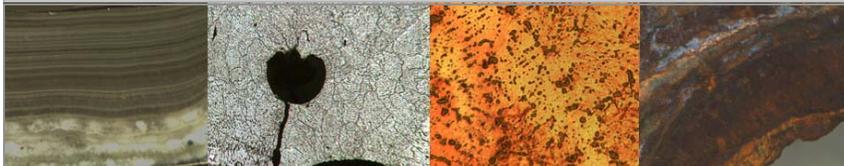


# NU S & B L S



**New Hampshire  
MATERIALS  
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**WELD FAILURES**

**FEBRUARY 2013 SUPPLEMENT ISSUE**

## Welcome to New Hampshire Materials Laboratory

Here at New Hampshire Materials Laboratory (NHML) our goal is to help you with all your testing needs. We offer a variety of analysis and tests whether it is a failure analysis, a material analysis, tensile strength, load testing and more.

In this Nuts & Bolts supplement, we discuss weld failures. A problem our customers see out in the field and we often see here at the lab.

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Tim Kenney

Laboratory Director

## Weld Failures

The failures of welds can be divided into three categories: design, deficiencies, weld related defects that can be founded by inspection, and failures in service including overload and fatigue. In this article we take a closer look at Hydrogen Assisted Cracking (HAC), also referred to as cold cracking. HAC is a common cause of weld failures in both structural components and castings.

There are several kinds of discontinuities that can occur in welds or adjacent heat affected zones. These discontinuities include cracks, slag inclusions, porosity, lack of penetration. Cracks are the most serious of these discontinuities because they greatly reduce the expected fatigue strength and tensile strength of a weld and may be difficult to detect by visual examination or radiography.

Cold cracks also known as hydrogen cracking are those that occur after the weld metal has cooled to room temperature. Hydrogen assisted cracking (HAC) can take place in either the weld or the heat affected zone. For HAC to take place, three conditions must be present:

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1. Atomic Hydrogen must be available for dissolution in the weld pool.
2. The weld metal or the heat affected zone cracking (HAZ) must be susceptible to hydrogen embrittlement. Hydrogen cracking can occur in low and medium carbon steels but it is usually associated with the higher hardenability that comes with higher carbon content and with alloyed steels
3. High Tensile stresses from weld constraint must also be present.

Base metal cracking is usually the result of high carbon, alloy, or sulfur content. Base metal cracking can be controlled by awareness of the effects of composition (above), high preheat, elevated interpass temperatures, minimal penetration by using smaller electrodes and lower current (providing less dilution), and the use of low hydrogen electrodes.

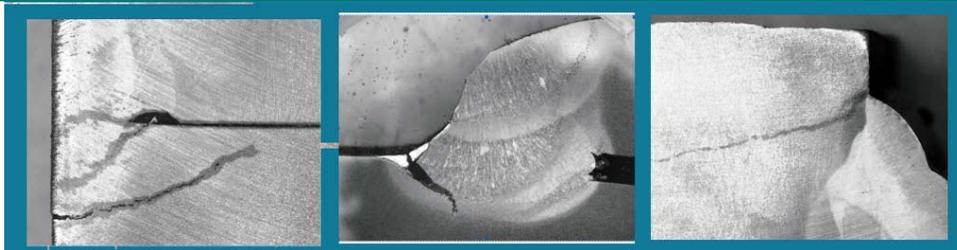
R.D. Stout describes the steps in the heat affected zone cracking (HAZ) as follows:

- Hydrogen is introduced into the molten weld metal dissolves into the weld pool atomic hydrogen.
- As the weld metal cools it becomes super saturated with hydrogen affected zone.
- With rapid cooling the hydrogen has insufficient time to diffuse out of the HAZ. Rapid cooling also increases the likelihood of the austenite transforming into martensite, and atomic hydrogen with solubility in martensite collects at discontinuities in the lattice.

External stresses from thermal contraction and constraint combined with the stress in the lattice from the trapped hydrogen causes the discontinuities to enlarge into cracks. The hydrogen present migrates to the new crack root causing the crack to continue to enlarge. This last step is the cause of the commonly occurring delayed cracking. Delayed cracking may shortly follow cooling but may not take place for 48 hours after welding.

Minimizing the hydrogen that can diffuse into the weld pool is important. Hydrogen can come from a number of sources. Hydrogen containing electrodes and moist electrodes are a common source of hydrogen. Dry, low-hydrogen electrodes should be used. Hydrogen can also come from surface contaminants such as oil, grease, and dirt. Hydrogen may also be introduced into the weld pool from rust and pain or other surface coatings.

Post weld stress relief is often desirable and sometime mandatory after the welding of hardenable steels. This generally involves heating the weldment to a temperature in the 1100-1200 °F range and holding the part at temperature for one hour per inch of thickness. This combination of time and temperature is usually sufficient for hydrogen diffusion. Section VIII of the ASME Boiler and Pressure Vessel Code provides a useful guide for conditions under which a post weld stress-relieving heat treatment should be performed.



Weld Failures

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