Ultrasonic Probes for Special Applications

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Abstract. In the area of material inspection using ultrasound one can find a lot of standard probes, which are adequate to inspect a great variety of specimens. Next to this, the usage of new materials or new material combinations as well as the introduction of new manufacturing processes requires the development of special ultrasonic probes. In this paper we present a small overview of special ultrasonic probes developed for very different applications.

Introduction

In the area of material inspection with ultrasound there are many special applications, for which special ultrasonic probes are needed.

A small collection of such special applications and the according special probes is presented in the following.

1. Inspection of thin objects with high frequencies
2. Spot Weld Inspection
3. Testing of coarse grained materials with low frequencies
4. Immersion Probes
5. Fast Scanning with Squirter Probes
6. Dry Coupling with Roller Angle Beam Probes
7. Rail-Inspection
8. Testing of Railway Axle Sets
9. Exterior Tube Testing with a Probe Cluster
10. Manual Inspection of Billets
11. High Temperature Probes

1. Inspection of thin objects with high frequencies

In order to inspect thin objects, frequencies above 15 MHz are required. As an example Figure 1 presents the pencil probe G25MPN. This probe provides a center frequency of 25 MHz and reveals a large relative bandwidth of more than 80%.

Figure 1 Pencil Probe G25MPN

These properties result in highly resolved backwall echo signals of e.g. steel plates with a thickness of 1 mm. Even in case of thinner objects, where the thickness is smaller than the wavelength and where therefore the echo signals cannot be separated any more, the wall thickness can be determined by means of the RTM method (Resonance Thickness Measurement) in the frequency domain, which yields an extremely high precision, see Figure 2.

The contact area of the conical delay block has a diameter of only 3 mm. Therefore this probe can be applied also in cases of bent surfaces, e.g. in press shops of car bodies.

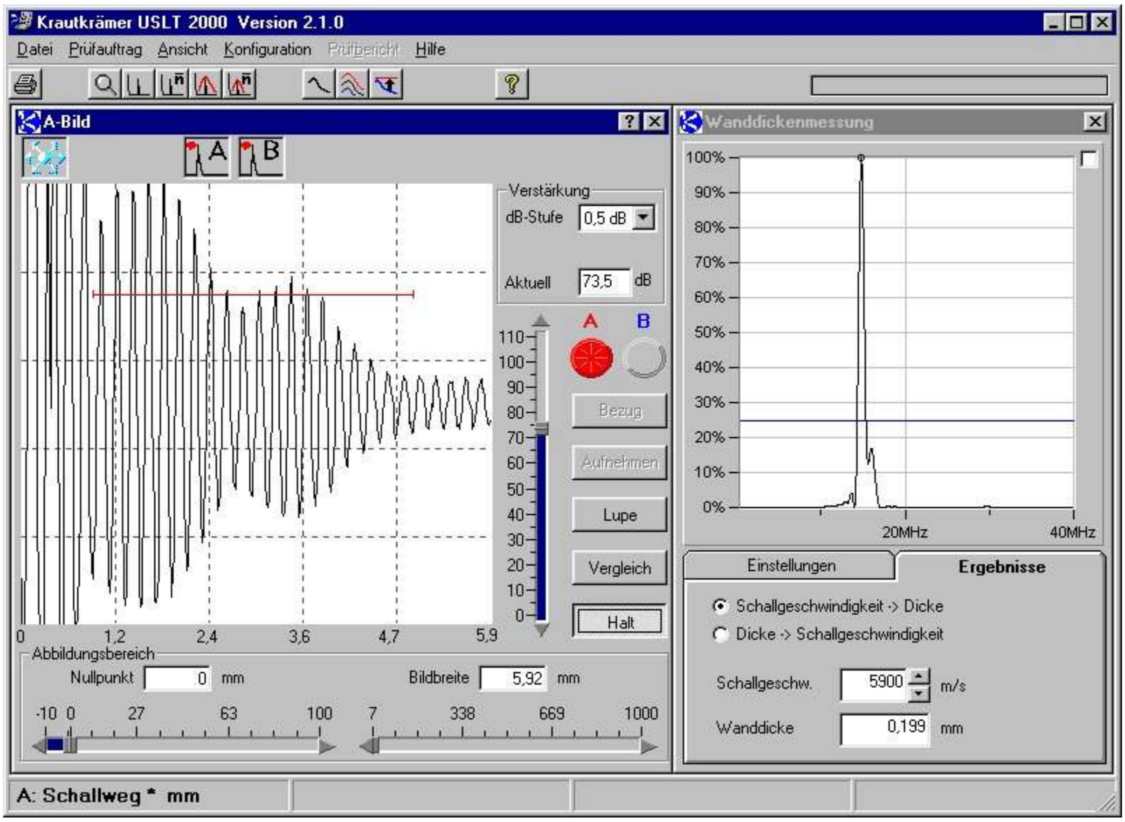

Figure 2 Thickness measurement by evaluation of the resonance signal of a 0,2mm steel plate – Result: 0.199 mm

2. Spot Weld Inspection

Another application in the automotive industry is the inspection of spot welds. For this a probe with a flexible contact face was developed, to enable a reproducible coupling also in the areas of the typical electrode indentations, Figure 3.

In order to determine the nugget diameter, probes with different transducer diameters are used. The spot weld probe family covers a range from 2,3 mm to 8,5 mm. To avoid mistakes concerning the connection of wrong probes, these probes are designed for a dialog with the instrument.

Figure 3 Spot Weld Probe

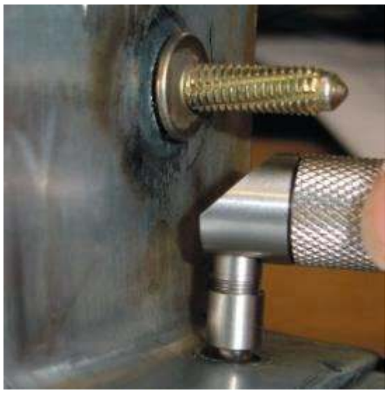

Figure 4 Spot Weld Probe G 20 MN 3,2 X B2

For the cases of limited geometrical access, special probe constructions are available, e.g. probes with an elongated nozzle or with a 45° mirror. An example is shown in Figure 4.

3. Testing of coarse grained material with low frequencies

For the inspection of coarse grained or coarse fibred material, like concrete, bricks, refractory stones or wood, sound frequencies below 1 MHz are required. For this purpose probe frequencies between 50 and 1000 kHz are used.

The probe G0,2R1 with its significant short pulse form respectively its large spectral bandwidth can be used for the pulse echo technique, see Figure 5.

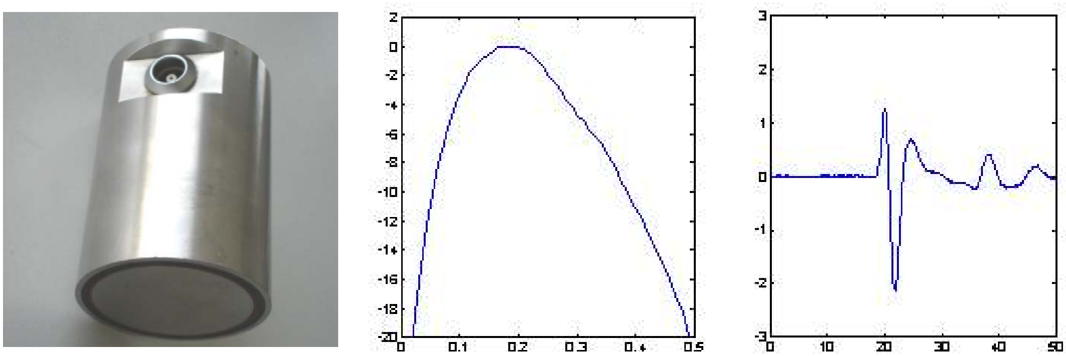

Figure 5 200 kHz Probe G 0,2 R1

On the other side probes with less damping and thus with high sensitivity are used for extremely attenuating materials in the transmission mode.
For the inspection of wood for example two probes of the type B 0,05 NN are applied according to Figure 6. Here the coupling is achieved via the tip of exponential horns.

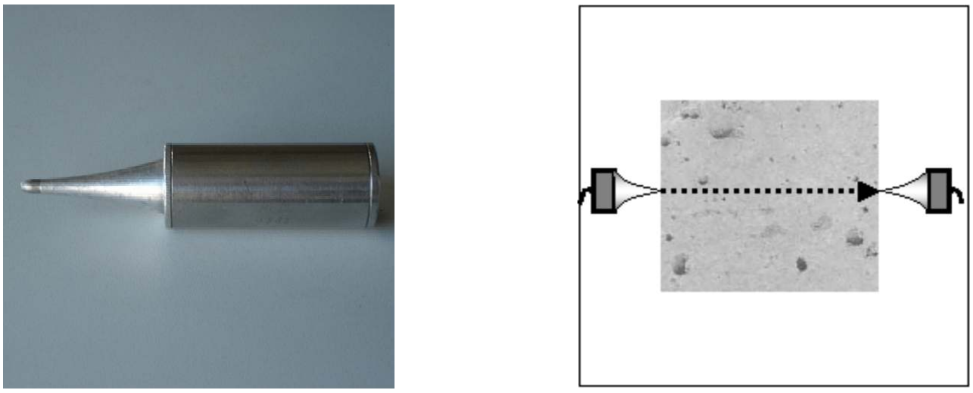

Figure 6 Probe B 0,05 NN with Exponential Horn

4. Immersion Probes

Beside the above mentioned probes for direct coupling there are probes, which are designed especially for the immersion technique – water proof, with direct cable connection and appropriate acoustical adaptation to water. Figure 7 presents as an example the probe H5M.

The immersion probes are available with frequencies between 2 and 20 MHz. Furthermore there are probe types with different bandwidths, focus types and housing diameters. The nomenclature is described schematically in Figure 8.

Figure 7 Immersion Probe

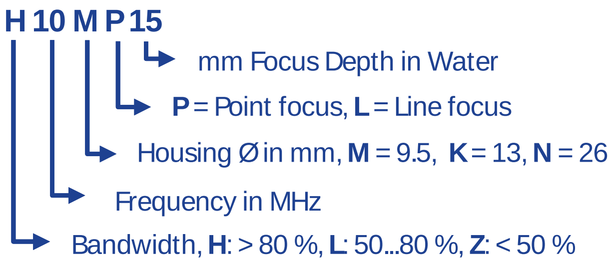

Figure 8 Nomenclature of the Immersion Probes

5. Fast Scanning with Squirter Probes

Scanning of large objects like rails or aircraft wings, which cannot simply be posted into an immersion tank, is done using special “Squirter Probes”. Some of these probes are shown in Figure 9.

The interior design of the squirter probes corresponds to the immersion probes. For example the squirter probe H5KF corresponds to the immersion Probe H5K, where the letter “F” stands for “Flowing Water”. In general, the nomenclature for the immersion probes can be applied also for the squirter probes.

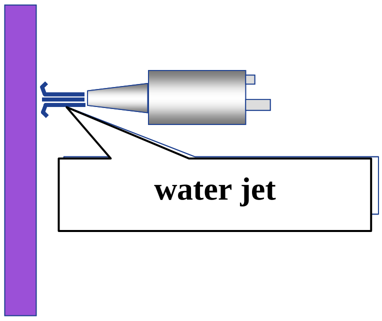

Figure 9 Squirter probe and principle of coupling via a waterjet

6. Dry Coupling with Roller Angle Beam Probes

While normally the sound is transferred into an object by means of a liquid coupling medium, in some cases oil or water is not allowed, if for example the objects shall be painted afterwards.

The inspection of butt welds or also overlapped laser welds is done using roller probes, e.g the probe WRL 55-4B1 according to Figure 10. This probe is designed for an insonification angle of 55° and a frequency of 4 MHz. Here the acoustical coupling is achieved by means of a relatively soft plastic tire.

A „fast“ weld inspection can be performed using fixtures or inspection systems, the design of which is adapted to the special inspection task and the geometry of the object to be inspected. Figure 11 presents an example of a simple device.

Figure 10 Roller Angle Beam Probe WRL55-4B1

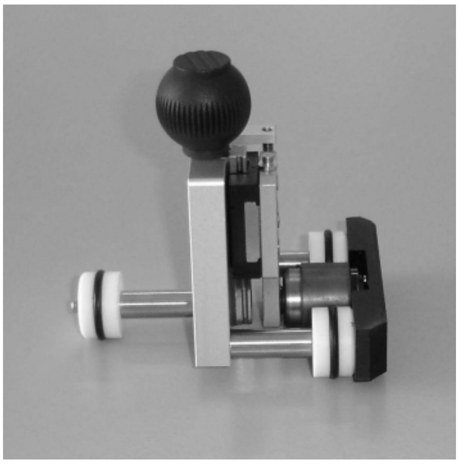

Figure 11 Roller Probe System

7. Rail Inspection

Before rails are delivered to the customer they are tested in testing machines using squirter probes.
After that, periodical rail net inspections are carried out by means of a rail test train.

In the region of railway stations the inspection is done using the rail test trolley SPG. A newer variant of the manually driven device is shown in Figure 12.

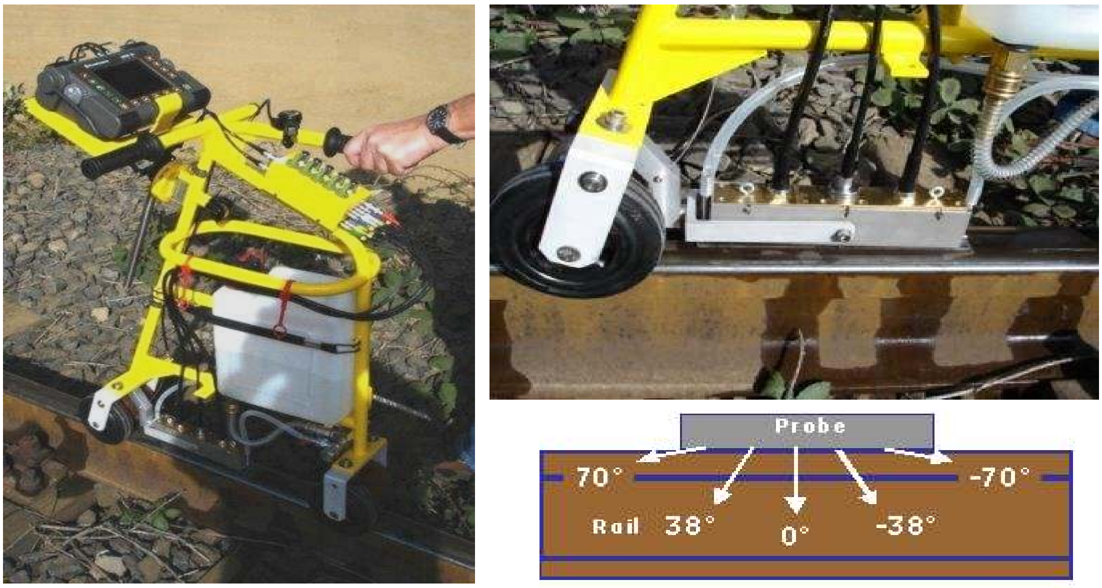

Figure 12 Rail Test Trolley SPG2 with Special Probe and Sound Directions

Beside the general inspection of the rail for cracks in the head, the center web and the foot using the SPG device, also the rail butt welds have to be inspected.
For this task the 45° tandem technique is applied. The “Rail Tandem Scanner STH2” is presented in Figure 13.
The appropriate probes for this tandem device are two angle beam probes SWB45-O2E.
The complete height of the weld is scanned by continuous synchronous displacement of the probes. The sound beam for the inspection of the center web weld is shown as overlay in the photograph, Figure 13.

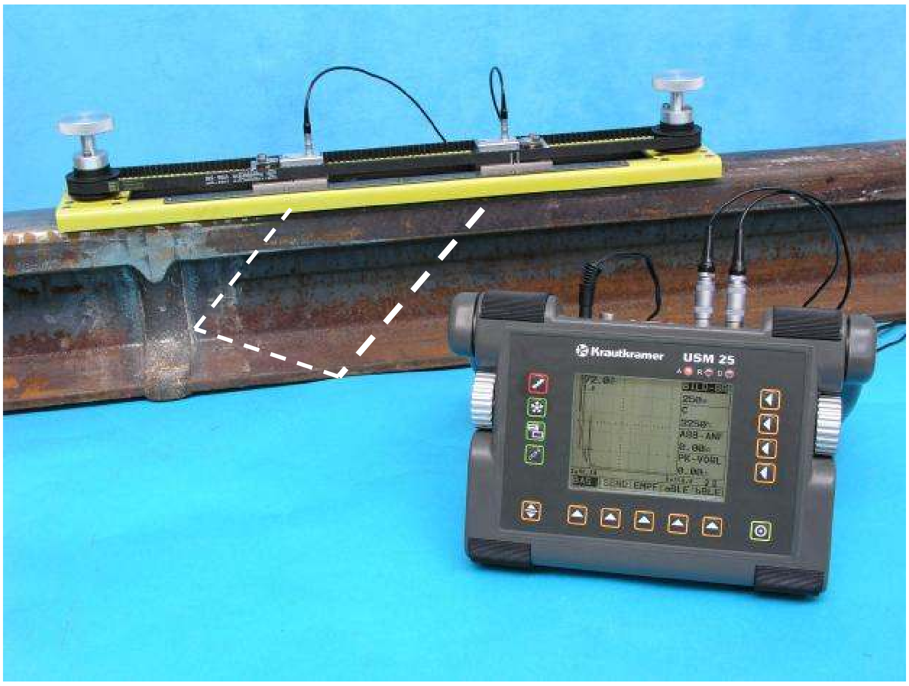

Figure 13 Rail Tandem Scanner STH2

8. Testing of Railway Axle Sets

For the inspection of railway axle sets various probes and probe wedges are applied, from which some are presented in the following.
In order to detect circumferential cracks according to Figure 14, cone probes are available to perform the test of the built in axle set from the center hole at the face of the axle. The complete circumference of the axle is tested by a rotation of the probe over 360°.

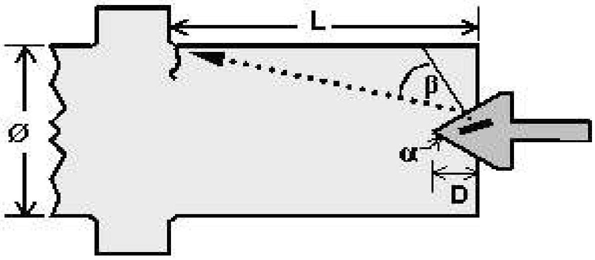

Figure 14 Cone Probe for Testing of railway Wheelset Axles for circumferential cracks from the center hole

As the cone probe must be adapted to the axles geometry, it is necessary to know the cone angle α, cone depth D, length L and Diameter Ø, see Figure 14.

Of course the inspection for transverse flaws can also be carried out from the axles face, Figure 15. For this purpose following attachable wedges are offered.

Type	Probe:
N .. YK	MB 2 S-OE or MB 4 S-OE
N .. YG3	B 2 S-OE or B 4 S-OE

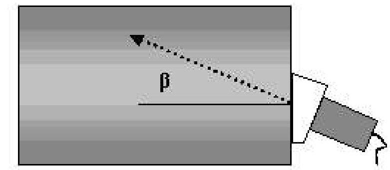

Figure 15 Attachable wedge for testing from the axles front face

The angles of the wedges are delivered customized for the special task, for pressure waves as well as for shear waves.

If the inspection must be carried out from the circumferential surface, then attachable wedges are used according to Figure 16. Also for these wedges the axle radius and the in-sonification angle are freely selectable.

Figure 16 Attachable Wedge and adequate probe for testing axles from the surface

In the case of hollow axle sets the inspection can be done also from inside, for example with the hollow axle probe of the type HW45/45 B4 with a customized diameter, Figure 17.

Figure 17 Double Angle Beam Probe for the detection of transverse flaws in hollow axles

9. Exterior Tube Testing with a Probe Cluster

If tubes or tube like objects, e.g. gas bottles, have to be tested at the same time for longitudinal flaws, transverse flaws and wall thickness, a so-called "Cluster" is applied, i.e. a probe holder device for several probes. Such a Cluster is shown in Figure 18

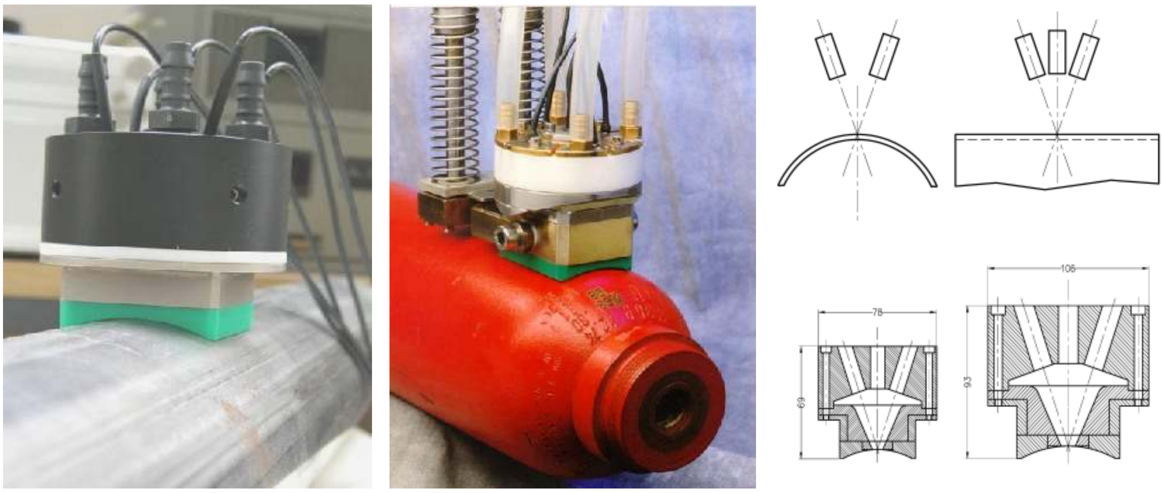

Figure 18 Probe Cluster

This Cluster holds 5 probes: two for longitudinal flaws, two for transverse flaws, and in the center one for the wall thickness measurement. These Clusters are offered in two sizes: **Cluster K** for probes of the series H..K (∅ 13 mm) and **Cluster M** for probes of the series H..M (∅ 9,5 mm), see also chapter "Immersion Probes".

10. Manual Inspection of Billets

A manual inspection of billets with a cross section of 150 x 150 mm can be done using a special scanning device, which provides a sensitivity for flat bottom hole reflectors of ∅ 1 mm and at the same time a relatively high inspection speed.

The high sensitivity in combination with a large scan width of 85 mm is performed by means of 10 Transmitter/Receiver Probes, mounted in two rows. In order to get a uniform sensitivity over the whole scan width, the 2nd row is displaced by a width of a half probe.

Figure 19 Inspection of Billets

Billets, which are broader than the scan width, are inspected with two scans. With an adjustable guiding plate at the side even one or more further scans in the middle of the billet can be scanned.
Water is used for coupling. The device contains an internal channel, which distributes the water uniformly over the whole scan width. The water coupling space is adjustable.
By means of three wheels a uniform scan over the billet length is guaranteed. The front wheel drives a position encoder, Figure 20.

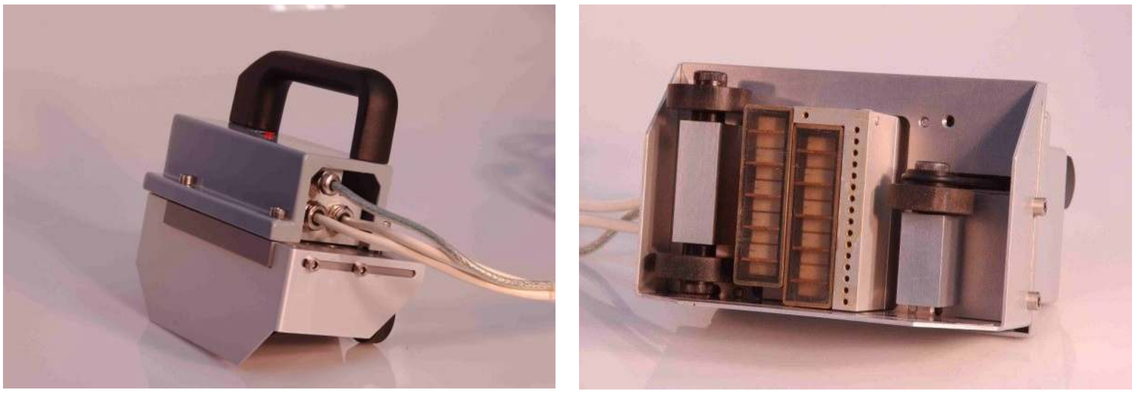

Figure 20 Manual Scanning Device. The right picture shows the scanning device from the bottom.

The scanning device can be used in combination with the ultrasonic instrument USIP40, designed for 10 channels. The software UltraProof (Figure 21) provides a display of the echo amplitude versus the scan path over all 10 channels. This permits a direct localization of all defect indications.

Necessary Equipment:

1. Billet Scanner [ID 68805]
2. UT Instrument USIP 40 in 10-channel design
3. Software: UltraProof

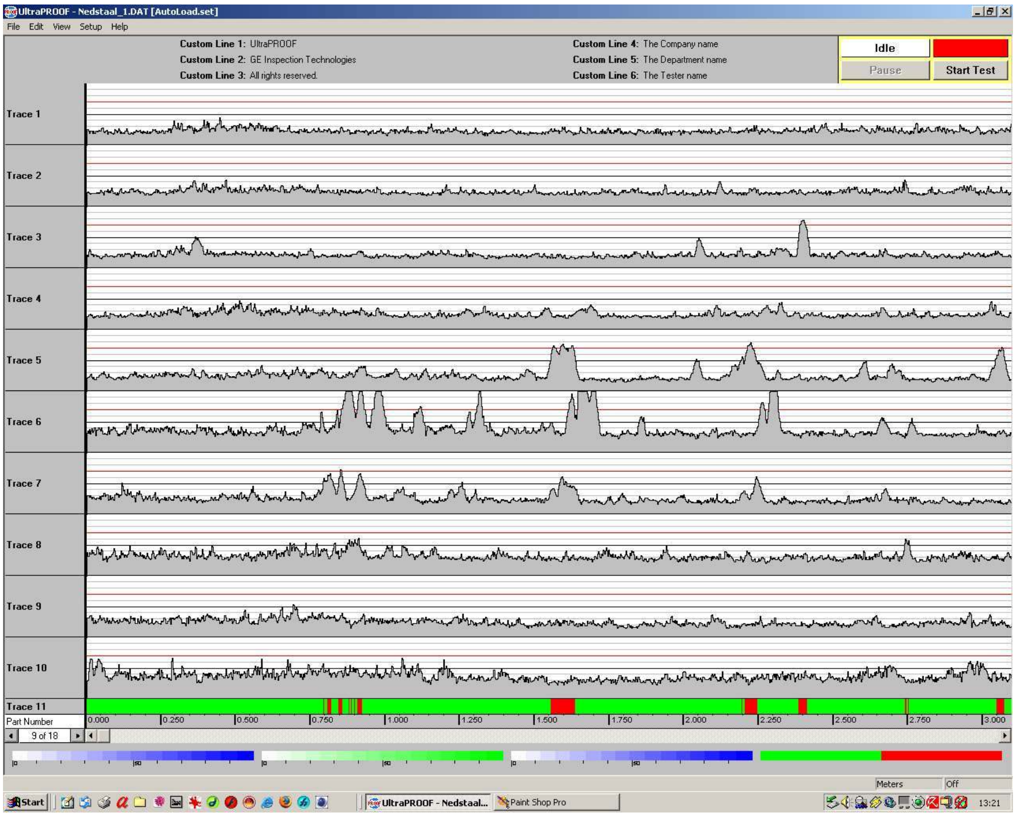

Figure 21 Ultraproof - Lineplots, 10 channels

11. High Temperature Probes

For measurements at higher temperatures probes are available, which withstand temperatures up to 300°C. As examples Figure 22 shows an angle beam probe and Figure 23 a straight beam probe, which withstand 250°C for long-term inspections and 300°C for short-term tests ($t < 5$ s).

Figure 22 Angle Beam Probe
W 60 B4 GV

Figure 23 Straight Beam Probe
B 4 GVN