

Measured parameters are presented in the table:

	Parameter	Standard min	Standard max	Min	Max	Errors	Status
Left end	Diameter at left, mm	528,5	531,5	530,2525	534,1225	366	☐
	Perimeter at left, mm	1660,33	1669,76	1671,92	1671,92	1	☐
	Roundness at left, mm	0	5,3	3,869995	3,869995	0	☑
	Bevel angle, degree	30	35	31,056	32,897	0	☑
	Bevel angle 2, degree	11	16	12,56425	14,80775	0	☑
	Bevel dulling at left, mm	1	2,6	1,7025	2,875	184	☐
	Cutting angle at left, mm	0	1,6	-34,475	4,5025	387	☐
	Wall thickness at left, mm	0,8	20,7	17,7475	19,29	0	☑
Right end	Diameter at right, mm	528,5	531,5	531,0575	534,65	339	☐
	Perimeter at right, mm	1660,33	1669,76	1674	1674	1	☐
	Roundness at right, mm	0	5,3	3,5925293	3,5925293	0	☑
	Bevel angle, degree	30	35	5,51175	33,231	469	☐
	Bevel angle 2, degree	11	16	13,029	82,518	57	☐
	Bevel dulling at right, mm	1	2,6	1,8	8,799999	116	☐
	Cutting angle at right, mm	0	1,6	1,36	9,445	466	☐
	Wall thickness at right, mm	0,8	20,7	17,77	19,68	0	☑
Pipe body	Diameter of pipe body	527	533	530,81	533,18	8	☐
	Perimeter of pipe body, mm	1655,62	1674,47	1665,8	1665,8	0	☑
	Roundness of pipe body, mm	0	5,3	2,369995	2,369995	0	☑
	Total pipe warping, mm	0	24,4	0,9	11,13	0	☑
	Pipe warping per 1 meter, mm	0	1,5	1,03	1,03	0	☑
	Pipe length, mm	10000	12200	11632,18	11660,71	0	☑
	Weld gain height, mm	0,5	3	1,775	3,5	418	☐
	Weld gain width, mm	0	30	24,82	31,35	71	☐
	Weld edge shift	0	1,80000007	0,04	0,86	0	☑
	Profile deviation at left, mm	0	0,8	0,41	1	295	☐
Profile deviation at right, mm	0	0,8	0,195	1,31	109	☐	

In the table the column «Errors» indicates the number of measurement points, the values in which do not fit into the allowed interval. The color of field in the column «Status» shows the meeting (green) tolerances or violation (red) tolerances of the measured values.

System major parameters:

Parameter	Value
Measure pipe diameter, mm	Upon Customer requirement
Measure pipe length, mm	Upon Customer requirement
Time for measuring pipe of max diameter, min	No more than 5
Positioning accuracy of the pipe relative to the manipulator, mm	No worse than 5
Positioning accuracy of the manipulator, mm	0,04
Accuracy of parameter measurement	
— linear (except pipe length), mm	0,1
— angle, degree	0,5
— pipe length, mm	2,0
Reconfiguration for a different size type	Automatic
Air pressure line	Up to 4 MPa
Time for reconfiguration for a different size pipe	2
Power consumption kVA	No more than 10
System dimensions incl. darkening booth (W×L×H), mm	3000×14200×4500
The system weight, kg	No more than 3 000
Power voltage, V	220/380
Current frequency, Hz	50
Ambient conditions	From +10 to +35 °C



ActiveTestGroup, Ltd.

Room 3H, liter A, 47 pr. Nepokorenykh,
Saint-Petersburg, 195220, Russia
Tel./fax: +7 (812) 600-20-35; +7 (812) 600-24-50
E-mail: office@activetest.ru
Website: www.activetest.ru



ScanMaster Systems (IRT) Ltd.

5b Atir Yeda St., Industrial Park. Kfar Saba,
4464305, Israel
Tel: + 9729 7791990; Fax: + 9729 7791989
E-mail: info@scanmaster-irt.com
Website: www.scanmaster-irt.com



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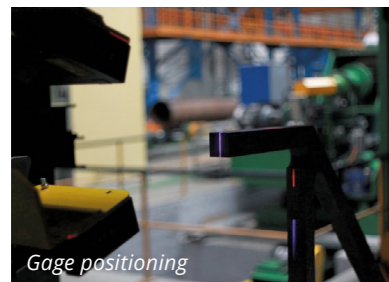
AUTOMATED SYSTEMS FOR GEOMETRIC PARAMETER MEASUREMENT OF PIPES



General view of system

System view inside darkening booth

Automated system is designed for geometric parameter measurement of welded pipes with diameter of 426–1420 mm. Principle of system work is based on the triangulation method to measure distance till the object with the use of laser gages. Diffuse dispersive component of the light reflected from the surface is collected on a certain point of matrix of light receiver. The position of this point is fixed by micro-controller, integrated in the gage. This position depends on the



Gage positioning

distance from the reflected surface. When the object is moving, the position of the laser point on the matrix is being changed. The gage processor calculates the distance to each position of the laser point. The accuracy of the calculation depends on many factors, but mainly on the correlation between the matrix size in pixels and distances range measured by the gage. Thus, the geometric profile of the object which the laser beam hits to is calculated. Laser gages are placed on three precision manipulators.

Laser gages have two colors — blue and red. This excludes their mutual influence. By patterns of program software with precisely known geometric parameters, the location of the origin of coordinates of each gage in

one common coordinate system is automatically calculated.

For geometric parameter measurement of pipe end the manipulator automatically positions the gages in the zone of the measurements. The pipe is moved up and rotated with the help of lifting and reversible rolls, the gages scan the pipe end all around. Thus, the following parameters are measured: bevel angle and bevel dulling, pipe wall thickness, diameter, roundness, cutting angle and total pipe warping. After pipe is fully rotated, the following parameters of welds are measured: weld gain height, weld edge width, weld edge shift, profile deviation to the left and to the right. Manipulator is raised to the original position and pipe is moved down.

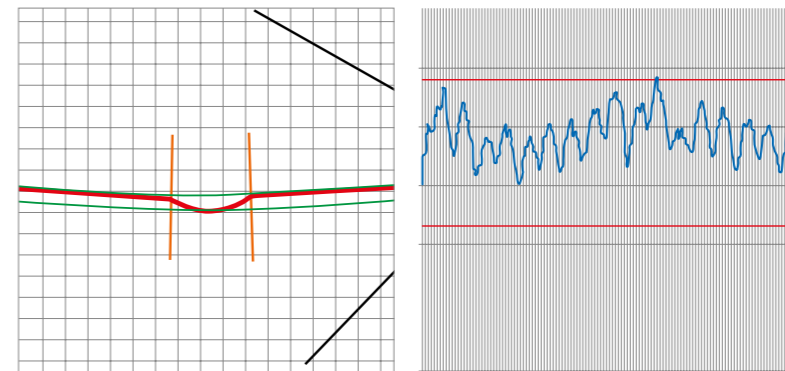
Configuration:

- ▶ Manipulator of laser gage positioning on the first end of pipe with controller.
- ▶ Manipulator of laser gage positioning on the second end of pipe with controller.
- ▶ Manipulator of laser gage positioning on the pipe body with controller.
- ▶ Mountings of laser gage fixture and positioning for measuring pipe warping.
- ▶ Mountings of laser gage fixture and positioning for measuring pipe weld parameters.
- ▶ A set of laser gages with protecting screens.
- ▶ A set of incremental encoders.
- ▶ Laser gage for preliminary definition of pipe diameter.
- ▶ Videocamera for tracking the weld.
- ▶ Control panel with switch, computer, touch panel.
- ▶ Reference blocks.
- ▶ Darkening booth.

- ▶ **APPLICATION AREA:** at production line of trunk line pipes.
- ▶ **MEASUREMENT METHOD:** contact-free, laser, triangulation.
- ▶ **OPERATION PERFORMANCE MODE:** automatic
- ▶ **OBJECT LOCATION:** on roller conveyor with lifting and reversible rolls.
- ▶ **OBJECTS:** the longitudinal electric welded trunk line pipes \varnothing 426–1420 mm.
- ▶ **COMPLIANCE ASSURANCE:** GAZPROM, Transneft.

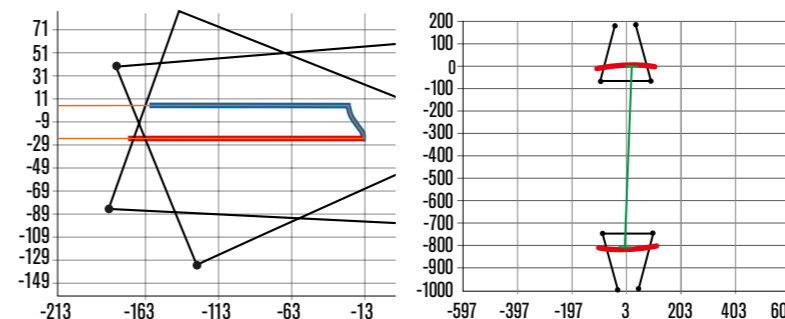
On the screen there is a demonstration of geometric arrangement of the gages during the measurements. The algorithm of the calculation program automatically determines, for example, the number of bevels at the end of the pipe. The reference lines for calculating the parameters are color-marked.

The results of measurements allow a detailed analysis of, for example, the changes in the thickness of the pipe wall while it was being formed by the press blades, the profile parameters and the height of the weld, the bevel, the diameter of the pipe body, etc.



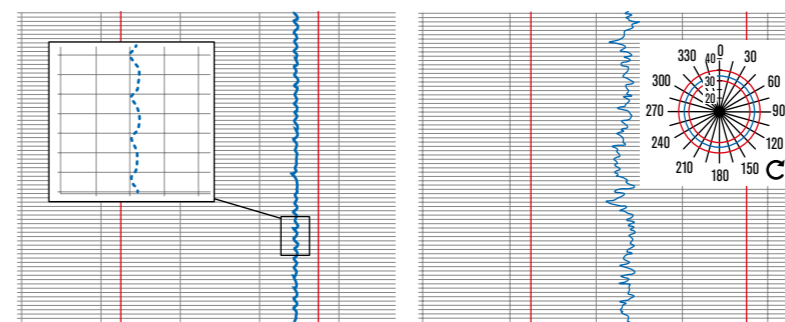
Left: an example of measuring the weld profile. Orange and green lines — reference lines for measuring the parameters of the weld.

Right: an example of measurement results of the distribution of the weld height along the length of the pipe. Red lines — the boundaries of the allowed values of the height of the weld.



Left: examples of measuring the profile of the bevel of the pipe end. Orange lines are reference lines to calculate the parameters.

Right: examples of measuring the diameter of the pipe body. Green lines are reference lines to calculate the parameters.



Left: an example of the measurement results of the distribution of the pipe wall thickness at the end along the perimeter. The insertion is the same, but on an enlarged scale.

Right: an example of measuring the distribution of the bevel angle along the perimeter of the end of the pipe. On the insert is a pie chart.

Software for the processing and analysis of measurement results includes various functions for processing, analyzing and evaluating the parameters of the pipe. In the main window of the program, any measured pipe can be selected from the drop-down list. The calculated parameters are downloaded and can be automatically saved in the specified directory.