When performing contact ultrasonic testing (UT), the surface condition of the inspected item is an important variable. Surface conditions include: cleanliness, contour and waviness, and roughness. Requirements for surface cleanliness are formulated in subdivision 6.26.3 of AWS D1.1 (AWS, 2010). Recommended waviness value needs to be less than 1.5 mm (0.06 in.) over a 50 mm (2 in.) span (ASNT, 2007). However, no criteria are given for acceptable roughness of scanning surfaces. A rough surface affects the examination in many ways, including, but not limited to: causing difficulty in moving the search unit; reducing the energy of the refracted beam due to scattering and increasing thickness of the couplant; causing a change in the mode transfer; and causing reverberation of the sound in the pockets on the surface, resulting in a wide front surface echo and increased dead zone.

The roughness of the scanning surface of an International Institute of Welding (IIW) calibration block is less than 3.17 µm (125 µin.) root mean square (rms), which is significantly less than the surface roughness of most structural elements. To find practical criteria for acceptable surface roughness, the following experiment was conducted.

First, the effect of roughness of the contact surface of a plastic shoe using angle beam search units on a receiving signal was investigated. Initially, the surface was polished using Coated Abrasive Manufacturers Institute (CAMI) grade 400 sandpaper, with an average particle size of 24 µm (0.00092 in.), and the response \( I_0 \) from a 1.52 mm (0.06 in.) diameter side-drilled hole on an IIW calibration block was recorded. Then, the surface was treated with sandpaper with a larger average particle size and the response \( I \) from the same hole was recorded. This step was repeated for treating the surface with sandpapers with the following P-grades: P220, average particle size 68 µm (0.00254 in.); P150, 100 µm (0.00378 in.); P100, 162 µm (0.00608 in.); P80, 201 µm (0.00768 in.); P60, 269 µm (0.01014 in.); P40, 425 µm (0.01601 in.); P36, 538 µm (0.02044 in.); and P24, 764 µm (0.02886 in.). Each step was performed using 70, 60, and 45° angle search units. Sanding was performed in such a way that uniform isotropic roughness was created over the entire treated surface. The difference in sound-path distances between the search unit and reflector (as \( I \) and \( I_0 \) were measured) for each step did not exceed 1%. A light oil was used as a couplant. To provide constant pressure, a fixed weight of approximately 1.4 kg (3 lb) was put on the top of the surface unit in all cases. The results for all of the tested search units were the same, so no dependence of incident angle was found. Surface roughness created by sandpapers P220 to P100 did not create any difference in the reflected signal \( I_0 – I = 0 \). Surface roughness created by sandpapers P80 and P60 decreased the reflected signal by 0.4 / 0.6 dB and roughness created by sandpaper P40 decreased the reflected signal more than 1 dB.

Then, sets of mild steel (ASTM A36) bars were prepared, as shown in Figure 1. The initial roughness of Face A and Face B (which were strictly parallel) was 3.7 µm (125 µin.) rms. A 1.59 mm (1/16 in.) diameter hole was drilled in the middle of the bar with axis parallel to Face A and Face B, so that the response from this hole for an angle beam search unit (70, 60, and 45° angles) was exactly the same from Face A and Face B. Then, Face A was treated with sandpapers P220 to P100, P150, P100, P80, P60, P36, and P24 and the differences in the responses from Face A and Face B were recorded. Before each step, the contact surface of the search unit’s plastic shoe was polished with P220 sandpaper. To avoid any additional effects from scratching of the plastic shoe during the measurements, first the response \( I_0 \) from Face A and then the response \( I_B \) from Face B was recorded. In all cases, the difference between the
sound path to the hole from Face A and Face B did not exceed 1%. The results are very similar to the results obtained when the effect of roughness of the contact surface of a plastic shoe were measured. No dependence of the incident angle was found. Surface roughness created by sandpapers P220 to P80 did not reduce the reflected signal ($I_A - I_B = 0$). Surface roughness created by sandpaper P60 decreased the reflected signal by approximately 0.5 dB. Surface roughness created by sandpaper P40 decreased the reflected signal more than 1 dB and surface roughness created by sandpaper P24 decreased the reflected signal more than 2 dB.

Based on the results described in the preceding section, the following recommendations can be made:

- The roughness of the contact surface of the plastic shoe using an angle beam search unit should be the same during calibration and examination. If scratching of the contact surface of a plastic shoe during scanning above the inspected surface exceeds the roughness created by sandpaper P80, the reference level should be rechecked.

- The roughness of the scanning surface is acceptable up to the roughness created by sandpaper P80. If the roughness of the scanning surface exceeds this roughness, the transfer correction (which is defined in subdivision S6.1 of Annex S of AWS D1.1) should be made.

All of these recommendations are applicable only for using angle beam search units that meet the requirements of subdivision 6.22.7 of AWS D1.1.

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