

# NDE 1-2-3: Inspection Techniques for Weld Applications

## Selecting the right nondestructive examination tool for the job

BY JESSE HERRIN

There's hardly a more definite way to test a weld's integrity than to push it past its breaking point. Unfortunately, no matter what destructive testing method you use,

you're left with a part or material that's no longer fit for service.

Nondestructive examination (NDE) techniques range from simple manual and visual tests to sophisticated tech-

nologies that can detect surface and subsurface flaws, porosity, variations in metallurgical structure, and other discontinuities without having to destroy, damage, or waste assets.

Whether you contract NDE services as part of a quality assurance program or your organization handles its own inspections, it's important to know the pros, cons, and latest developments in tools and techniques for weld applications.

Let's take a closer look at the various approaches.

## Penetrant Testing

Penetrant testing (PT) has been used for decades to find surface-breaking flaws in metal and other non-porous materials. It involves applying a colored liquid to the surface and allowing capillary action to draw the penetrant into open cracks; the liquid becomes visible under ultraviolet light or by the contrasting color of the dye being used, indicating the presence of defects to the technician.

In a localized area, PT can be affordable and efficient. However, it requires chemicals and extensive surface preparation, including the removal of paint or coatings. The time and cleanup involved are compounded in a big work environment.

## Magnetic Testing

Magnetic testing (MT) uses magnetic fields to locate surface and near-surface discontinuities in ferromagnetic material. Fine ferromagnetic particles are applied to the material and are drawn into any surface-breaking defects. MT is only effective on ferrous



Fig. 1 — Handheld eddy current tools increase test speed and are easy to use. Color touchscreens and C-scan capability provide real-time visual feedback to the technician and the welding crew.

material, and like PT, surface prep and cleanup add time to the inspection. Neither technique produces a detailed digital record of the inspection results.

## Radiography

Conventional radiography uses x-rays or gamma rays in combination with film to indicate welding flaws. The image quality will vary with the skill of the technician, and because the results take time to develop, the feedback to the technician is not immediate. Also, having radiation at the job site can be disruptive and a safety concern to work crews.

## Eddy Current

Eddy current testing is ideal for detecting surface and subsurface defects in conductive materials. The technician places a probe or coil to a metal surface; the probe generates an electromagnetic field that induces electrons to flow in the material. Any discontinuities in the metal will distort the flow of electrons, which is captured and analyzed by an eddy current instrument.

The newest generation of handheld eddy current tools has increased test speed, accuracy, and repeatability, especially on long weld runs and large inspection areas. Instruments like Zetec's MIZ-21C have the processing power, software, and battery life to perform inspections virtually anywhere. They also generate a digital record of inspection that can be stored, analyzed, and compared against a history of results. Their C-scan capability provides real-time visual feedback to the technician and the welding crew — Fig. 1.

Eddy current array (ECA) takes eddy current a step further. ECA probes have multiple coils in one assembly, positioned at longitudinal, transverse, or off-axis orientations, and fire at coordinated times. Technicians can capture more information in a single pass.

One practical limitation of ECA is that the excitation coils need to be close to the material for accurate flaw detection and signal quality. Probe suppliers now offer flexible probes that allow the coils to stay nominally perpendicular to the material's surface — Fig. 2. In the case of a nonferromagnetic weld, for example, a flexible

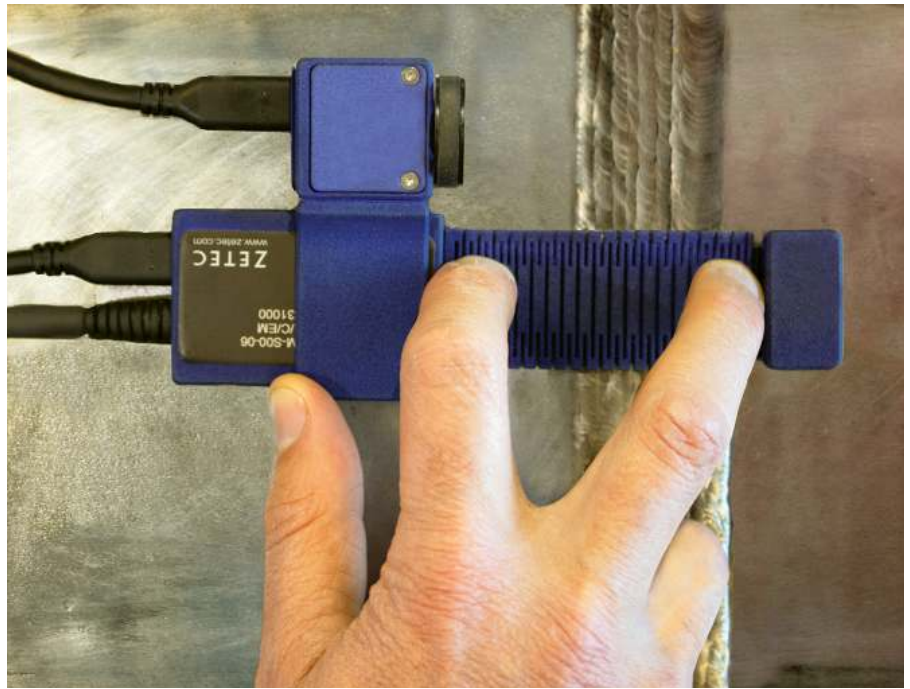


Fig. 2 — Eddy current excitation coils need to be close to the material for accurate flaw detection and signal quality. Probe suppliers now offer flexible probes that allow the coils to stay nominally perpendicular to uneven surfaces and encapsulate the weld bead, transition zone, and heat-affected zones in one pass.

surface array probe can encapsulate the weld bead, transition zone, and heat-affected zones in one pass.

## Ultrasound

Ultrasonic testing (UT) uses high-frequency sound energy to indicate flaws both on and beneath the surface.

Ultrasonic waves enter the material at precise intervals and a set angle. When a wave encounters a defect, some of that energy is reflected back and generates an echo. The time it takes for that energy to reflect back to the probe is calculated and analyzed by the test instrument and presented instantaneously as a graphic on a screen. The inspector can validate completed



Fig. 3 — Improved portability and processing have brought PAUT weld inspections to locations that were once considered out of reach. (Photo courtesy of Zetec, Empresas Concremat.)

welds and provide feedback to the crew as they go about their work.

Phased array ultrasonic testing (PAUT) is an advanced inspection method that uses multiple individual elements (typically from 16 to 64) in a single probe. By exciting each element in a controlled manner, a PAUT instrument can produce a precise beam shape and generate views of a flaw with greater speed and accuracy. Like ECA, the results are immediate, digital, and detailed on a C-scan. Because of advancements in software, portability, and battery life, technicians can bring this computing power virtually anywhere — Fig. 3.

A conventional or standard UT probe is capable of generating and receiving a single ultrasonic beam. PAUT's multiple independent ele-

ments in a single probe make it possible to capture and store all time-domain signals (A-scans) from every transmitter-receiver pair of elements in the array, a technique called full matrix capture or FMC. FMC allows this "full matrix" of raw A-scan signals to be processed in real time. Signals can also be saved for offline processing using different sets of reconstruction parameters for any given focal law or beam (aperture, angle, or focus depth).

With the right combination of probes situated on either side of a weld, PAUT can detect all welding flaw types and provide reliable through-wall sizing in one pass, which increases probability of detection and improves the productivity of the inspection team simply by reducing the number of scans and manipulations that need to be done.

## Conclusion

Nondestructive examination technology continues to evolve in ways that produce inspections that are quick to set up and complete while delivering a high probability of detection. Given the full range of techniques available, it's possible to strike the right balance of inspection speed, detection capability, and cost effectiveness — without having to destroy the piece you're testing. **WJ**

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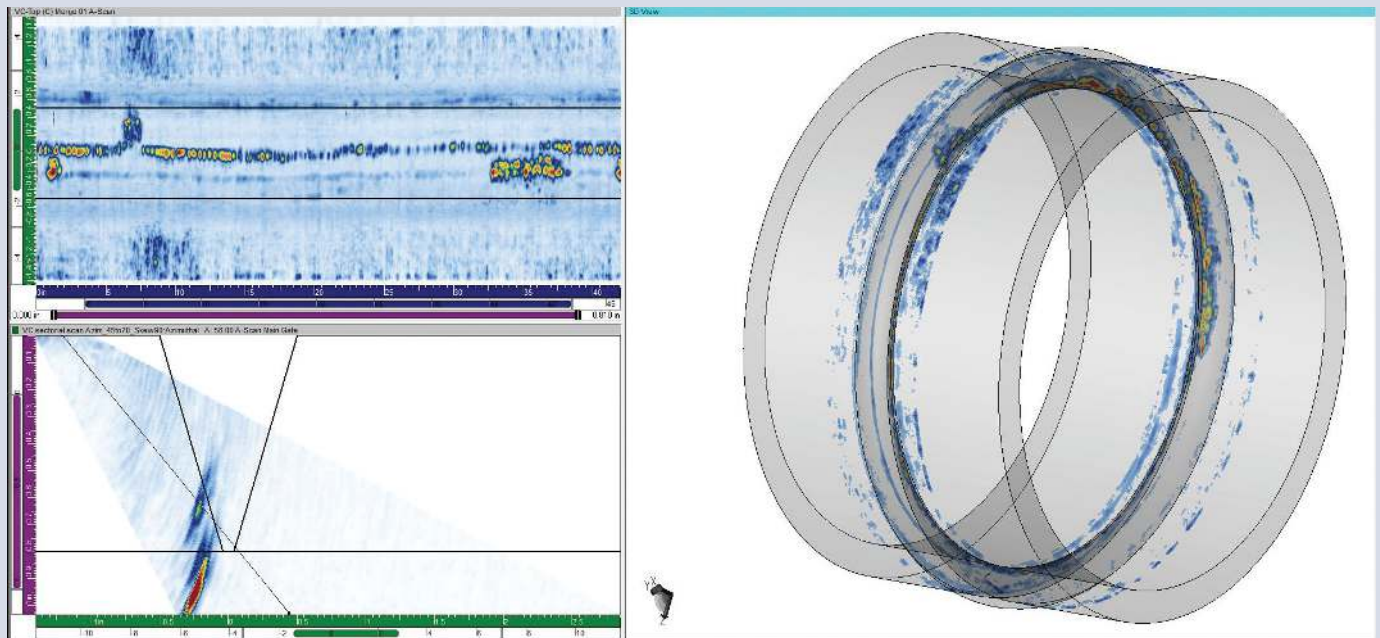
# A Clearer Picture: How PAUT Delivers 3D Results

Today's phased array UT instruments and software give technicians the computing power to transform traditional two-dimensional (2D) inspection data into full-color, three-dimensional (3D) visualizations.

The process involves merging data from 2D scans taken from different positions and angles and overlaying it onto a computer-aided design (CAD) file or 3D rendering of the pipe, joint, weld, or other type of specimen under test. Software can also simulate acoustic beams and characterize the energy distribution from any given probe, including single-

element (conventional UT), one-dimensional linear arrays, and 2D matrix arrays. These renderings are so clear and detailed that you don't need a deep understanding of UT scans to easily recognize corrosion, weld defects, and other indications on the screen.

Having a clean, easy-to-interpret picture on the screen, in the moment, lets inspectors and clients alike clearly see the condition of their assets and inform their decisions about safety, uptime, and code compliance.



Phased array UT software creates a 3D visualization by layering inspection results, seen in the A-scan data on the left, over a CAD file or rendering of the component under test, on the right. The bright "hot spots" indicate corrosion or changes in thickness.