

# TubeInspect and TubeInspect S

## Technical information

The tube measuring system **TubeInspect** incorporates advanced technology for the high-precision measurement of bent tubes, used in the determination of set-up and correction data for CNC tube bending machines and part control for quality assurance in production within the scope of DIN ISO 9000 ff.



TubeInspect



TubeInspect S

Bent tubes are important parts in various industrial products, such as brake lines and liquid carrying conduits in mechanical and plant engineering. **TubeInspect** is a tube measuring system for the non-contact measurement of three-dimensionally bent tubes. It allows for the measurement of bent tubes of all shapes and colors such as brake lines, moulded tubes, flexible rubber tubes, and free formed and exhaust pipes.

Thanks to the unique combination of an optical coordinate measuring machine with the potential of a programmable optical gauge, **TubeInspect** is in the position to replace mechanical gauges.

For more information contact:  
ACCUREX DIMENSIONAL MEASUREMENT SYSTEMS  
phone: 800-535-5798 or [info@accurexmeasure.com](mailto:info@accurexmeasure.com)

Offices in Northeast, Southeast and Midwest USA

**AICON 3D Systems GmbH**  
Biberweg 30 C  
D-38114 Braunschweig

tel. +49 (0)531 58 000 58  
fax +49 (0)531 58 000 60  
[info@aicon.de](mailto:info@aicon.de)  
[www.aicon3d.com](http://www.aicon3d.com)

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## Functional principle

- The functional principle of the optical tube measuring system **TubeInspect** is based on a photogrammetric method. Its main characteristic is the non-contact measurement which uses digital images of the object instead of measuring the object itself. In the first step, when starting the measurement, the cameras generate the measuring images within a few milliseconds thanks to synchronized triggering. Thus even highly flexible tubes (e.g. thin brake lines) can be measured without sticking to a certain waiting time. With the help of photogrammetric calculations, all results are merged to a complete three-dimensional model of the tube. This is the basis for further analyses such as the determination of bending elements, calculation of X, Y and Z coordinates of the bending points, and the comparison to the CAD drawing.

## Performance features

- **TubeInspect**, as a programmable optical measuring system, is in the position to replace cost-intensive mechanical gauges. With the measurement of the sheath tolerance based on a tolerance envelope, **TubeInspect** can reproduce the inspection criteria of a mechanical gauge. The graphic showing the result is easy to understand and refers to the traditional gauge check.

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- The tube to be measured is placed in the optical measuring cell without special fixtures or holding devices.
- A deflexion, caused by the self-weight of thin or elastic parts, is compensated by the automatic deflexion correction in the measuring software.
- The measurement time depends on the length of the tube and its number of bends. The measurement only takes 2 -30 seconds.
- The actual contour of the relevant tube to be measured is compared with the nominal data that are stored in the database of the measurement computer.
- **TubeInspect** delivers user independent, reliable and repeatable results, and thus meets the high requirements to measurement capability tests such as MSA or Gage R&R study.
- Data reports can be printed or saved. Thereby, a quality proof of the measured tube is available. Optionally, it is possible to generate data files for SPC (Statistical Process Control) that can e.g. be exported to statistic programs. The necessary interfaces can be delivered on request (e.g. interface to qs-STAT).
- **TubeInspect** can be connected with modern CNC bending machines in order to transmit corrections online. This allows for a significant reduction of setup processes and standby time in production. For the correction of standard tube geometries, the AICON standard interface to bending machines **TubeInspect NET** is required.
- Tubes of which no CAD data is available can be measured as master tubes, and the results can be sent to a CAD system.
- The spectrum of application is made even broader with the optional software module **FLEX** which is used for the measurement of flexible tubes, moulded tubes and tubes with fixtures and attachments.
- **TubeInspect** is ready for the automatic 100% inspection in the robot cell. For this application, the software module **AUTOMATIC** is required.

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## Measurable tube spectrum

- Tube diameters from 1mm to 200mm
- Measurable tube lengths: see measuring volume, longer tubes can be measured in several steps while the results are automatically connected.
- Bending angles from 1° to 180°
- all materials and surfaces (exception: transparent materials such as glas)
- bend in bend shapes
- moulded hoses
- tube-hose combinations
- combinations of tubes and moulded hoses
- fixtures, supports and attachments with the help of adapters
- free-formed geometries

Non-cylindrical end of tubes or pre-manufactured tubes with screw-joints can be measured only to a limited extend. Due to the large diversity of tube shapes and measuring tasks, it is not possible to eliminate the eventuality that certain tube geometries can only be measured partly or with a low accuracy.

Tube geometries with intersection points hard to acquire, tube sections that can only be made out in a limited way, or geometries with coordinate points from fixtures and flanges may be measurable with the optionally available software modules.

Very flexible tubes or tubes with hose sections can be measured with the software module **FLEX** that is optionally available. The prerequisite for the successful comparison of actual and target data of tubes with hose sections are comparison data with stretched hose lengths.

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## Technical Data

### Dimensions and weight

	<b>TubeInspect</b>	<b>TubeInspect S</b>
<b>Measuring volume:</b>		
Length / Width / Height	2400mm / 1200mm / 700mm	1200mm / 1200mm / 700mm
<b>Dimensions</b>		
Length / Width / Height	3150mm / 1520mm / 2350mm	1850mm / 1520mm / 2350mm
<b>Weight</b>	approx. 2000kg	approx. 1200kg

### Measuring time, number of bending points

Measuring time for 15 bending points	approx. 15 seconds
Minimum no. bending points (without start and end point)	1
Maximum no. bending points	99

### Measuring accuracy

Sheath tolerance (1 Sigma) (for ideally round tubes)	± 0.1 mm
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### Mobile control terminal for operator

Length x Width	600 mm x 650 mm
Height	1200 mm
Weight	100 kg

### Coat/colour

Tube measuring system	Grey white RAL 9002 blue RAL 5015
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## Software

Basic software:	<b>TubeInspect</b> measuring software
Measurement of moulded hoses and tube-hose-combinations :	Software module FLEX
Measurement of free-formed geometries:	Software module FREEFORM
Connection to robot control:	Software module AUTOMATIC
optional software interfaces:	CAD import and export formats (on request)  Data transfer to statistic programs (e.g. qs-STAT) on request
Connection to bending machine:	Network module <b>TubeInspect</b> – NET

Note: Import of AICON correctional data file to the particular CNC control program of the bending machines is not included, and has to be requested at the bending machine manufacturer.

[Interfaces to bending machines are available from ACCUREX. These ACCULINK interfaces will allow AICON correctional data to be imported to most CNC benders. ACCUREX can also prepare custom interfaces if required.](#)

## Standard equipment tube measuring system

### Image acquisition system

The digital cameras are located above the measuring field. They acquire the tube from different viewing angles. For the spacial orientation of the cameras, there are uniformly distributed reference points on the measuring field.

**TubeInspect** is equipped with 16, **TubeInspect S** with 10 high resolution digital cameras (1.3 megapixels) that transmit their images to the controlling computer via a firewire interface (IEEE 1394).

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### Equipment of measuring cell (hardware)

- Housing with 4 adjustable feet, powder-coated,  
Colouring: grey-white: RAL 9002 and blue: RAL 5015
- Motor-driven shutter blinds (front and side) to protect from extraneous light and dust
- Special mountings for cameras
- Measuring field with transmitted lightening
- Self-illuminating 3D reference points embedded in the measuring field
- Makrolon® plate for measuring field (exchangeable consumable)
- Mobile control terminal (in ergonomic standing height, located on the right side of the tube measuring machine)
- optional rubber air springs for the damping of hits and vibration, type FAEBI 150 or other model

### Computer system

19" industry PC with Intel Core 2 Duo (E8200) processor, 2 GB RAM, Firewire connection, 200 GB HDD, 3 ½" disc drive, CD-ROM drive, DVD burner, keyboard with mouse, color-graphic monitor, network interface card, operating system Microsoft® Windows® XP or Vista.

If more powerful PC systems are also approved on the date of delivery, we will reserve the right to apply those, too.

### Operating software

The measuring software **TubeInspect** runs with the operating systems Microsoft® Windows® XP or Vista.

The design data of the tube to be measured are deposited in a tube data base. The data collection is either done manually by the user or automatically by means of an import function for the data file (e.g. VDA interface). Both coordinates (X, Y, Z) of the bending points or bending data (Push/Bend/Rotate) are calculated by **TubeInspect** automatically.

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For each section of the tube, individual tolerances can be fed in the system. The alignment of the measurements is done via best fit, weighted best fit or 3-2-1 alignment.

The comparison between the collected data and the target data runs fully automatically. The measured actual geometry is compared to the target geometry (saved in the tube data base) by means of the best-fit method or of a pre-determined alignment for the particular tube. The results from the comparison measurement are displayed in graphics showing the sheath deviations. Moreover, a graphical overlay of the target and actual tube data is provided. Due to this color-coded depiction, the user can instantly see if the part fits into the defined tolerance. Moreover, the measured actual data are displayed as bending elements (push/rotate/bend) and coordinates of the bending points (X/Y/Z) including the deviations to the target data. All results can be saved and printed as reports.

Tubes, of which no CAD data or bending coordinates are available, can be measured as master tubes, and the calculated results can be transmitted to a CAD system or to the bending machine.

## Optional expandability

### Software module FLEX

The software module FLEX measures tube-hose-combinations, combinations of tubes and moulded tubes, moulded tubes, fixtures and attachments. The measurement is possible by applying positioning adapters.

### Software module FREEFORM

The software module FREEFORM allows for the measurement of free-formed geometries. A feedback of the correctional data to a free-formed bending machine is in preparation.

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## **TubeInspect AUTOMATIC**

This is the module for the remote control of the tube measuring system **TubeInspect**, as it is needed in a robot cell. The remote control can be done both unidirectional with a trigger signal and bidirectional with a software interface.

## **Software module TubeInspect NET**

This is the module for the export of an AICON correction data file in ASCII-format to an arbitrary number of bending machines via a TCP/IP network.

Note: The data import of the AICON correction data file to the particular CNC control program is not included and will be delivered on request by the particular bending machine manufacturer.

## **Software interface statistics software (e.g. qs-STAT)**

This is the interface between **TubeInspect** and the statistical analysis software (e.g. qs-STAT).

## **Measurement adapters**

For the measurement of attachments and flanges, of non cylindrical tube ends, and for the measurement of very long tubes, measurement adapters can additionally be applied. AICON offers a standard range of positioning, straight line and connecting adapters.

## **Positioning notes**

When positioning the tube measuring system **TubeInspect**, it is necessary to leave free a work space of approx. 0.5m to the back side and 1m to each other side.

Power supply in Germany : 400 Volt, 16 A / 480 Volt, 32A

Power supply out of Germany: on request

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