

# Understanding Destructive Testing

*Common weld tests such as tension, bend/flex, shear, hardness, and impact are explained*

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Welds play a crucial role in product safety, quality, reliability, strength, and durability in many industries. From the manufacture of automobiles, planes, and ships, to the construction of highways, bridges, buildings, and pipelines, the effective application of welds is a key ingredient to a successful end product. Standards writing institutions, including the American Welding Society and others around the world such as ASTM, ISO, EN, and JIS, have put in place standards that provide consistency in test procedures for welds.

Tested in both a dynamic and static state, common weld tests include tension, bend/flex, shear, hardness, and impact.

## Tensile Testing

Tensile testing (or tension testing) is one way of evaluating a weld's strength and ability to withstand loading. Cross-weld, or cross-joint, tensile testing is most commonly used to evaluate the strength of butt-joint welds joining the ends of two pieces of material. A cross section is cut so that the tensile specimen is oriented across the weld. Tests performed on these specimens will encompass the weld material, the heat-affected zones (HAZs), and the base material at each end.

In some cases, longitudinal testing along the length of the weld may also prove useful if more data are needed specifically for the weld metal or HAZ.

Testing standards such as ASTM E8, ISO 6892, EN 10002-1, and JIS Z 2241 define how to perform proper tensile testing on metallic materials. These standards define critical elements, such as the equipment needed to perform the testing, how to prepare test specimens, proper measurement techniques, testing speeds and control parameters, calculation results, and how to report the results. Since welded specimens are nonhomogeneous over their gauge length, the primary test results of interest are typically the ultimate tensile strength (UTS) and the location of the fracture. However, typical tensile results such as Young's modulus, yield strength, percent elongation, and area reduction may also be recorded for reference purposes. Details related specifically to tensile testing of welds can be found in AWS B4.0:2007, *Standard Methods for Mechanical Testing of Welds*.

Tensile testing of welds is also common for welded wire reinforcement. Also known as welded wire fabric (WWF), this product is comprised of steel wires arranged in longitudinal and transverse series. Each intersection of wires is welded to create a wire grid that is used for the reinforcement of concrete (ASTM A497). Test standards such as ASTM A497 and ISO 15630-2 pro-



*Fig. 1 — Shown are Instron® 100-kN pneumatic wedge-action grips, which help to maintain accurate alignment of the specimen during tensile testing. (All photos courtesy of Instron®.)*

vide details on how to conduct a weld shear test on the weld joining a longitudinal and transverse wire. This test is typically conducted using a shear fixture that can be loaded in the tensile direction. The maximum load required to break the weld is recorded as the weld shear strength.

To ensure accurate tensile properties throughout the test, the grips (Fig. 1), load string, and frame of the test system must maintain accurate alignment of the specimen in relation to the center of the load cell. Without this alignment, premature failure can occur.



Fig. 2 — A guided bend test on a welded sample.

## Bend/Flex Testing

Bend/flex testing on welds provides manufacturers with a quality control check to determine the ductility and soundness of the weld and/or the weld process. Defects with welds generally exist due to incomplete penetration and fusion of the weld to the base metal. These types of defects may not always be visible to an X-ray test, so a destructive bend/flex test is very important to understand the resistance of the weld. Specific thicknesses and correct alignment of the test specimens are specified by several standards such as ASTM E190 and AWS B4.0.

Guided bend tests on welds typically involve bending a flat specimen using a plunger and support arrangement to allow bending the specimen 180 deg — Fig. 2. Visual inspection of the weld is required and any tears or defects are reported along with the bend radius. If the specimen fails prior to bending 180 deg, the achieved bend angle should also be recorded.

Equipment used for bend tests should provide proper alignment, accurate load readings, and proper test control. The test machine should also have enough travel to successfully complete the bending of the specimen.

## Hardness Testing

Hardness testing of welded material is an excellent example of the traditional challenges associated with microhardness testing. A series of traversed hardness measurements across the weld, and most importantly in the heat-affected zone (HAZ), can determine if the weld is applied correctly and within specifications. Traditional testing techniques require manual stage traversing and manual indentation reading via a microscope system — Fig. 3. The results obtained are subjective and dependent on each individual's interpretation; therefore, the accuracy, consistency, and reliability of the test data are questionable. Other

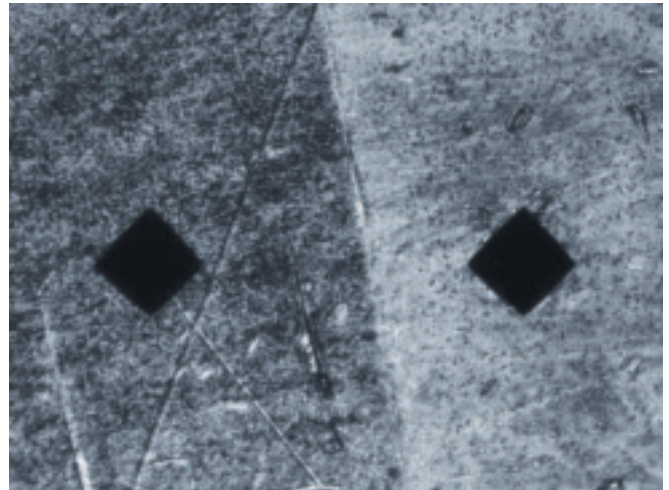


Fig. 3 — Cross section of welded tubing. Advances in digital camera technology, application software, and testing hardware have made image analysis of hardness tests more reliable.

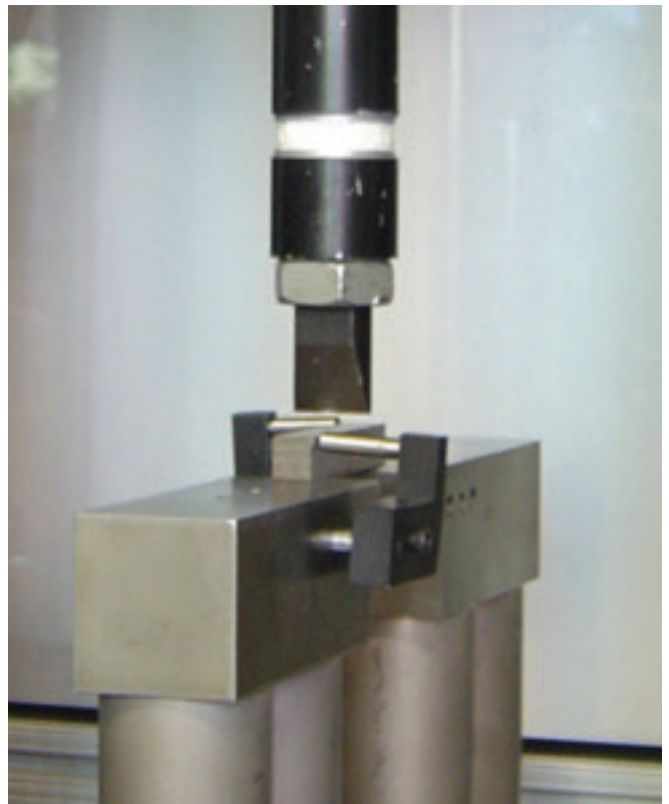


Fig. 4 — A Charpy V-notch impact test being performed on a welded specimen.

disadvantages to this approach are the associated costs, extensive labor requirements, and fatigue factor resulting from repetitive microscope work. Adding to the difficulties in weld analysis is the stark contrast between the HAZ and the surrounding areas. For years this minimized or negated the effectiveness of automatic indentation reading packages, requiring time-consuming manual test procedures.

Recent advances in digital camera technology, application software, and testing hardware have played a significant role in the emergence of image analysis as a viable tool in weld assessment.

## Impact Testing

Impact testing of welded material, using instrumented pendulum and drop weight testers, provides information about the impact strengths and behavior properties of the weld. Weld properties behave differently if a preexisting fracture in the weld is exposed to a sudden impact, even more so at low or high temperatures. With this in mind, designers must understand what affects unpredictable occurrences, such as seismic activity, head-on collisions, or flying debris, have on their structural designs. The fracture strength of a weld is temperature dependent, so it is important for the design engineer to understand the weld's brittle-to-ductile transitional state. Drop-weight tear tests and Charpy V- (Fig. 4) and U-notch tests are common impact tests on metals.

Instrumented testing allows for accurate data measurement — displayed in table and graph formats — for energy, velocity, time, and deflection properties. The ability to examine the load/energy vs. time curves enables the user to identify the initiation of brittle fracture in structural steels. This information is essential when evaluating the ability of a product or component to withstand yield point loading in the presence of a small flaw.❖

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