure 2.

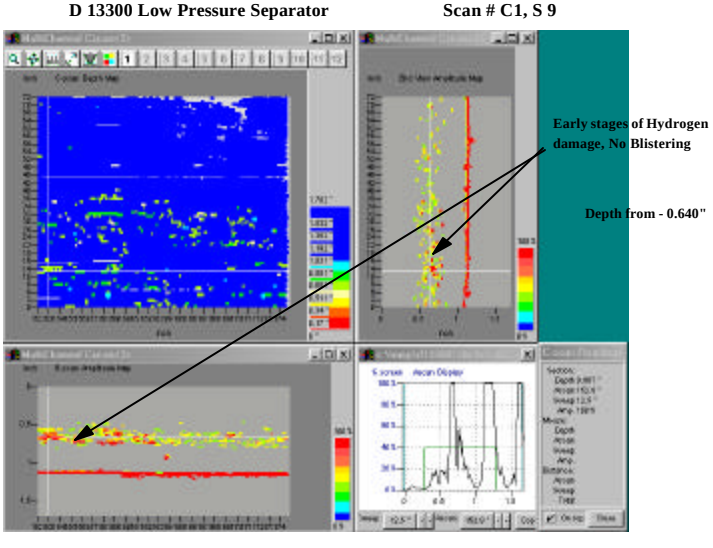


Figure 2 – Early stages of Hydrogen damage, no blistering

P.O. Box 398 Humble, TX 77347 Phone: 281-543-5636 E-Mail: mail@mechanicalintegrityinc.com

Ultrasonic Detection of Wet Hydrogen Damage

In contrast, a blister detected with compression data shows a clear loss of "back-wall echo" below the blister (see figure 3).

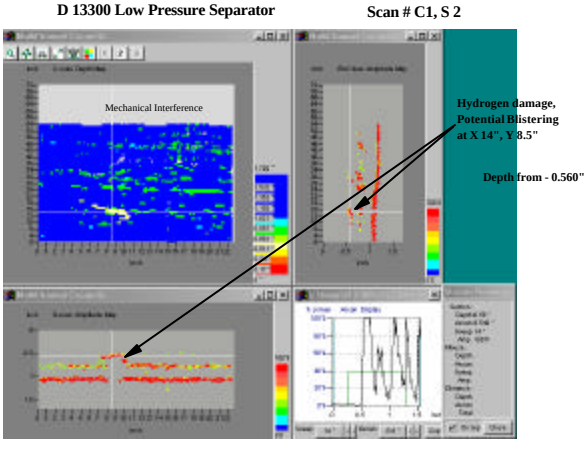


Figure 3 – Hydrogen Damage, Potential Blistering

This was then re-inspected with a special array (figure 4) to determine if Step-Wise cracking was present (figure 5).

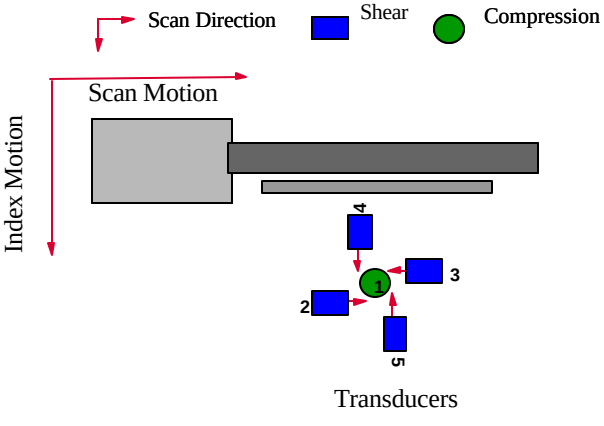


Figure 4 – Special Array used to determine Step – Wise Cracking

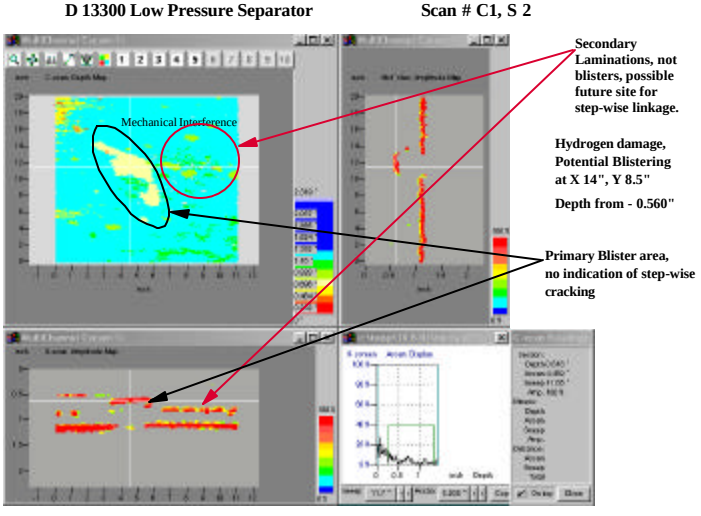
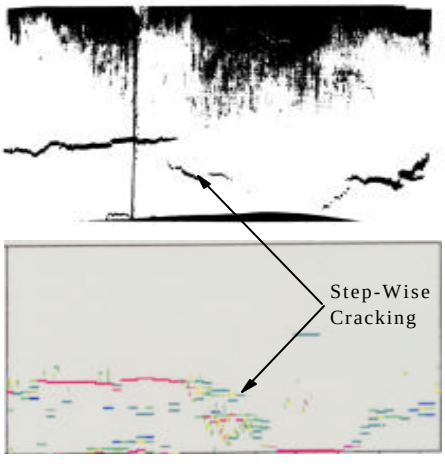


Figure 5 – Secondary Laminations, Hydrogen Damage, Primary Blister Area, no Indication of Step-Wise Cracking

In this case the high-resolution scan did not show any shear wave indications from the blister areas. A point to note is that a number of laminar indications exist adjacent to the blister. These will be likely to become a source for Step-Wise cracking at some later date.

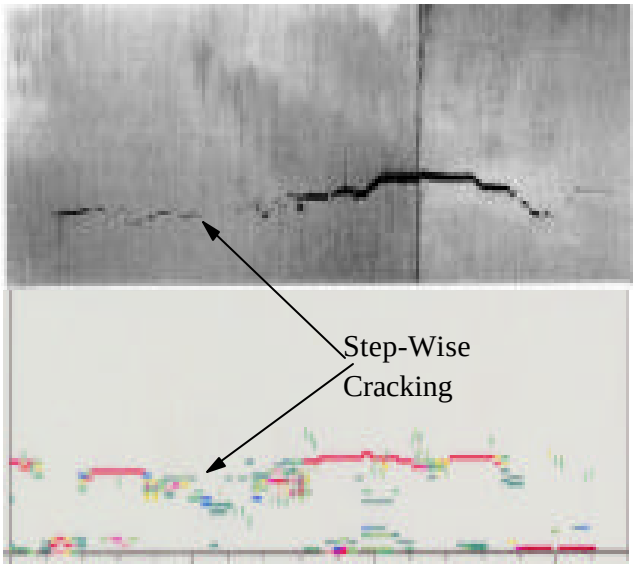
Step-Wise cracking examples are provided in the following illustrations:

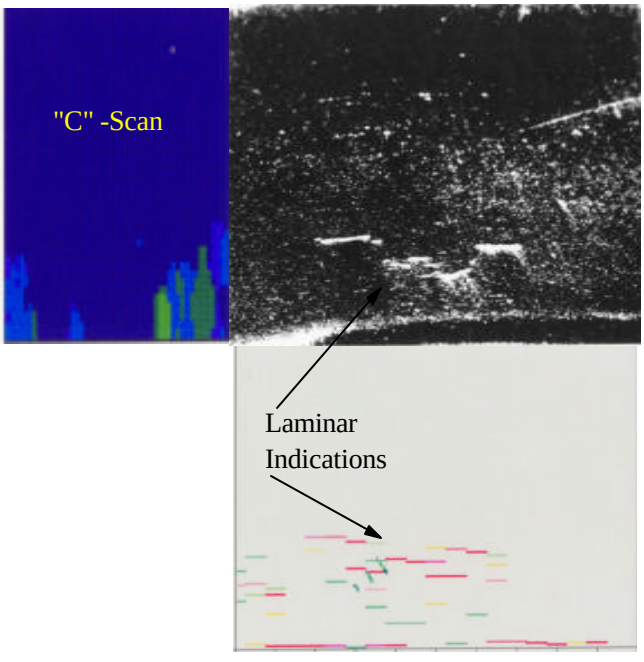


P.O. Box 398 Humble, TX 77347 Phone: 281-543-5636 E-Mail: mail@mechanicalintegrityinc.com

Mechanical Integrity

Ultrasonic Detection of Wet Hydrogen Damage





Weld inspection is preformed in the regular pulse echo mode with two shear and two compression probes. SOHIC is detected in the heat-affected zone of the weld and reported in the same “B” and “C” Scan mode.

Care has to be taken in the calibration of the ultrasonic sensors as high-level gains can lead to misinterpretation of results. The following illustration shows laminar indications so fine that they could only be identified visually with fluorescent dye Penetrant.

CONCLUSION:

1. Automated Ultrasonic techniques are effective in the detecting and monitoring of HIC and SOHIC.
2. The damage can be classified and monitored for severity.
3. The remaining ligament can be measured from the compression data.
4. Any additional risks can be detected from shear wave data.

P.O. Box 398 Humble, TX 77347 Phone: 281-543-5636 E-Mail: mail@mechanicalintegrityinc.com