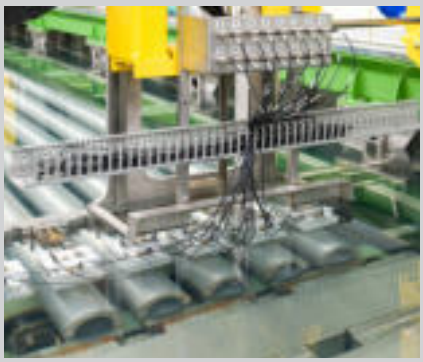
## Material Testing for Quality Control









**ECHOGRAPH Systems**
Automated Ultrasonic Inspection

KARL DEUTSCH

# ECHOGRAPH UT Systems
# Company Portrait

**KARL DEUTSCH has developed ultrasonic testing equipment since 1951 and has shipped the first automated inspection system in 1965. Many improvements for the ECHOGRAPH electronics, the robust testing mechanics and the ultrasonic probes have led to our current state-of-the-art.**

The company is located in Wuppertal, a city near Duesseldorf and Cologne, Germany. At the moment 130 highly motivated employees work for the company. Additional 20 employees in international sales offices support our customers worldwide.

KARL DEUTSCH offers a large product range: Portable testing instruments such as ultrasonic flaw detectors, ultrasonic sensors for manual and automated applications, magnetic particle testing systems, crack detection liquids (magnetic particles and dye penetrants) and systems for dye penetrant inspection. Furthermore the portfolio of KARL DEUTSCH contains phased array testing systems due to a partial ownership of the French company M2M Phased Array Technologies and a joint product development with the BAM in Berlin. A strict quality management system according to DIN EN ISO 9001 is maintained.

## Systems workshop

**Staff in works 2 (systems workshop)**

KARL DEUTSCH provides testing systems and machines from a single source with an in-house construction department, a mechanical workshop and a department for producing and programming the Siemens-PLC. In total, 1500 m² are available for the systems assembly.

**Works 1 (erected in 1967, extended in 1972) is the headquarter where the administration, the applications lab and electronics R&D is located. Portable test instruments, sensors and crack detection liquids are produced here.**

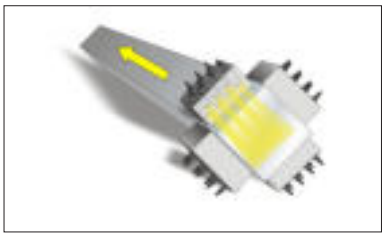
**Works 2 was built to cater to the systems business. The first workshop hall was built in 1978 and extended in 2004 and 2006. In 2008, a segment of Wuppertal's historic skytrain (inaugurated in 1900) was purchased and newly mounted as an industrial monument.**

**View into the system's workshop where a large immersion test tank is about to be assembled. The mechanical workshop allows the fabrications of the key components.**

**Large testing machines often require complex logistics during assembly. The total workshop area of 1500 m² and two cranes permit also the assembly of large-scale systems.**

# ECHOGRAPH System Types KNPS STPS HRPS
# Ultrasonic Inspection of Billets and Bars

**ECHOGRAPH-KNPS:** Continuously cast billets are regularly tested with ultrasound during the production process. The testing speed of round or quadratic billets with typical dimensions between 50 and 180 mm is 1 m/s. In this process stage especially the quadratic billets exhibit considerable tolerances (convex or concave surfaces, different edge radii and twisted profiles), which demand a flexible guidance of the probe holders on the billet surfaces. By means of spring systems the sensors can be guided along the profile within a working range of several centimetres. While formerly block cast billets were tested with only two probes for core defects, nowadays an inspection with the highest possible coverage of the cross section area is required. Therefore today, typically 28 probes are applied. The typical test sensitivity ranges from 1.5 to 5 mm FBH.

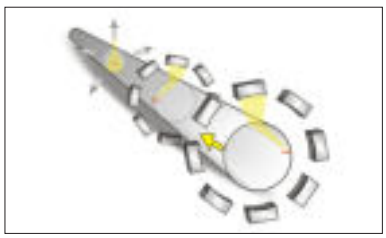


**Testing of quadratic billets with 28 probes in 4 probe holders**

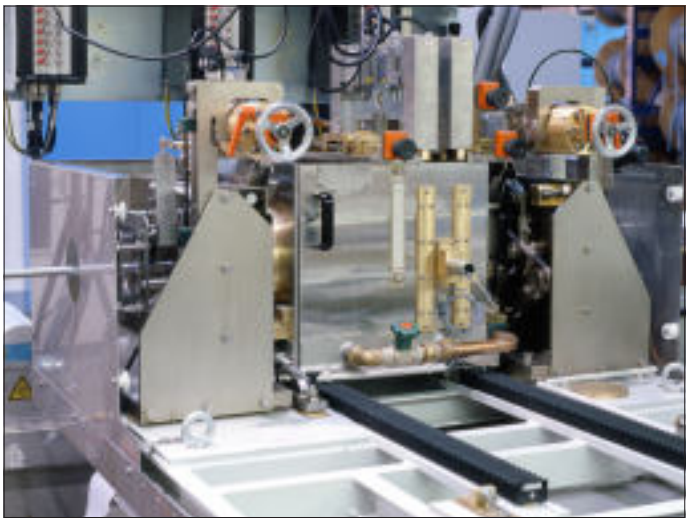
**ECHOGRAPH-STPS:** In a further process stage the billets are rolled to bars, which still have black surfaces. The straightness tolerances in this stage require a guiding of the probes on the surface within a range of several millimeters. Coupling is carried out with water jets (squirters). The typical diameters for this inspection task are 15 to 130 mm. The higher the number of probes, the larger is the covered cross section. This type of system can be equipped with 3 to 15 sensors. The mechanical design enables a very easy and quick diameter adjustment. The typical testing sensitivities are in the range between 1 and 2 mm FBH.

**Testing of (e.g. black) bars with 9 probes in 3 probe holders**

**ECHOGRAPH-HRPS:** Bars with bright (machined) surfaces are often used as raw material in the automotive and aerospace industry. The cross sections must be completely covered. For this purpose an immersion tank setup is available with typically 21 sensors (16 angle beam probes and 5 straight beam probes). The inspection speed is in the range between 1 and 2 m/s. The good surface condition allows accordingly higher inspection sensitivities between 0.7 and 1.5 mm FBH. Currently, this testing concept is suitable for diameters from 10 to 100 mm.

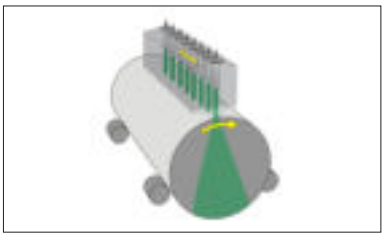


**Testing of (e.g. bright) bars with 21 probes in immersion technique**



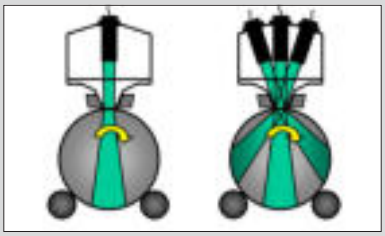
# ECHOGRAPH Systems Types ALPT RPTS TTPS
# Ultrasonic Inspection of Round Billets

**ECHOGRAPH-RPTS:** Larger bars or billets with round cross sections are inspected with rotation of the billet and linear feeding of the ultrasonic probes. Several probes are used to increase the test speed. For good surface quality, clean-cut billets ends and reasonable straightness, all probes can be mounted into the same probe holder. The probe holder is mounted to a carriage which travels along a testing portal. The typical billet diameters for such test portals begin with 100 mm, i.e. in a range, where systems with linear throughput would require an extremely high number of probes to fully cover the cross section. The testing sensitivity depends on diameter, material structure and surface condition.



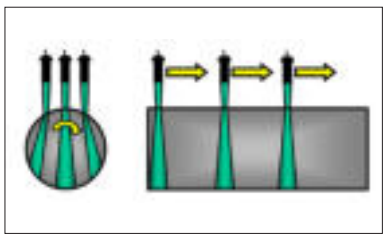
**Inspection of billets with rotation of the billet and linear feeding of probes**

**ECHOGRAPH-ALPT:** For casted aluminium billets with rough surfaces the probes are mounted into several probe holders which are evenly distributed along the billet. Otherwise, the testing concept is similar to the ECHOGRAPH-RPTS system. Straight beam probes are used for the core defect detection. In some cases additional angle beam probes are provided to test the near-surface zones. The testing system in the right picture contains ten straight beam probes for core defect detection in accordance with ASTM B 594-90, i.e. 1.98 mm FBH. In addition, six angle beam probes detect surface defects in the billet ends.



**Straight beam and angle beam testing for round billets**

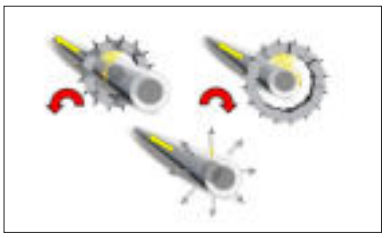
**ECHOGRAPH-TTPS:** The hightest testing sensitivity can be achieved with an immersion tank testing system because of the best possible coupling conditions. This test tank is designed for aluminium billets in the aerospace industry. The billet diameters range from 172 to 620 mm and the lengths between 0.3 and 2m. The test sensitivity is 0.8 mm FBH for the straight beam probes. Additional angle beam probes detect surface flaws. The sensitivity adjustment and TCG-curve recording is carried in a fully-automated manner. The test results are given in C-scan format.



**Three straight beam probes and six angle beam probes**

# ECHOGRAPH System Types HRPR RPSR RPTR
# Ultrasonic Inspection of Seamless Tubes

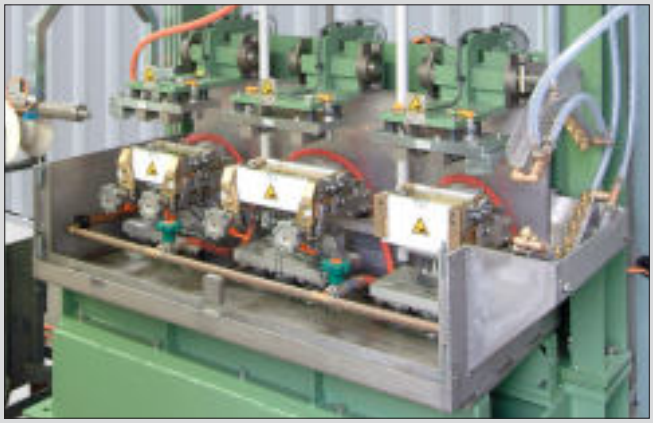
**ECHOGRAPH-HRPR:** The criterion for the selection of the appropriate testing system is the diameter of the tube. The insonification directions depend on the test requirements. The most important inspection task is the detection of longitudinal defects with an angular insonification in both circumferential directions. The tube is surrounded by two probe rings with overlapping sound beams. A wall thickness measurement is often carried out with eight straight beam probes. The detection of transverse and oblique defects requires additional probe rings. Tubes with diameters between 10 and 170 mm can be inspected with the system ECHOGRAPH-HRPR. The great advantage of this system is the high testing speed of up to 2 m/s. The tubes are linearly moved without any mechanical rotation of tubes or probes. The detectability of short defects and little mechanical wear is a special feature of systems with stationary probes..



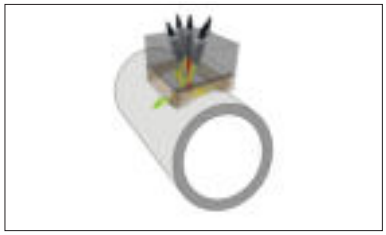
**High speed tube testing with stationary probes (40 probes in 3 rings)**

**ECHOGRAPH-RPSR:** Tubes with larger diameters (e.g. up to 610 mm) can be tested in partial immersion with this system. The probes are positioned below the tube in water-filled chambers. The probes remain in their position, while the tube is moved helically over the test chambers. This method also permits a good coupling of larger probes (multi-channel probe batteries or phased arrays). A tube conveyor must be provided, where the linear and rotational tube movement must work without any slip. Typically, three test chambers are provided: a) longitudinal defects, b) transverse or oblique defects and c) wall thickness measurement & laminations.

**Helical tube testing in partial immersion and three test chambers**



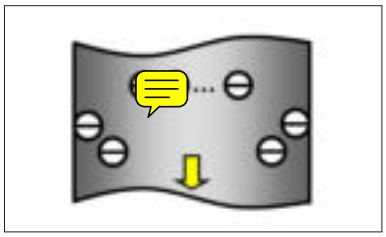
**ECHOGRAPH-RPTR:** A third possible testing concept is a portal system. This system is best suited for an offline inspection. A conveyor system charges the tubes. After the tube is fed into the portal, it is rotated by means of a roller block. The number of probes depends on the required throughput. The probe holders are positioned in the 12 o'clock position and are moved linearly along the tube. Thus the tube is scanned helically. Typical diameters range from 150 to 600 mm. Again, five incidence directions are employed to cover all relevant defects and to measure the wall thickness.



**Tube testing with testing portal and multi-probe holders (cluster)**

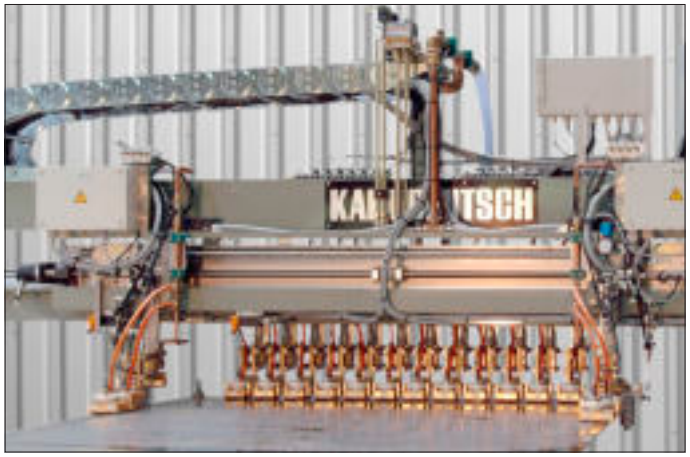
# ECHOGRAPH System Types BAPS SNHF RPTR
# Ultrasonic Inspection of ERW-Pipes

**ECHOGRAPH-BAPS:** The production of ERW-pipes includes several steps of NDT. The usage of NDT has two major goals: Early information about the welding procedure as a feedback for the production line and secondly, the final inspection of the finished pipe. Several ultrasonic systems are typically encountered during the production process.

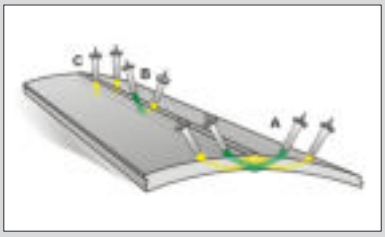


**Strip testing with probes for both strip edges and for the strip middle**

A strip tester is often used for testing the pipe body before welding. The strip edges are tested with separate probe holders and 100% ultrasonic coverage. Linear or oscillating test traces for the strip middle probes are possible. This example shows a testing system with 16 probe holders. Dual-element probes must be used due to the thin strip thickness. Each probe uses one transmitter and can contain one to three receiver elements. All probes are mounted to a testing bridge and can be moved offline above a test plate for dynamic and convenient calibration.

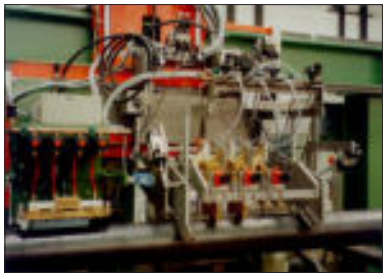


**ECHOGRAPH-SNHFS:** Directly after welding, a first ultrasonic weld inspection is carried out with an online weld testing system. The detection of longitudinal defects is carried out with 4 probes (2 for external defects and 2 for internal defects). Optional lamination probes inspect the heat-affected zone. An oscillating deburring check using one straight beam probe is sometimes added to verify the proper descarfing of the internal pipe wall. Typical testing speeds range between 10 and 35 m/min and correspond to the welding speed. Water jet coupling eases the inspection of the hot pipe directly after welding (see picture).



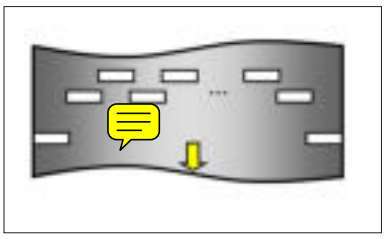
**Weld testing with A) longitudinal, B) transverse and C) lamination probes**

**ECHOGRAPH-SNHFT:** After pipe cutting and the hydrostatic test, the final weld inspection can be carried out with a testing portal where the weld is turned into the 12 o'clock position. A portal shows the advantage that the weld is inspected without pipe movement, thus avoiding vibrations which could degrade the test results. Almost similar probe configurations are used for the offline weld test. Optional transverse probes can be provided. Water jet coupling for the angle beam probes allows high testing speeds (typically up to 1...1.5 m/s) and therefore an overall high throughput rate. If no strip testing system is employed, the pipe body test can be performed in a separate testing system. (e.g. ECHOGRAPH-RPTR) or a second full-body probe carriage is provided (small picture, left side).

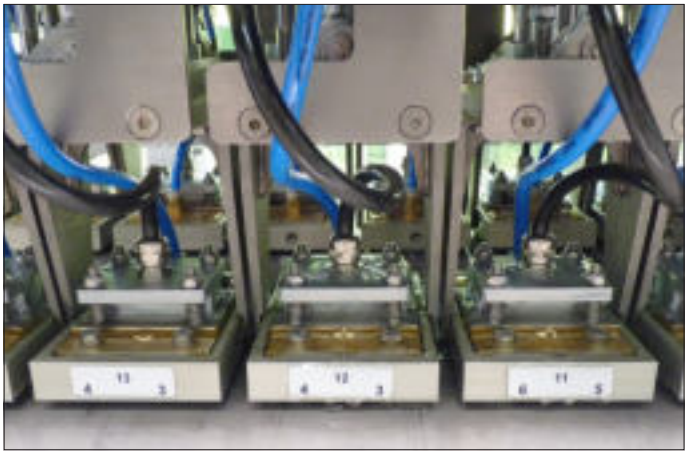


# ECHOGRAPH System Types BAPS SNUS SNUL
# Ultrasonic Inspection of Submerged-Arc-Welded (SAW) Pipes

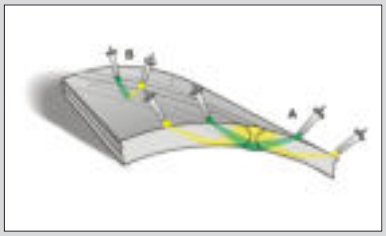
**ECHOGRAPH-BAPS:** Helically welded as well as longitudinally welded pipes have to be inspected with ultrasound if their later use is for the transportation of oil and gas. Helically submerged arc welded pipes (HSAW) are manufactured in a continuous process from a virtually “endless” strip. Consecutive strips are connected by means of a butt weld. The ECHOGRAPH-BAPS strip testing system must be mounted on a rotatable carrier, which is placed directly before the welding machine. The rotation angle corresponds to the pipe weld angle. Recent requirements suggest solutions with high ultrasonic coverage. An overlapping probe arrangement with 100% ultrasonic coverage is shown in both pictures. The heavy plates for SAW-pipes with longitudinal welds are typically tested in the plate mill with up to 400 testing channels and up to 100 probes.



**Strip and plate testing configuration with 100% ultrasonic coverage**



**ECHOGRAPH-SNUS:** The wall thicknesses for HSAW-pipes are limited to max. 20 or 25 mm because of the forming process. Therefore, four sensors are typically sufficient for the detection of longitudinal defects. Also two (e.g. on-bead) probes are provided to detect transverse defects. These six probes (see small figure) are applied during the first online weld test (e.g. on endless pipe directly behind the welding machine) as well as in the final offline system (for the pipes which are already cut to their final length). The detection of delaminations in the heat affected zone and in the pipe ends are additional inspection tasks for the offline test.



**Angle beam probes for the inspection of HSAW-pipe welds**

**ECHOGRAPH-SNUL:** Larger wall thicknesses can be produced in case of longitudinally submerged-arc welded pipes (LSAW). This often requires further tandem probes in order to detect longitudinal lacks of fusion in mid-seam reliably. Transverse probes can be realised on-bead to avoid the cumbersome calibration of the conventional X-setup. Lamination probes cover the heat-affected zone. Two testing concepts are found. Most common is a machine stand and the inspection of a linearly moving pipe (small picture). Higher throughputs and superior test results can be obtained by means of a testing portal with resting pipe during test (large picture).

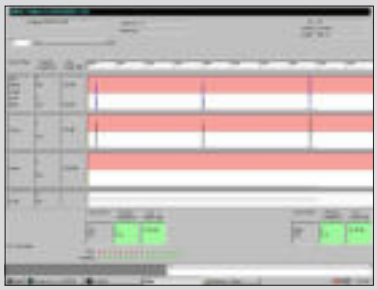
# ECHOGRAPH Systems Types STFL SCHN TTPS
# Ultrasonic Inspection of Pressure Cylinders, Rails and other Components

**ECHOGRAPH-STFL:** This testing system is designed for rough environmental conditions and high throughput. The system is therefore ideally suitable for the manufacturer of gas cylinders. The cylindrical part of the cylinder is tested in a helical testing trace. Defects of all relevant orientations are detected in one test run. While the cylinder is rotating, the probes are linearly guided along the longitudinal axis of the cylinder. Two probe holders and 10 probes are typically employed (test principle similar to ECHOGRAPH-RPTR).

**ECHOGRAPH-SCHN:** The standard configuration of an ultrasonic rail testing system contains 16 probes, where seven probes are used for the inspection of the rail head, six probes for the rail flange and three probes for the rail base. Straight beam probes are usually chosen. Water jet coupling provides good access to the complex and strongly curved rail profile. The probe holder adjustment can be designed manually or fully automatically. The testing speed is typically 1 m/s and the test sensitivity 1.4 mm FBH.

**ECHOGRAPH-TTPS:** Bearing rings can be inspected in an immersion tank testing system. The bearings are designated for high-speed trains and therefore the testing sensitivity is in accordance with DIN EN 12080. This specification enforces a 0.5 mm flat bottom hole as calibration reflector which imposes the highest requirements on the mechanical precision. This reflector must be detected with straight beam ultrasonic incidence either by direct defect echo evaluation of by detecting a reduction of the back wall echo. Four similar straight beam probes are used to increase the throughput. The ring is tested under rotation- with helical test tracks.

**ECHOGRAPH 1155 Electronics:** The evaluation of the ultrasonic signals is carried out with the digital ECHOGRAPH 1155. This multichannel ultrasonic electronics is specially designed for automated ultrasonic testing. Four flaw gates, two amplitude thresholds, a programmable TCG (time-corrected gain, sometimes also called DAC for distance amplitude correction) and multiple evaluation parameters a standard. A remote diagnosis and service can be provided by TCP/IP directly from KARL DEUTSCH in Germany. Data exchange with a host computer or an SQL data base is possible as an option.





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