High temperature hydrogen attack (HTHA) is a phenomenon which occurs within some industrial processes when the presence of hydrogen, subjected to high temperature and pressure, makes plants and systems susceptible to damage. This reaction can cause an industrial plant to suffer serious failure, which may lead to both expensive repairs and loss of production.

HTHA can be detected in a number of ways, but the reliability of some of the techniques used in its detection is questionable. We have developed a series of procedures featuring the latest advances in ultrasonic imaging and data processing techniques in order to achieve a greater level of confidence in both HTHA inspection results and inspection repeatability.

Available techniques in accordance with American Petroleum Institute (API 941)

**Backscatter**
The backscatter technique is used to detect suspicious areas affected by hydrogen attack. The front of the attack in the material can be measured and imaged. The remaining wall thickness (un-attacked) is assigned a color.

**Time of flight diffraction (TOFD)**
With time of flight diffraction (TOFD) testing it is possible to inspect welds for defects resulting from HTHA. It can be used for the detection of both macro and micro cracks. Macro cracks can easily be identified with TOFD. Micro cracks, however, can be challenging to discriminate from other types of weld defects. Also here a verification is found by cross-referencing the results to a Pulse-Echo or Phased Array UT examination.

**Velocity ratio measurement**
Velocity ratio measurement is based on the principle that the longitudinal and transverse sound velocities are affected by HTHA, by means of which the percentage of attack can be measured. By cross-referencing the results with the backscatter measurement, a confirmation of the amount of attack is established. In addition, the methodology used allows for a differentiation between small inclusions and HTHA.

A typical display of the backscatter technique

Ts = Unattacked wall thickness  
Ta = Attacked wall thickness  
Cl = Longitudinal sound velocity in unattacked material  
Ct = Transverse sound velocity in unattacked material  
Cla = Longitudinal sound velocity in attacked material  
Cta = Transverse sound velocity in attacked material

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Areas for application

Backscatter and velocity ratio measurement are used for the inspection of the parent material. Time of flight diffraction is used for the inspection of the weld material.

Benefits at a glance

- Digital techniques.
- High reliability and reproducibility.
- Clear presentation of results.
- Numerous different geometries can be examined.
- Damage progress can be accurately monitored.

## Inspection strategy

<table>
<thead>
<tr>
<th>Susceptibility</th>
<th>Operating conditions</th>
<th>Inspection strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>At or above Nelson Curves</td>
<td>High inspection coverage: backscatter mapping, velocity ratio measurement, ToFD, 45° shear wave inspection</td>
</tr>
<tr>
<td>Medium</td>
<td>Up to 25 °F below Nelson Curve</td>
<td>Medium inspection coverage, backscatter mapping, manual, velocity ratio measurement, ToFD, 45° manual. (no requirement to open vessel)</td>
</tr>
<tr>
<td>Low</td>
<td>Between 50 °F below Nelson Curve</td>
<td>Low inspection coverage: manual backscatter, ToFD</td>
</tr>
<tr>
<td>None</td>
<td>More than 50 °F below Nelson Curve</td>
<td></td>
</tr>
</tbody>
</table>

## About TÜV Rheinland:

Founded 140 years ago, TÜV Rheinland is a global leader in independent inspection services, ensuring quality and safety for people, the environment, and technology in nearly all aspects of life.

## Our expertise – your benefit:

TÜV Rheinland Sonovation has many years of experience of using the TOFD technique in every industrial segment from power generation to projects in the defense, manufacturing, chemical and petrochemical industries. Our aim is to achieve customer satisfaction by offering the latest and best technologies available.

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