TUBE MEASURING
NON-CONTACT MEASUREMENT FOR TUBE PRODUCTION

QUALITY IMPROVEMENT BY DIMENSIONAL MEASUREMENT
For more than 25 years, LAP GmbH is specialised in development, manufacturing, installation and commissioning of laser systems for dimensional measurement of raw and finished products in the metals and steel industry. Nearly all components, specially the sensors, are taken from own production in Lueneburg, Germany.

Since the year 2000, the demand of end customers for tighter tolerances, better quality management, checking and verification is continuously increasing. Tube manufacturers responded by investing in high tech metrology. LAP offers applications or integrated systems. The non-contact optical measuring systems meet the demands as well of seamless tubes as of welded tubes.

LAP may look back on many years of experience concerning the integration of optical dimensional measurement applications for long and flat products. In 1997, LAP already realised a two-axes diameter measurement on tubes with temperatures higher than 1200 °C, installed at Vallourec & Mannesmann Düsseldorf Rath, at the world’s oldest hot Pilger mill.

Today, LAP 3-axes measuring systems with patented evaluation algorithms are standard in prevailing stretch reducing mills.

If you want to capture complete tube profiles of hot or cold profile, square or circular tubes on every single tube, LAP offers a state-of-the-art light section measurement system. This new system is extremely versatile as well for optimisation of production processes as for verification of the final dimensions.

**Measurement Solutions for the Tube Production**

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**Your benefits from using LAP Laser Measuring Systems**

**More than 25 years of experience**
LAP has many years of experience in developing, market launching and realising of several hundreds of measuring applications worldwide in the steel and metals industry.

**All from one source**
From design to commissioning, including hardware, software and service – for all measured values, you have one single partner: LAP.

**Patented technology**
Unique online three-point outer diameter and out-of-round evaluation of three-high stand milled tubes with patented algorithms.

**Made in Germany**
Production and pre-inspection in Germany by German Quality Standards.

**For your success**
Increase your overall operating efficiency by better quality, less crop, higher throughput and consistent documentation.
WORLDWIDE, MORE THAN 200 LAP SYSTEMS ARE SUCCESSFULLY IN USE

TATA TUBES GREAT BRITAIN
HARTLEPOOL 42” MILL PLANT
TATA Tubes Hartlepool 42” mill produces longitudinal welded tubes up to an outer diameter of 42”. After chamfering, the tubes reach final inspection. At the feeding roller table, LAP installed two industrial robots to measure several shapes and dimension at both tube ends. The fully automated measuring process has been integrated with the process control in cooperation with TATA.

The following values are captured sequentially at both tube ends:
- Inner and outer diameter along the tube circumference
- Wall thickness
- Ovality
- Shape and thickness of weld seam
- Angle of chamfers
- Rectangularity of tube ends to tube body

VALLOUREC & MANNESMANN FRANCE
DEVILLE LES ROUEN PLANT
Combined measuring application to capture the outer diameter in two axes directly at the exit of the piercer and to measure the length of the tubes in the following lateral transport using CCD cameras. Both measurements use the heat emission of the tube. Two CCD cameras, positioned at an angle of 90° to each other, measure the outer diameter and ovality of the hollow. The parallax error is compensated automatically. Two more CCD cameras capture the length of the hollow. The dimensional values of the hollow are used for process optimisation in the following plug mill.

BENTELER STAHLROHR GERMANY
DINSLAKEN PLANT
Early 2009, at the Dinslaken plant of Benteler Stahlrohr GmbH, an LAP RDMS 250.3 Swing has been installed at the runout of the stretch reducing mill. The RDMS 250.3 Swing with patented three point evaluation is a precision measuring system for outer diameter and ovality of seamless three-high stand milled tubes. By using three METIS laser scan micrometers positioned at 120° to each other and the patented three-point evaluation algorithm, the system not only measures the outer diameter, but also captures the typical ovality errors caused by three-high stands. A pyrometer included in the RDMS housing measures the tube temperature to calculate the final dimensions of the cold tube in the systems software.
SEAMLESS TUBES

APPLICATIONS FOR PILGER MILLS
BEFORE PILGER MILL:
- Hollow length and diameter
- Check of piercer diameter
AFTER PILGER MILL:
- Outer diameter, ovality
- Piercer head detection
- Final length after hot saw
AFTER REDUCING MILL:
- Outer diameter, ovality
- Outer contour
PLUG MILL APPLICATIONS
AFTER FURNACE:
- Length of hollow
AFTER PIERCER:
- Outer diameter and length of hollow
AFTER PLUG STAND:
- Outer diameter and ovality
STRETCH-REDUCING MILL APPLICATIONS
AFTER FINISHING STAND:
- Outer diameter and ovality

WELDED TUBES

APPLICATIONS FOR SPIRAL TUBE WELDING
UNCOILING:
- Strip width and centered position
- Strip thickness
BEFORE TRIMMING:
- Centered position
AFTER TRIMMING:
- Edge shape (both sides)
SPHEROIDISATION, AFTER WELDING POSITION:
- Outer diameter, ovality
- Outer contour
AFTER EXPANDER:
- Straightness
AFTER FINISHING (FINAL INSPECTION):
- Both ends: inner/outer diameter, rectangularity, chamfer angles, Length
- Middle: outer diameter, ovality, Length

APPLICATIONS FOR CIRCULAR LONGITUDINAL WELDED TUBES
UNCOILING:
- Strip width and centered position
- Strip thickness
BEFORE TRIMMING:
- Centered position
AFTER TRIMMING:
- Centered position
AFTER SHAPING AND LONGITUDINAL WELDING:
- Length: (cut optimisation at flying shears)
- Outer diameter and ovality
BEFORE EXPANDER:
- Straightness
AFTER EXPANDER:
- Straightness
- Outer diameter contour at both tube end: (inspection of expanding results)
AFTER FINISHING (FINAL INSPECTION):
- Both ends: inner/outer contour, rectangularity, chamfer angles, welding seam thickness profile
- Middle: outer diameter, ovality
- Length

APPLICATIONS FOR RECTANGULAR LONGITUDINAL WELDED TUBES
UNCOILING:
- Strip width and centered position
- Strip thickness
BEFORE TRIMMING:
- Centered position
AFTER TRIMMING:
- Centered position
AFTER SHAPING AND LONGITUDINAL WELDING:
- Length: (cut optimisation at flying shears)
- Outer contour along tube, width and thickness, convexity/concavity, rhomboidality, rectangularity, edge radius
AFTER FINISHING (FINAL INSPECTION):
- Length
THICKNESS MEASUREMENT

STRIP THICKNESS MEASUREMENT USING LASER TRIANGULATION
The simplest method for non-contact thickness measurement is laser triangulation. Depending on site and environmental conditions, you may use two opposing sensors in an O-frame or a C-frame. The sensors are protected against humidity, dirt and temperature by housings or frames with air purging.

TRIANGULATION SENSORS:
ATLAS, POLARIS, ANTARIS, CALIX

PRINCIPLE: TWO OPPOSING SENSORS WITH A DEFINED DISTANCE (A) EACH DETECT THE DISTANCE TO THE SURFACE (d1, d2). THICKNESS IS CALCULATED BY SUBTRACTION (D=A-d1-d2).

LENGTH MEASUREMENT

LENGTH MEASUREMENT USING LASER DOPPLER
Laser Doppler sensors can measure the length even of hot surfaces without contact. They may also be protected by an adequate housing including air purge.

PRINCIPLE: A LASER SPOT IS PROJECTED ON THE MOVING SURFACE. DEPENDING ON REFLECTION IN OR AGAINST MOVEMENT DIRECTION, THE REFLECTED BEAM HAS A DIFFERENT PHASING. USING THIS PHASING DIFFERENCE, THE SPEED, AND BY A CERTAIN PERIOD THE LENGTH, CAN BE CALCULATED.

LIGHT SECTION SENSORS:
OPTARIS M

LENGTH MEASUREMENT USING BACKLIGHT AND CAMERA
PRINCIPLE: A LONG LIGHT SOURCE EMITS A BAND OF LIGHT WHICH IS DETECTED BY A CAMERA. ANY OBJECT CROSSING THE LIGHT CAUSES A SHADOW WHICH IS RECORDED BY THE CAMERA. FOR A FIXED DISTANCE, THE WIDTH CAN BE CALCULATED IN RELATION TO CALIBRATION VALUES.

WIDTH MEASUREMENT

WIDTH MEASUREMENT USING LASER TRIANGULATION
Width may also be measured using two laser triangulation sensors. The subtraction method allows the object to have different widths or to be at different positions between the sensors without influence on the measuring result.

PRINCIPLE: BASICALLY, WIDTH MEASUREMENT WORKS LIKE THICKNESS MEASUREMENT. AS A SINGLE SPOT IS DIFFICULT TO PLACE ON AN EDGE AND LITTLE UP OR DOWN MOVEMENT MAY CAUSE THE SENSOR TO LOSE THE EDGE, ANTARIS BAND USES A SHORT LINE PERPENDICULAR TO THE EDGE. THE EDGE JUST NEEDS TO BE SOMEWHERE IN THE RANGE OF THE LINE TO BE DETECTED.

WIDTH MEASUREMENT USING LASER DOPPLER
Laser Doppler sensors can measure the length even of hot surfaces without contact. They may also be protected by an adequate housing including air purge.


LIGHT SECTION SENSORS:
OPTARIS M
**MEASURING THE OUTER DIAMETER OF TUBES USING LASER-SCAN MICROMETERS**

Laser-scan-micrometer consist of emitter and receiver. LAP METIS sensors use a light plane generated by a laser beam, which is deflected by a rotating prism and directed by a lens. In the receiver, the laser is focused on a diode. For each pass, the laser needs a fixed time interval. If there is an object in the laser plane, the receiver is shadowed for a certain amount of time. This time is proportional to the dimension of the object.

**MULTI-AXES – RDMS:**

One micrometer can measure one axis of an object, e.g. the diameter. To get the ovality or further dimensional values, several measuring axes are necessary. These multi-axes systems in round steel housings form LAP RDMS series.

**MEASURING THE OUTER DIAMETER OF TUBES USING LIGHT-SECTION**

Light-section sensors can do a lot more than only measuring diameter. Because of this, they are normally used, when more dimensional values need to be collected.

**PRINCIPLE:** Camera detects a laser line emitted by the sensor. The laser line plane is perpendicular to the transport direction of the tubes to be measured. If a tube crosses the plane, the laser line follows its surface contour. Thus, the camera records the surface profile in its detection area. To cover the whole surface and diameter, several sensors need to be placed around the tube.

**MEASURING THE OUTER DIAMETER OF TUBES USING BACKLIGHT AND CAMERA**

**PRINCIPLE:** A long light source emits a band of light which is detected by a camera. Any tube crossing the light causes a shadow which is recorded by the camera. For a fixed distance, the diameter can be calculated in relation to calibration values. Using two perpendicular systems, the parallax error can be compensated automatically and the ovality can be calculated.
MEASURING THE OUTER CONTOUR OF TUBES USING LIGHT-SECTION

At contour measurement, light-section sensors can show their full performance. The complete surface of a tube can be recorded and measured. Depending on constellation, besides diameter, ovality and contour also welding seams and surface faults can be detected.

**Principle:** A camera detects a laser line emitted by the sensor. The laser line plane is perpendicular to the transport direction of the tubes to be measured. If a tube crosses the plane, the laser line follows its surface contour. Thus, the camera records the surface profile in its detection area. To cover the whole surface and diameter, several sensors need to be placed around the tube.

Camera View

LIGHT-SECTION SENSORS: OPTARIS M

**Principle:** An oscillating mirror projects a laser point on the surface of an object. The reflected beam is directed onto a CCD by a mirror oscillating synchronously. By connecting the measuring angle to the measured distance you get a line profile.

Camera View

MEASURING THE OUTER CONTOUR OF TUBES USING SCANNING TRIANGULATION

The setup for laser-triangulation-scanner is similar to the setting for light section sensors. While the latter use a permanent laser line, triangulation-scanner generate a laser point, which oscillates perpendicular to the tube. Thus, not the whole surface is covered, but – depending on transport speed and scanning frequency – a tight web of measuring points. Measurement will cover diameter, ovality and contour. Welding seams will be detected at regular intervals. Surface faults will only be detected, if their size is larger than the measurement grid.

Camera View

SCANNING TRIANGULATION SENSOR: ANTARIS SCAN
MEASURING THE STRAIGHTNESS OF TUBES USING SCANNING TRIANGULATION

The setup for laser-triangulation scanner is similar to the setting for laser scan micrometers. While the latter only detect shadowing in one axis, ANTARIS SCAN records the complete line profile in its range.

PRINCIPLE: AN OSCILLATING MIRROR PROJECTS A LASER POINT ON THE SURFACE OF AN OBJECT. THE REFLECTED BEAM IS DIRECTED ONTO A CCD BY A MIRROR OSCILLATING SYNCHRONOUSLY. BY CONNECTING THE MEASURING ANGLE TO THE MEASURED DISTANCE YOU GET A LINE PROFILE.

STRAIGHTNESS MEASUREMENT USING LASER-SCAN-MICROMETERS

For straightness measurement you need at least three micrometers, one in the middle and two at the ends of the tube. To detect deviations in all directions, the tube is turned along its longitudinal axis during inspection.

STRAIGHTNESS MEASUREMENT USING LASER TRIANGULATION SENSORS

A chain of displacement sensors can also be used for straightness measurement. As the laser beam only hits the tube on one side, the tube has to be turned around its longitudinal axis to get all deviations.

SCANNING TRIANGULATION SENSOR: ANTARIS SCAN

LASER-SCAN-MICROMETER: METIS Emitter and Receiver

TRIANGULATION SENSORS: ATLAS, POLARIS, ANTARIS

STRAIGHTNESS
TUBE-END INSPECTION

AUTOMATIC MEASUREMENT OF TUBE-ENDS

For connecting tubes the correlation of dimensions and geometry at the ends of the tubes is of utmost importance. A robot with a C-shaped measuring frame at the end of its arm collects all relevant data. Three triangulation sensors and one light section sensor are placed in the measuring frame. They provide the measurement data for outer and inner diameter, outer and inner contour, wall thickness, rectangularity in relation to the tube’s longitudinal axis and chamfer angles. The measuring frame is rotated 360° around the tube’s longitudinal axis, following the tube’s circumference. Due to the fixed turning point you get a complete image of the measured values in relation to their angle.
WITH LAP YOU INVEST IN EXPERIENCE AND PRECISION

ALSO FITS IN WITH YOUR SYSTEM

An optimised selection and design of suitable sensors manufactured in-house combined with optimum configuration of the measuring field in measuring frame constructions manufactured in-house ensures that a measuring system can be integrated both mechanically and electrically in virtually any location in the tube production line.

STAYS THE COURSE UNDER EXTREME CONDITIONS

LAP supplies solutions for extreme requirements. Our applications perform equally well at high temperatures when rolling larger tubes (> 1000 °C) as at extremely low ambient temperatures (< -30 °C). We can measure at the end of a piercing mill, despite the high accumulation of dust and cinders. We can also measure several different variables at extremely short intervals to a maximum degree of precision.

PRECISION RIGHT FROM THE START

Each sensor is linearised and calibrated at the factory during production at LAP. The sensor’s measuring characteristics such as linearity, repeatability and measurement accuracy are tested and documented. The sensor is parametrised for the measurement task it performs. The sensor then must undergo a 24-hour endurance test. Once installed in the measuring frame, all sensors are referenced with one another using certified reference and calibration master pieces and calibrated as a system. If requested by the customer, LAP can also perform measurement capability analyses and verify the measurement system’s ability to perform the measurement task prior to installation.

QUALITY MANAGEMENT AND CONTROL

LAP measuring systems make it possible to systematically verify tube dimensions at the various manufacturing stages. Deviations in the objectives for each stage thus become transparent; all employees involved in the process are kept up-to-date about the current standard of quality and can quickly take corrective action. As the tube measurement data is saved, this makes it possible to carry out long-term analyses of similar production cycles and help pinpoint the causes of undesirable developments. Integration of LAP measurement results in the customer’s own quality management systems or PLC software modules is guaranteed via existing network structures, e.g. Ethernet TCP/IP and SQL database access.

DOCUMENTATION AND TRACEABILITY

The dimensional values recorded by the LAP measuring systems are saved locally on the LAP system together with the customer or order-specific reference data sets and archived on a long-term basis. The type and scope of this long-term storage can be adapted to the specific needs of the customer. Thanks to the storage media available today, long-term archiving over more than one production year is possible. Once archived, measured data for a tube can be displayed on the screen using convenient query tools without interrupting the current measurement which continues in the background.

CUSTOMISED WARNING SYSTEMS

In addition to measuring the main tube dimensions, LAP measurement systems can also be used for various monitoring tasks that are unrelated to the tube manufacturing process. Acoustic and visual warning signals promptly draw the user’s attention to undesirable developments. The warning messages and associated measured values are visualised and stored in the measurement system. In addition to a measured dimension, the trigger for warnings could also be, for example, the start weight of hollows, selection of a suitable piercing head or the position and orientation of the strip in the feeder.

CONSTANT PRODUCTION VALUES FOR THE WHOLE BATCH, MADE POSSIBLE BY IN-LINE-MEASURING
STANDALONE SOLUTIONS

LAP measurement systems can, depending on what the customer wants, be conceived as a straightforward standalone solution with no data connection to the works host system through to a network solution fully integrated into the existing works topology. With the standalone solution, the measuring process can be performed automatically by the LAP measuring system or initiated by the user. A connection with the Level 2 Automation or higher-level production process control systems is not required. The measured data recorded and analysed using the standard LAP software or a customer-specific analysis software is displayed via the local HMI and stored in a local database.

LEVEL 2 CONNECTION

Level 2 connections of LAP measurement systems via digital, analogue and system bus interfaces allow the exchange of digital and analogue information and error or event messages with existing automation systems.

PROGRAMMING AND SOFTWARE

The software installed in the LAP measuring systems which records, analyses, saves and displays the measured data and the data transfer interface software is programmed in-house by LAP software specialists.

DATA INTERFACES AND INTEGRATED NETWORK SOLUTIONS

LAP measurement systems can be connected to the work’s own production process control systems, databases or host systems in many different ways and can be fully-integrated into the network. The data connections normally serve to adopt order-specific data and tube reference data from the network/database at the works, and make this available to the network/database once again with the measured data. Different departments and employees can access the measurement results obtained from all areas of the works via installed HMI clients.

A well established service organisation ensures a consistently high standard of LAP service worldwide. Our subsidiaries and qualified certified partners are available to give advice and lend a hand. If the need arises, specialists from our works in Lüneburg can also be onsite within a very short space of time. This highly customer-proximate service organisation is supported by an effective spare parts logistics operation which supplies spare parts to virtually any location in the world within 24 hours.

SERVICE THAT REALLY HELPS YOU OUT

SERVICE QUALITY – THE LAP STANDARD

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PRODUCTS FOR THE PRODUCT – THE SERVICES

Measurement technology by LAP, high-tech - and designed to reduce care and maintenance to a minimum. To ensure long term use and optimum availability of your system, LAP has developed service offerings tailored to individual requirements. These range from purely preventative measures through to offerings that ensure maximum production security. LAP service employees and partners receive regular training on the technology used in our products and their applications. Suitable seminars are provided by the LAP Academy should your personnel require further training.

SERVICES WITH A CERTIFICATE – THE LAP SERVICECARD

LAP looks after your system throughout its entire life cycle. When your system is commissioned and handed over, you will receive your LAP ServiceCard which contains important information such as the contact details for the LAP subsidiary or LAP partner who will be looking after you. The certificate that comes with the LAP ServiceCard tells you which services are available. Additional services are available for specific regions. You can find out from your LAP subsidiary or LAP partner about these special versions of the LAP ServiceCard.
HIGH-TECH QUALITY FOR STEEL INDUSTRIES BY LAP

For more than 30 years, LAP has been developing, manufacturing and distributing laser measurement systems, line lasers and laser template projectors for industrial and medical applications. LAP products are high-precision devices Made in Germany. Using LAP laser systems, our customers improve performance and increase the quality of their products as well as the effectiveness of their processes.

As a result of continuous product innovation, LAP has become a world leader in lasers for projection and measurement. LAP products are setting the standards in a wide range of markets from manufacturing to heavy industrial environments and medical applications. Environmental protection is important to us. We use solar panels, green electricity and roofs planted with grass. Our production is planned by standards of sustainability.

Quality has always been part of our commitment. We are content if you are. We know your high demands. To meet your requirements, the quality management of LAP is certified by DIN EN ISO 9001:2008 for industrial products and by EN ISO 13485:2007 for medical engineering products.

www.lap-laser.com/STEEL

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