Ultrasonic Phased Array Examination of Butt Fusion Joints of High-Density Polyethylene (HDPE) Pipe

Background

High-density polyethylene (HDPE) piping has been used in place of steel alloys in the petrochemical, power, and mining industries due to its exceptional resistance to corrosion and erosion. Recently, HDPE has also been used for nuclear safety-related cooling water applications. The application of nuclear quality assurance requirements creates reasonable assurance that the production fusion joint is sound. Ultrasonic time-of-flight-diffraction (TOFD) inspection of fusion joints is an easily employed nondestructive examination tool that can be used to provide some assurance of fusion-joint integrity. As a supplement to this test, ultrasonic phased array (UTPA) inspection of simulated fusion joints has also been evaluated as a non-destructive examination tool in order to provide additional assurance of fusion-joint integrity. This application note outlines the potential for phased array inspection of HDPE pipe joints.

The HDPE joint process is typically subject to the following flaws: lack of fusion, cold fusion (partial bond), inclusion (embedded foreign objects), and voids. There is currently no consensus in the industry as to the nature and size of rejectable flaws; however, non-destructive examination is often requested to detect these conditions.

HDPE material has some specific acoustic characteristics that make butt joint inspection difficult. The impedance and sound velocity of the material is similar to that commonly used for ultrasound wedge materials, which makes it difficult to use these materials to achieve appropriate refraction of sound at the interface. In addition, coupling between wedges and the material can be difficult to achieve. Also, HDPE material is very attenuative, which often prohibits the use of higher ultrasonic frequencies. It also exhibits a natural high frequency filtering effect. To overcome these hurdles, low frequency phased array probes mounted on phased array water wedges are used.

Cross section of an HDPE fusion joint
Equipment

The following equipment is used for the inspection:

- 1 OmniScan MXU PA with 32:128 module or greater
- 1 CHAIN Semi-automatic Scanner (X or XY version)
- 1 CFU03 or comparable water delivery system
- 1 PA Splitter (OMNI-A-ADP05)
- 2 2.25L64-48X12-A2-P-5-OM phased-array probes
- 2 SA2-N68L-HDPE-WHC custom PA water wedges (U8721948)

or

- 2 .25L16-12X12-A1-P-5-OM phased array probes
- 2 SA1-N68L-HDPE-WHC custom PA water wedges (U8721949)

**Note:** The custom PA wedges listed above have been designed with specific applications variables in mind. Should the application set up vary significantly from the expectation these wedges may no longer be suitable and design changes recommended. For additional information, please contact eto@olympusndt.com.
Typical procedure

The linear array probe 2.25L64-A2 allows for simultaneous testing with two different scanning configurations. As shown below, it allows for one or more linear scans at fixed angles such as 65° and 75° longitudinal wave (diagram at the left). It also allows for performing a sector scan from a fixed aperture (diagram at the right).

The 2.25L64-A2 probe is mounted on a water wedge designed to generate 60° longitudinal wave sound waves in the HDPE material. The inspection can be performed from both sides of the welds simultaneously. The probe assembly is mounted on the CHAIN Scanner and the inspection is performed with one complete rotation around the pipe.

The same procedure is used with the 2.25L16-A1 probe but this probe can typically only perform a sector scan.

Results

This section presents results obtained on a 265 mm (10.5 in) diameter HDPE pipe with a 25 mm (1 in.) thick wall containing different artificial reflectors. It should be noted that no weld beads were present for these tests. The configuration used was a sector scan from 50° to 87° LW (actual steering angles not verified).

The picture below shows the results obtained when inspecting vertical 3 mm flat
bottom holes located at different depths. All FBHs are detected with an excellent signal-to-noise ratio.

FBH depth: 22 mm 19 mm 13 mm 6 mm 3 mm

The picture below shows the results obtained when inspecting with saw cuts with different remaining walls. All saw cuts are detected with an excellent signal-to-noise ratio. Even the diffraction echo of the tip of the saw cut is clearly detected allowing height measurement of the indication.

Remaining wall: 13 mm 6 mm 3 mm

**Conclusion**

The use of ultrasonic phased array in conjunction with the OmniScan and other appropriate tools has shown to be a valid method for non-destructive inspection of artificial reflectors in HDPE. This technique could show promise as a complementary technique to TOFD for inspecting HDPE butt fusion joints.