GEKKO

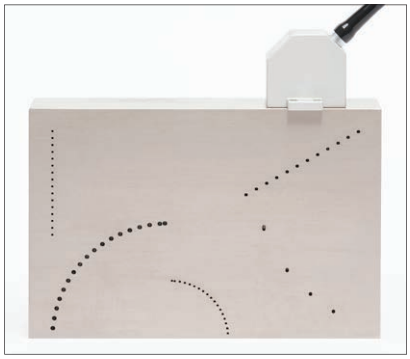
Portable Ultrasonic Flaw Detector for Phased Array, TOFD and Conventional Probes

KARL DEUTSCH

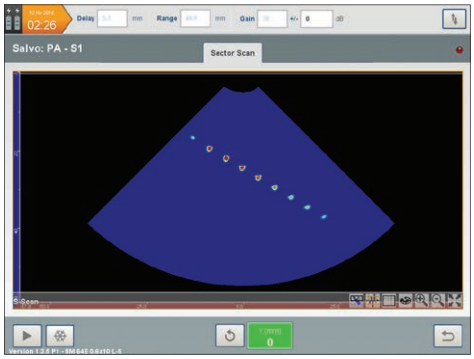
B-Scan Imaging

Sector Scan and Linear Scan

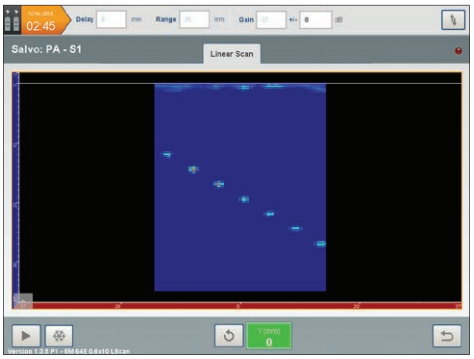
Phased array probes consist of multiple piezoelectric elements, which can be excited one by one or time-delayed. The sound fields of several elements which form a so-called virtual probe are superimposed. Thus, the resulting sound field can be electronically moved (linear scan) or swivelled (sector scan). Both longitudinal and transverse waves, but also surface and creeping waves can be generated. Electronic focusing of the sound field in certain depths or depth ranges permits the indication of B-scans (cross-sectional views perpendicular to the surface) with high resolution.



Phased array calibration block, according to ASTM E 2491



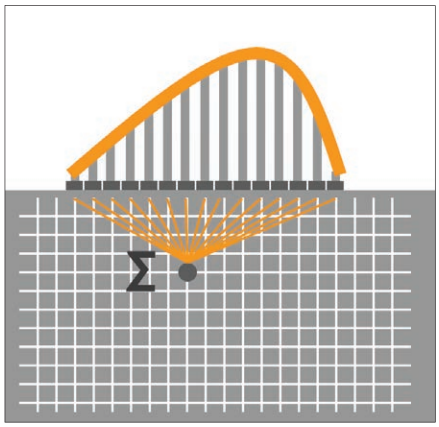
Sector scan generated by swivelling the sound field within an angular range of -45° to +45°



Linear scan generated by electronically moving the sound field within an array probe

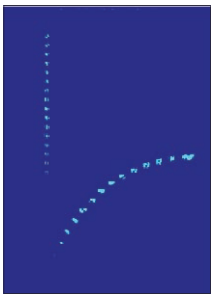
In the example given above a sector scan and a linear scan of a row of side drilled holes in an ASTM reference block are shown. The GEKKO also features a calibration function that adjusts the echo amplitudes for all sound paths and angles to the same value. The lateral spatial resolution equals the diameter of the focused sound field. Sector and linear scans are the traditional B-scan techniques. With the new TFM method even higher resolutions can be achieved:

Total Focusing Method (TFM)

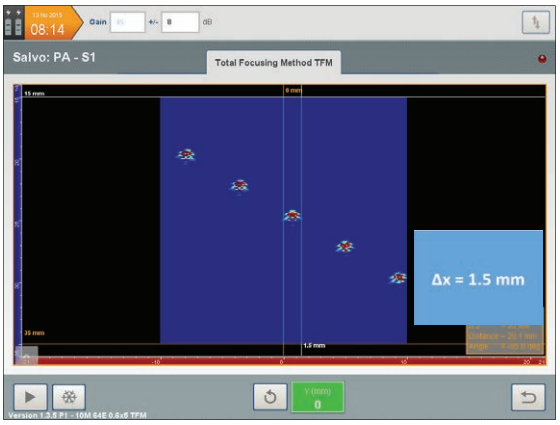


Definition of a test area as x-y-grid

Test block with side-drilled holes



TFM-B-scan



Reflector sizing with cursors

The Total Focusing Method is a unique feature and comparable to sampling phased array techniques. It integrates all interactions between all array elements and all pixels in a defined inspection area. Thus, it generates B-scans with an extremely high spatial resolution of 1 (!) wavelength if a phased array probe with 64 elements is used. Up to 25 frames per second can be achieved, thus providing real-time imaging.

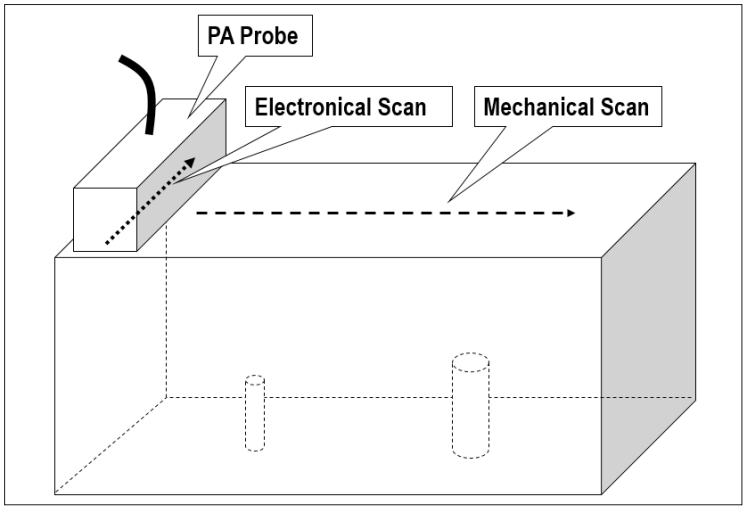
Reflector sizes are measured with the aid of cursors. The example shows the TFM-B-scan of a row of 1.5 mm diameter side-drilled holes. As a result the correct hole diameter of 1.5 mm is shown.

Three-Dimensional Acoustical Imaging (3D-Tomography)

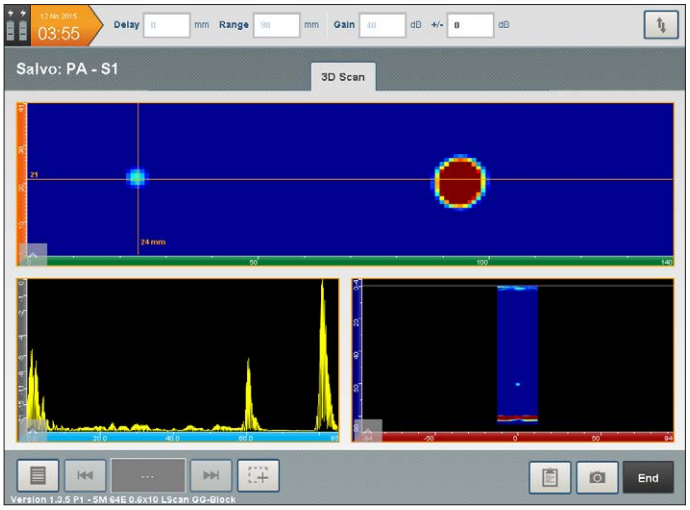
3D-Imaging

By mechanically moving a linear phased array probe (PA probe) many B-scan images are generated and thus a three-dimensional dataset is produced. This dataset can be visualized in the so-called C-scan format (top view of the test object). By moving the vertical cursor within the C-scan the respective B-scan is selected. The vertical cursor in a B-scan is used to select the corresponding A-scan.

The following example shows a plane object scanned with a plane linear array with straight beam longitudinal waves.

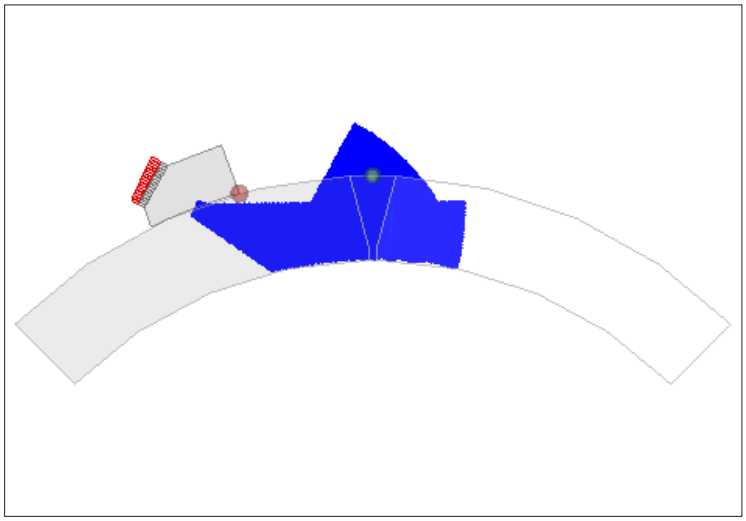


Inspection setup, test object with flat bottom bores

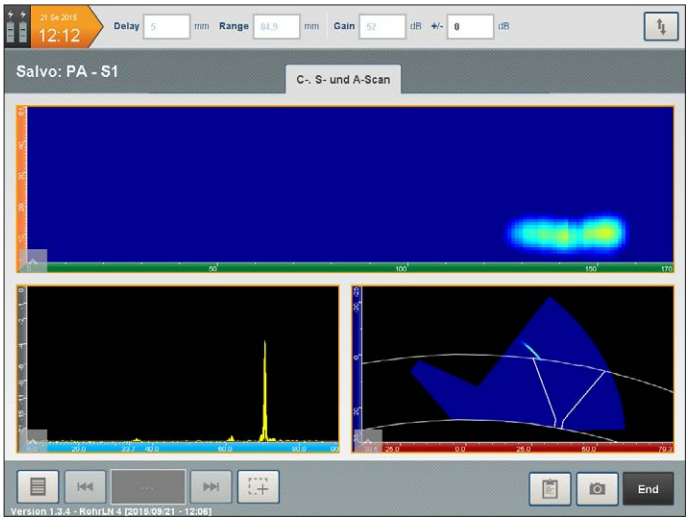


3D test result: A-scan, B-scan and C-scan

The GEKKO also supports testing on curved surfaces. This allows to inspect longitudinal welds on pipes, for example. The B- and C-scans show the reflectors in correct positional arrangement.



Adjustment of UT parameters and probe position on a tube

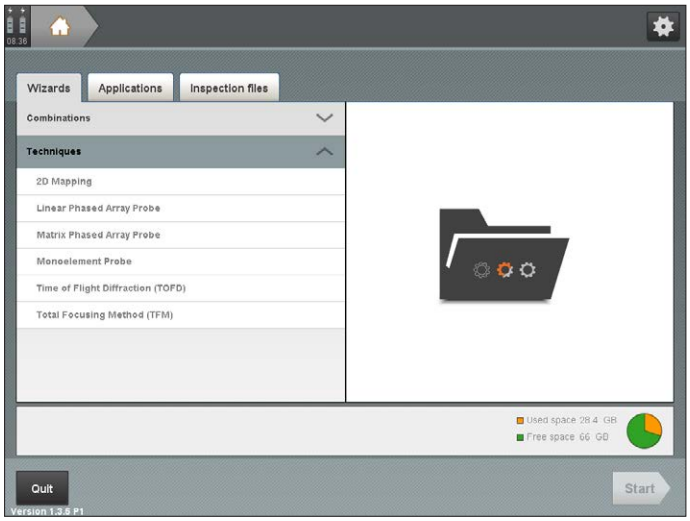


Test result of an inspection on a longitudinal pipe weld

“Folding” the soundfield at the inner backwall of the pipe enables a clear verification of the correct coverage of the weld and facilitates the evaluation of indications.

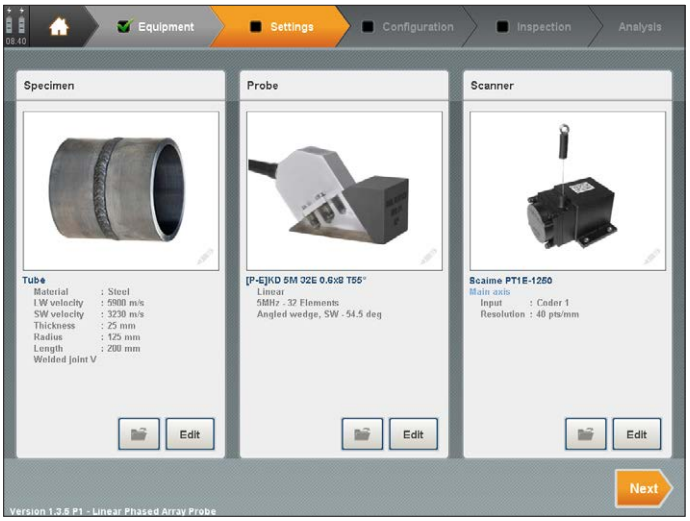
Menus

The “Look & Feel” design of the menus enables easy parameter setting and instrument operation



Menu Home

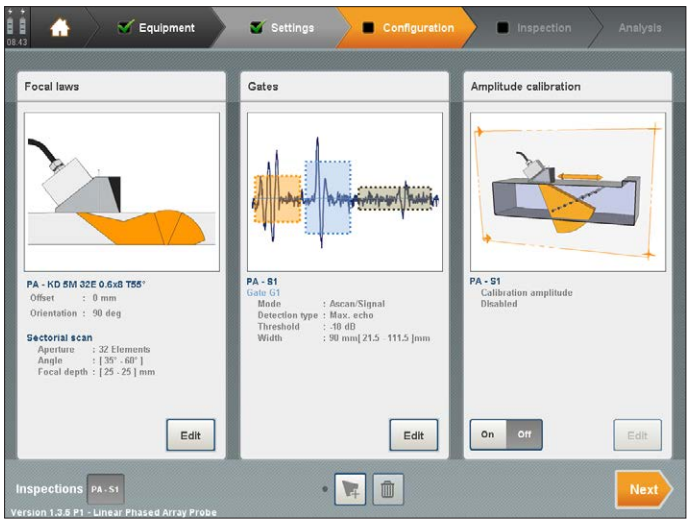
From the parameter sets under “Wizards” individual applications can be configured. These may be stored under “Applications”. Measurement results are stored under “Inspections”. Parameter sets from the Wizards cannot be deleted or altered and thus ensure always a safe starting basis.



Menu Equipment

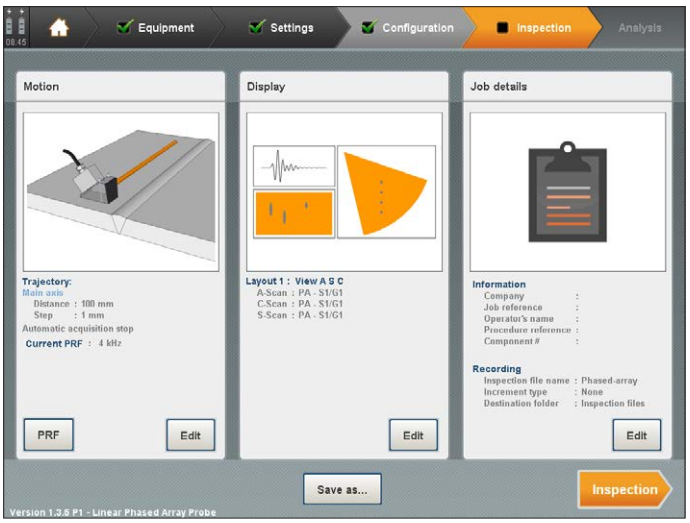
- for test objects,
- probes and wedges and
- scanners and position encoders.

All parameters and photos can be saved and loaded as a whole or individually.



Menu Ultrasonic Testing (UT) Parameter

- Parameter adjustment for the selected B-scan type (linear scan, sector scan or TFM scan) and the probe position and orientation for proper soundfield coverage
- Selection of data acquisition gates, including type, position and threshold
- Amplitude calibration for phased array TCG (Time Corrected Gain), ACG (Angle Corrected Gain) and for monoelement probes TCG and DAC (Distance Amplitude Curve)

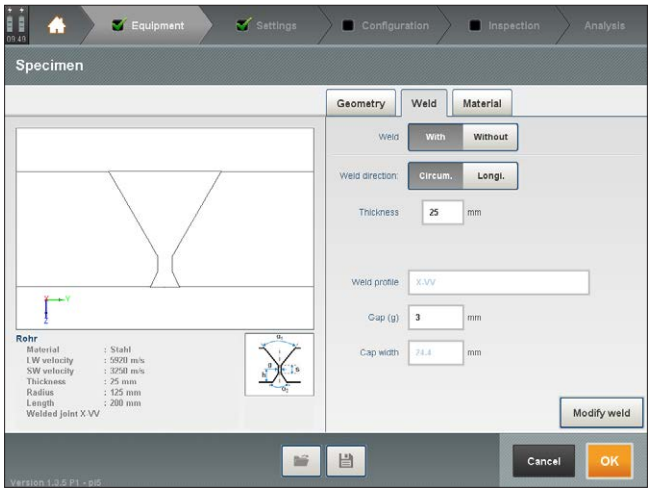


Menu Configuration

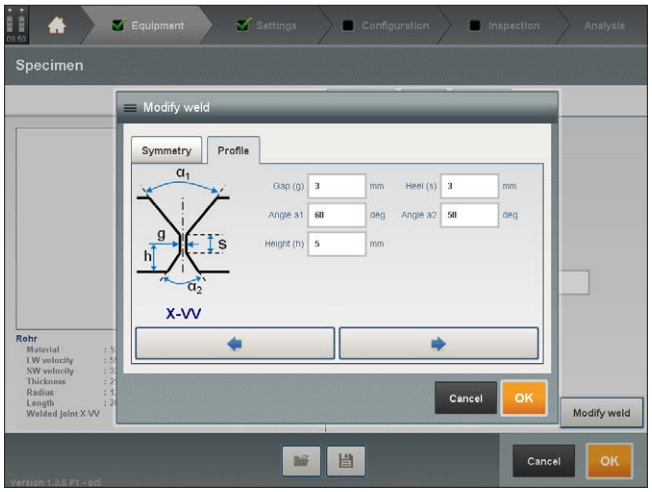
- Scanning options: Selection of scan type (time-based or encoded), reference points of object, probe and even probe groups, scan length and step width
- Display options: Selection of image type (A-, B-, C-, D-scan, TOFD-scan, with individual definition of the number of the probe, salvo and acquisition gate
- Preparation of the inspection report layout

Tools and Wizards

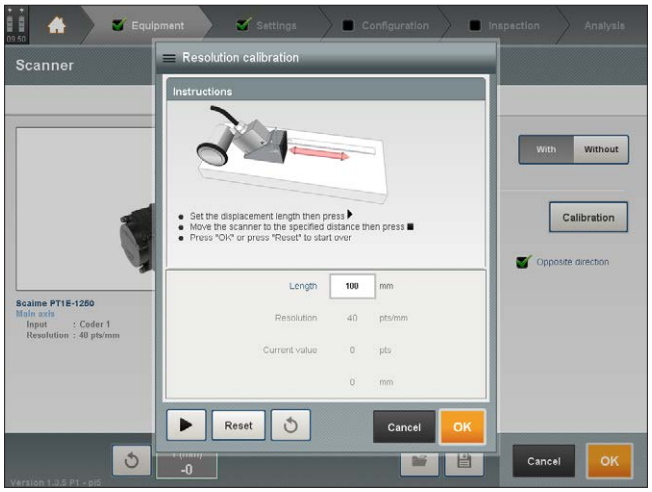
Helpful tools and wizards to facilitate operation



Specimen wizard for flat plates and tubes, with or without weld. Also DXF-files can be imported.

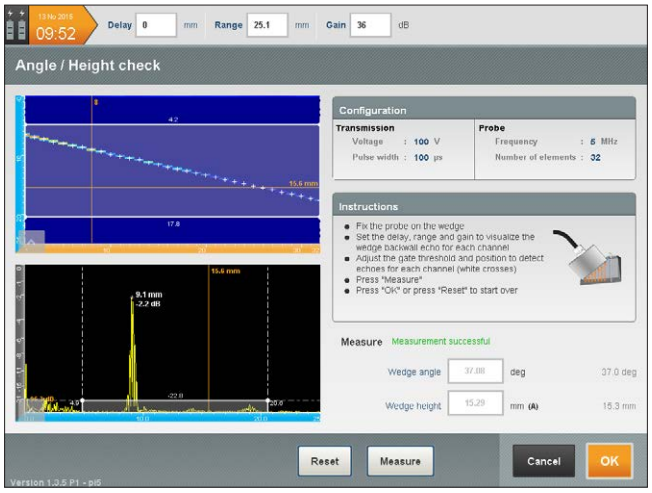


Weld wizard with 14 symmetrical and 7 asymmetrical weld types. Definition of individual geometries.

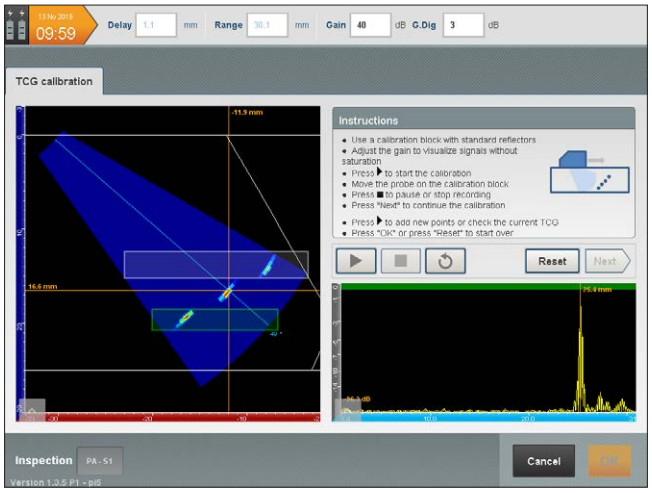


Tool for the calibration of position encoders

Submenu for measurement and equalizing of element sensitivities



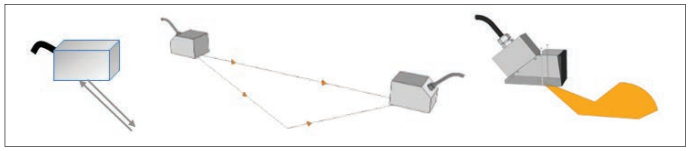
Automatic measurement of the angle and height of angled wedges



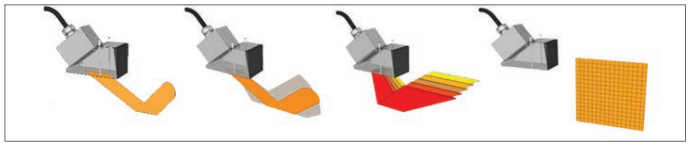
Tool for the sensitivity adjustment including Time Corrected Gain (TCG) and Angle Corrected Gain (ACG)

Combinations

Combination of Different Techniques



Monoelement Probes | TOFD | Sector Scan



Linear Scan | Multi-Salvo | Matrix Probe | TFM

The different techniques can be combined as a multi-probe setup and/or multi-salvo selection for the probes.

Several probes can be driven in parallel and a combination of several test tasks can be carried out simultaneously. For weld testing, a two-sided phased array insonification is common. Often, this is combined with the Time-Of-Flight Diffraction (TOFD) method which enables a precise determination of crack depth expansions by measuring the time-of-flight differences. The handling of several probes requires a scanner with different probe holders and a position encoder. Manually driven scanners and motorized scanners are available.

Weld Testing with 2 x Phased Array and TOFD

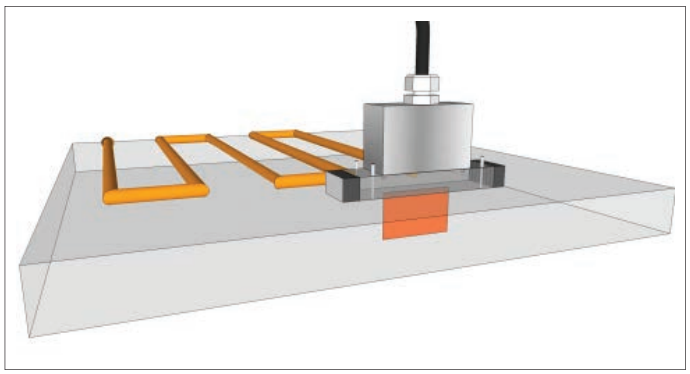
Scanner for manual testing of flat butt welds and circumferential tube welds with position encoder, magnetic wheels and probe holders for 2 x Phased Array and TOFD

Double gimbal-mounted probe holders

For phased array probes with wedge type 1814.13x

For TOFD probes with wedge type 6148.xxx

Combination of Several Encoders: Area Scanning with 2D-Mapping



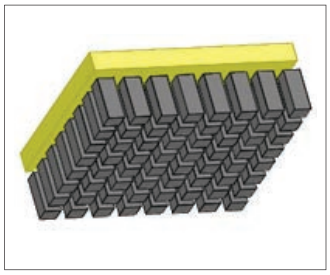
The GEKKO supports meandrical area scanning!

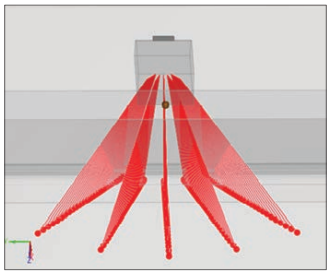
If test specimens are larger than the scan width of a phased array probe, the area can be scanned meandrically. The individual C-scan tracks are then composed to a complete C-scan.

- The mechanical scan can be done either with a motorized scanning system or with an x-y-scanner for manual testing.
- 2D-scanning of areas is useful for volume testing and for corrosion mapping. A C-scan presents inclusions in the volume and a D-scan informs about residual wall thicknesses in the case of corrosion mapping.
- The GEKKO supports up to three position encoders.

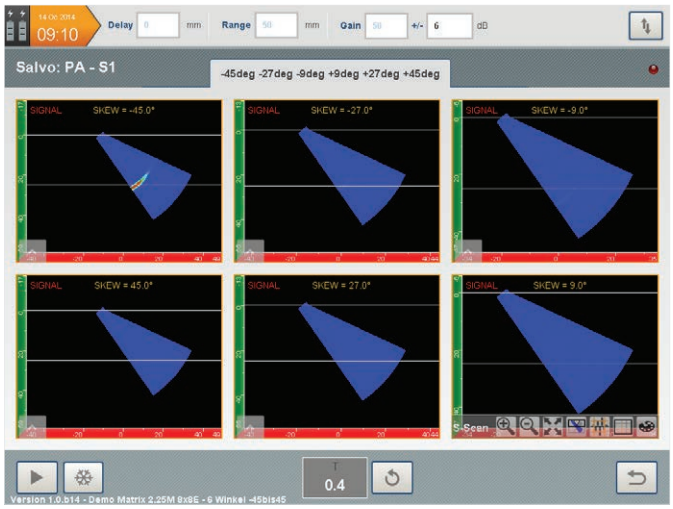
Matrix Arrays, Report Generation

Matrix Arrays





Thanks to its 64 parallel channels the GEKKO supports matrix arrays with 8 by 8 elements, for instance. This feature allows to generate sector scans which are skewed sidewards under definable angles. Therefore a weld can be scanned for longitudinal and oblique flaws at the same time. The example shows 6 sector scans from -45° to +45° with an indication in the sector scan for -45°.



Sector scans for 6 skew angles

Reports: Test Procedure & Inspection Result

Indication table

Indication #1

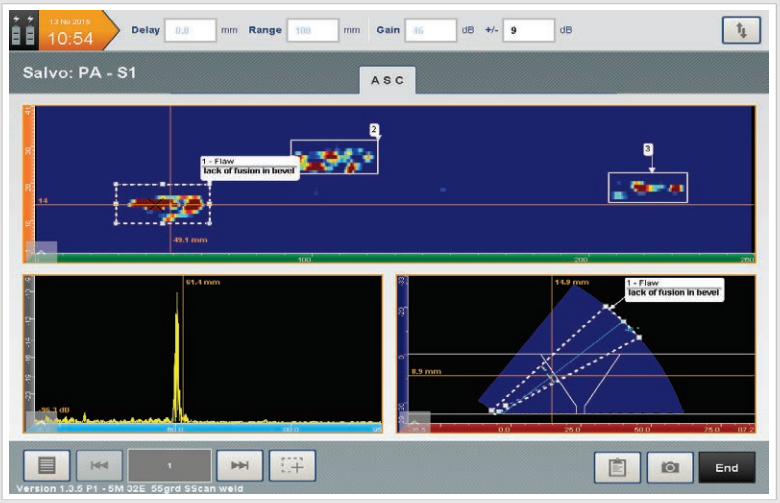
Id : **1**
Position
Max :

Value	X	Y	Z
-0.9 dB	-10.9 mm	68.6 mm	9.7 mm

Box :

Xmin	Xmax	X	Ymin	Ymax	Y
-31.7 mm	20.9 mm	52.6 mm	54.7 mm	87.9 mm	33.2 mm

Images



Remarks :

lack of fusion in bevel

After set-up of the parameters the test procedure can start and the results can be exported. The following items are selectable for the report (additional entry fields can be defined):

- Date and place of the inspection
- Inspector
- Object parameters
- Probe parameters
- Scanner parameters
- UT parameter settings
- Gate parameters
- TCG and sensitivity settings

After analysis of the inspection data, a complete inspection report is generated with a table of indications and optionally with images of the defect indications. Parameters without a test result, or only with an example on how a test result may be represented, can be used as an instruction for testing. The test procedure and inspection report are exported as a PDF and can be stored on a memory stick.

“GekkoView” software for an external PC:
The included software “GekkoView” permits exporting of the inspection result to an external computer. This enables the operator to continue the inspection work while another staff member takes care of further data analysis and report generation.

Technical Data

Dimensions	408 mm x 284 mm x 130 mm
Weight	7.5 kg (including 2 batteries)
Power supply	2 Li-ion batteries (hot swap possible)
Battery runtime	At least 3 hours 15 minutes
Internal memory	SSD 128 GB
Connections	Power supply 230 V 1 x IPEX connector for phased array probes, 64 channels 4 x Lemo 00 connectors for monoelement, TR and TOFD probes 3 encoder inputs 1 analog input for smart flexible probes 1 VGA output 3 x USB2
Screen	10.4“ diagonal, touch-screen 1024 x 768 pixel resolution Brightness 400 cd / m^2
Pulsers	Negative square pulse, width 30 ns to 1250 ns 10 to 100 Volt for phased array probes 10 to 200 Volt for monoelement probes Pulse repetition frequency 10 Hz to 10 kHz
Maximum number of focal laws	1200
Digitizing depth	Up to 65,000 samples
Sampling frequency	10 MHz to 100 MHz
Signal averaging	Up to 64 times
Gain	Analogue 0 to 46 dB Digital -40 to +40 dB
Input impedance	50 Ω
3 dB bandwidth	0.55 to 14.3 MHz for Phased Array 0.60 to 25 MHz for conventional UT
Cross-talk damping between the channels	> 50 dB for excellent signal-to-noise-ratio

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KARL DEUTSCH Pruef- und Messgeraetebau GmbH + Co KG
Otto-Hausmann-Ring 101 · 42115 Wuppertal · Germany
Phone (+49-202) 7192-0 · Fax (+49-202) 71 49 32
info@karldeutsch.de · www.karldeutsch.de

DIN EN ISO 9001 certified

KARL DEUTSCH