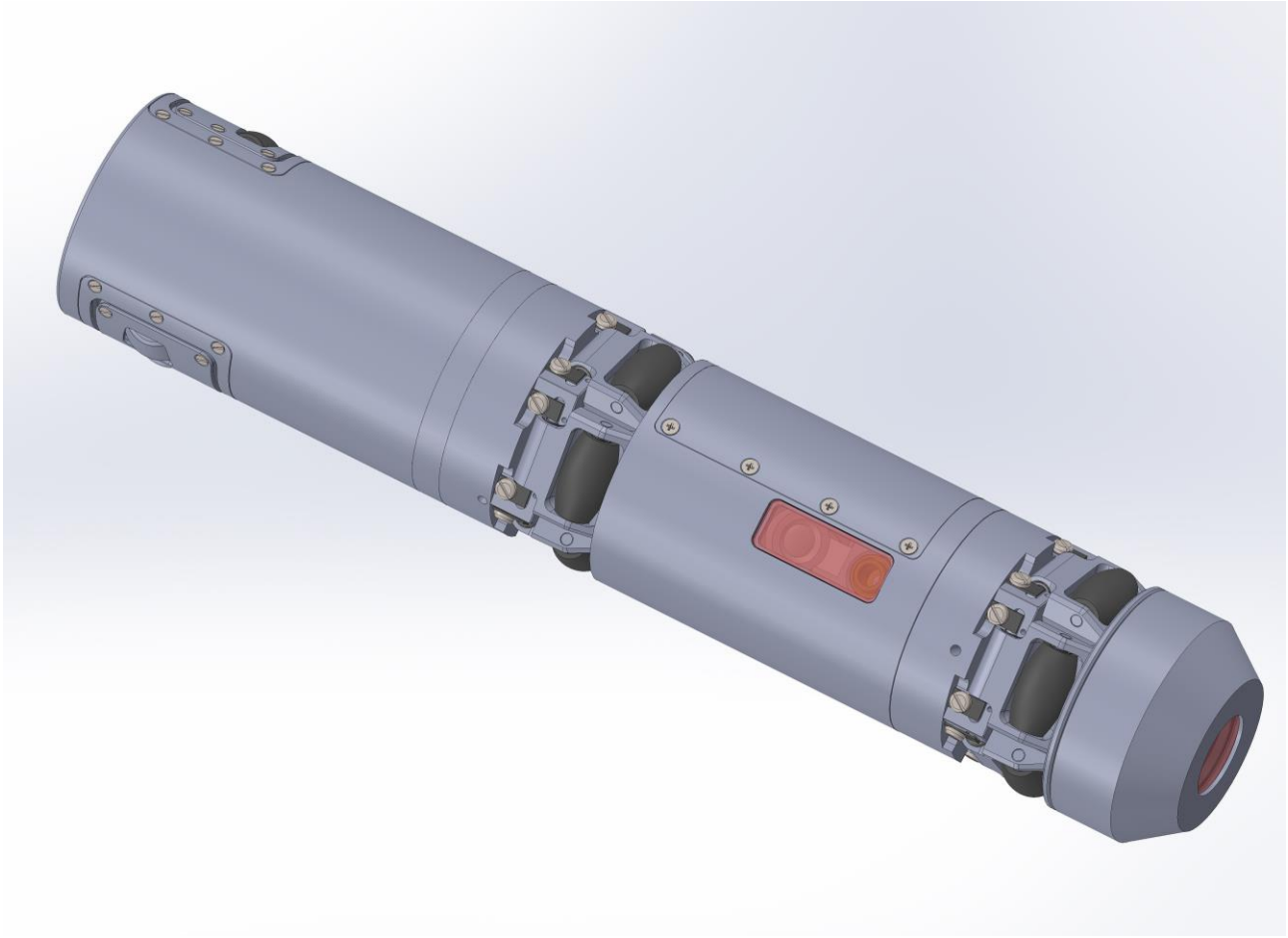
OPTICAL MEASUREMENT SYSTEMS
D-TEST



Complete Barrel Measuring and Inspection System

PS Series

User's manual

Safety precautions

- Read this manual carefully prior to using the system.
- Use supply voltage and interfaces indicated in the system specifications.
- In connection/disconnection of cables, the system power must be switched off.
- To obtain stable results, crucial 10 minutes warm-up should be performed.

Electromagnetic compatibility

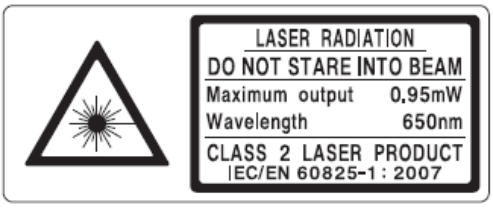
The system is developed for industrial use and meet the requirements of the following standards:

- EN 55022:2006 Information Technology Equipment. Radio disturbance characteristics. Limits and methods of measurement.
- EN 61000-6-2:2005 Electromagnetic compatibility (EMC). Generic standards. Immunity for industrial environments.
- EN 61326-1:2006 Electrical Equipment for Measurement, Control, and Laboratory Use. EMC Requirements. General requirements.

Laser safety

The system corresponds to the 2M safety classes according to IEC 60825-1:2007

The system makes use of an c.w. 660 nm or 405 wavelength semiconductor laser. The system belongs to the 2M laser safety class. The following warning label is placed on system's parts:



The following safety measures should be taken while operating the system:

- Do not target laser beam to humans;
- Do not disassemble any parts of the system;
- Avoid staring into the laser beam;

General information

The system is intended for the video inspection and the laser non-contact measuring and scanning of internal surface of pipes, tubes and barrels. The system allows to measure following parameters:

- inner diameter;
- ovality;
- out-of-roundness;
- non-straightness (warpage);
- distance from the edge of the pipe;
- rifling height;

- rifling width;
- rifling angle;

Basic data and performance characteristics

Name of parameter	Value, mm	Resolution, mm	Linearity, mm
Inner diameter Ovality Out-of-roundness	57-120 - -	0,005 0,005 0,005	0,01 0,01 0,01
Non-straightness (warpage)	±4 (X) ±4 (Y)	0,001 0,001	0,005 0,005
Rifling height Rifling width	0.5 -4.5 2 - 7	0,05 0,05	0,1 0,1
Rifling angle (deg)	-	0,004°	0,008°

Complete set to be supplied

Designation	Name	Quantity	Weight, kg
PS-SP	Self-moving wireless probe	1	
PS-LS	Adjustable laser source	1	
PS-TL	Target for laser beam adjustment	1	
PS-CC	Connection cables	1	
PS-LN	Wireless data router	1	
PS-CB	Calibration block	1	
PS-S	Software	1	
PS-UM	User manual	1	
Options:			
PS-EX (d)	Pipe extender		

Structure and operating principle

Structure

Figure: The PS-120/154 (long version) system without transport box

Operation principle

In order to prepare for the measurement, the laser source is to be placed at one end of the tube. The target for laser beam adjustment is to be placed at opposite end of the tube. The user should aim the laser beam in the centre of the target using special adjustment screws and then remove the target.

Figure. The adjustable laser source (PS-125)

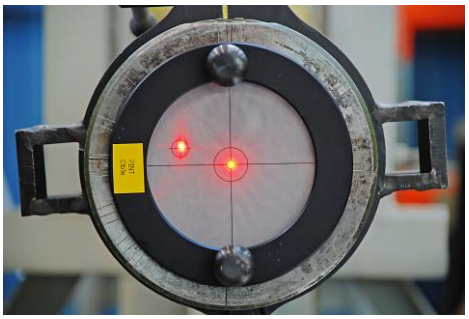


Figure. The target for laser beam adjustment (PS-125)

Then the probe is to be inserted into the tube. All the rest processes are handled automatically after pushing «Start» button. Status of measuring is displayed on the laptop/PC screen. The final report can be printed or stored in a database or in a memory card.

The laser source is connected to AC/DC power unit or battery by the cable. The probe is connected by wireless Wi-fi connection and has an internal battery. The probe motion control and data transaction are wireless. The probe moves along the tube automatically following a measurement template.

The probe carries out measurements over the entire barrel surface excluding the areas (at the beginning and at the end) which do not exceed 60 mm. One may use a special extender (option) allowing measurement of the whole surface.

The system uses special spring-loaded extending rollers to adjust the probe in the tube. Replacement of centring rollers and drive unit permits controlling wide range of tubes with inner diameters from 57mm to 120mm.

The module which is located on the front of the probe can be easily replaced and provides either video inspection (Video Channel) or non-straightness (warpage) measuring (Non-straightness Channel);

The Video Channel houses a 5 Mpix camera with fish-eye lens and 3 channel LED lighting system especially designed for hi-res video inspection of tube interiors.

The laser distance gauge measures the distance from the probe to the tube muzzle end to bind measured results to the probe position.

Self-moving wireless probe

The self-moving wireless probe contains following modules and sensors:

- rotating laser triangulation scanner;
- non-straightness (warpage) PSD sensor;
- temperature sensor;
- 3-channel LED lightning system;
- video inspection camera;
- inclinometer;
- laser distance sensor;
- accelerometer;
- moving module;
- centering module;
- electronic module;

Using of pipe extender

The probe carries out measurements over the entire barrel surface excluding the areas (at the beginning and at the end) which do not exceed 60 mm. One may use a special extender (option) allowing measurement of the whole surface.

The universal (adjustable) pipe extender (for wide range of the pipe) is available to order as well.

Figure. The extender for PS-125 (Diameter 125 mm)

Basic technical data

Name of parameter	Value
Operating temperature	- 20…+ 65° C
Storage temperature	- 50…+ 65° C
Humidity	up to 98%
Power supply	Rechargeable battery SAFT 34570 220 V AC, 50 Hz (or 24V DC)
Battery lifetime	Up to 8 hours
Power	5 W
Interface to PC	Wi-Fi IEEE 802.11n
Antenna	2.4 GHz, 6 dB
Moving speed	11 m per minute

Example of item designation when ordering

Following modifications are available to order:

PS-	57/120	125	120/159
Type of barrels	Smooth/rifled	Smooth	Smooth/rifled
Range of inner diameter	From 57 to 120 mm	From 120 to 130 mm	From 120 to 159 mm
Type of laser sensor (inner diameter)	Rotating laser triangulation scanner	6-beam laser triangulation sensor	Rotating laser triangulation scanner
Non-straightness (warpage) PSD sensor	Option (-NS)	+	Option (-NS)
Temperature sensor	+	+	+
3-channel LED lightning system	+	-	+

Video inspection camera	+	-	+
Laser distance sensor	+	+	+
Inclinometer	+	+	+
Accelerometer	+	+	+
Moving module	Option -SM	+	Option -SM
Pipe extender	Option -PE (d)	Option -PE (d)	Option -PE (d)
Long version	-	-	Option –L
Special version for the vertically arranged pipe with a winch	Available Type PSV- Ask for more info	-	Available Type PSV- Ask for more info

Example: PIOS-57/120-NS-SM-PE (57, 98, 120) — the self moving system for inner diameter from 57 to 120 mm with PSD warpage sensor and pipe extruders for inner diameters 55, 98 and 120 mm.

Dimensions

Overall dimensions

Overall dimensions of all parts of the system are shown on Figure below. All parts of the system are made of anodized aluminium. Detailed CAD documentation is available here link.

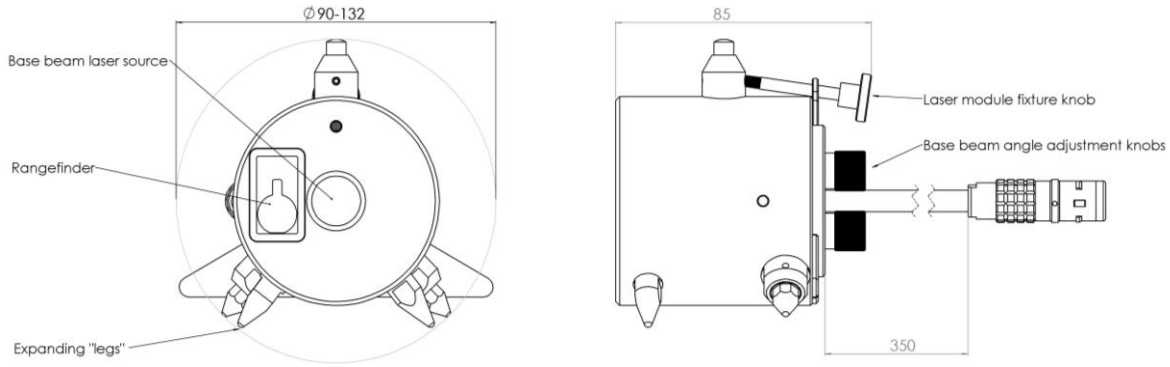


Figure. PS-57/120 adjustable laser source

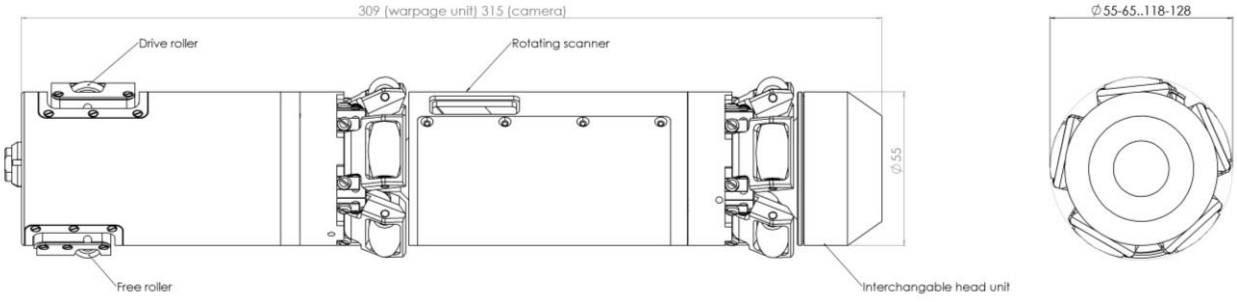


Figure. PS-57/120 probe.

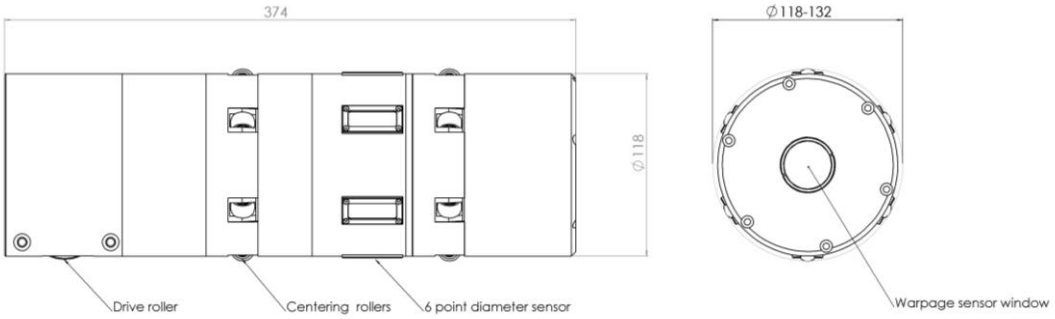


Figure. PS-125 probe.

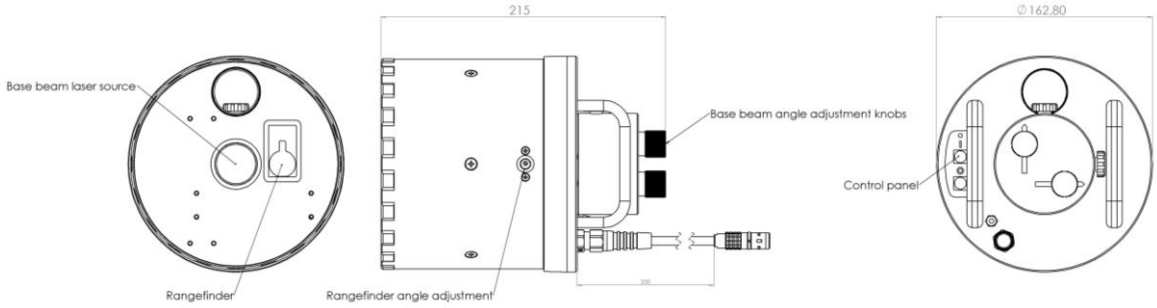


Figure. PS-125 adjustable laser source.

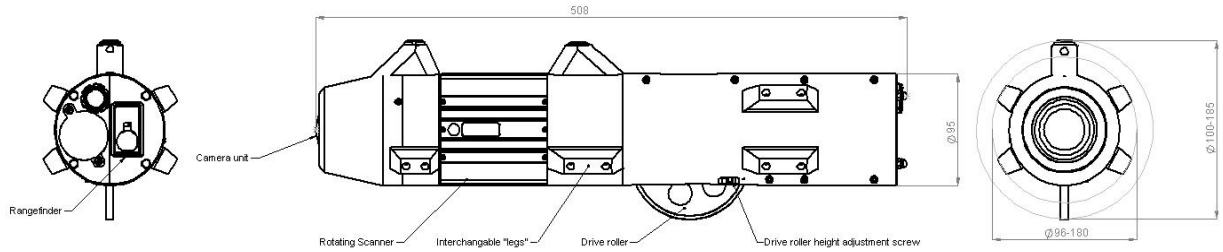
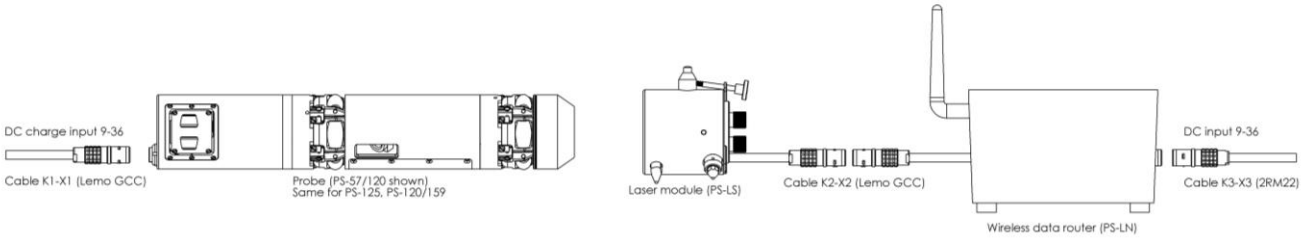


Figure. PS-120/159 adjustable laser source

Connection

The connection diagram is showed below:



All systems in the PS series have a similar wire connection.

Measurement procedure

Preparation for use

Before using the system should be got out of the transport box. If the system has been stored in extremely hot or cold conditions all parts of the instrument must be kept in normal environment for at least 10 minutes prior to using.

Measurement

The operator connects all cables as it showed in **Connection** chapter.

The laser source is to be placed at one end of the tube. The target for laser beam adjustment is to be placed at opposite end of the tube. The operator should aim the laser beam in the centre of the target using special adjustment screws and then remove the target.

The probe is to be inserted to the tube.

The system includes special software, which allows operating and calibrating the device. The software can be installed on any Windows-based PC/laptop. The computer must have Wi-Fi wireless adapter or integrated wireless chip.

In order to measure, the operator launches **ps_software.exe** file and then fills out (or select from macros's library) following fields:

- identifier of the pipe (pipe's number);
- list of sections to control (by OZ axis);
- limits values for all parameters;

All the rest processes are handled automatically after pushing «**Connect**» and «**Auto**

measure» buttons. Status of measuring is displayed on the laptop/PC screen. The final report can be printed or stored in a database or on a memory card. The operator is able to use “Manual mode” to control particular sections as well.

Software

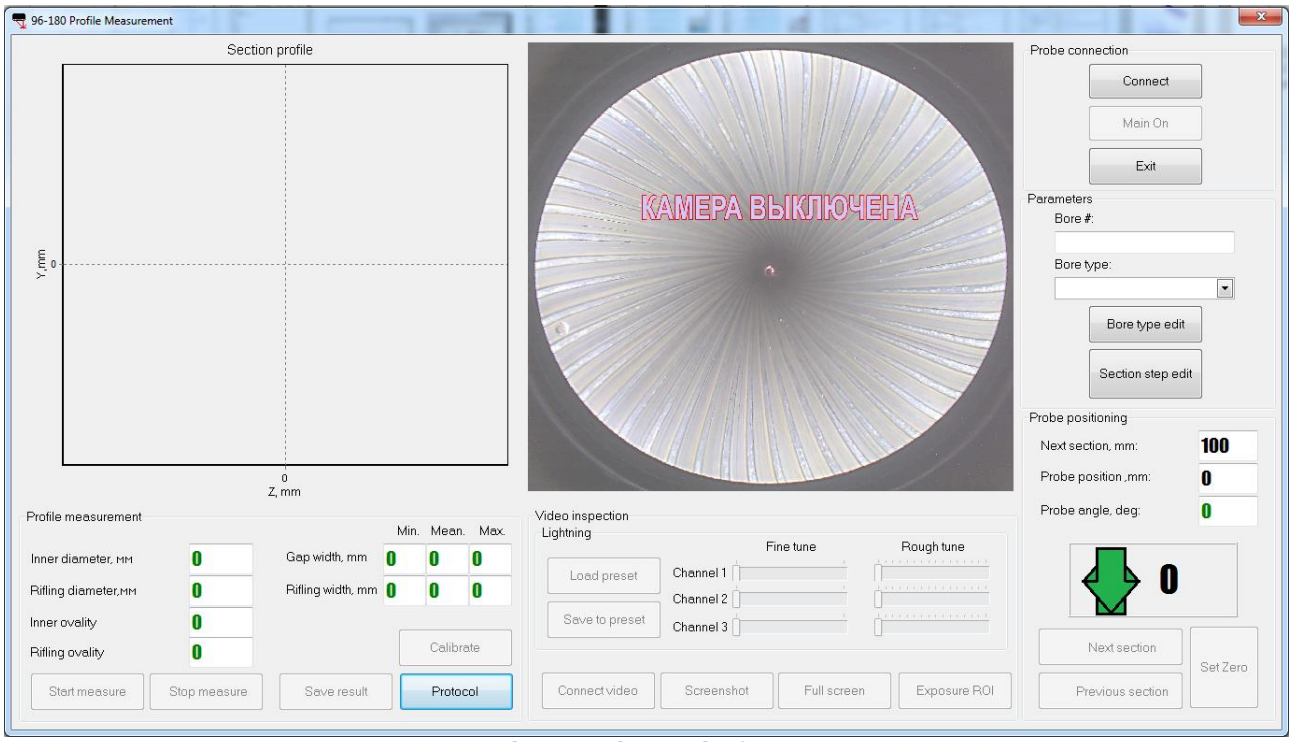


Figure. The main form

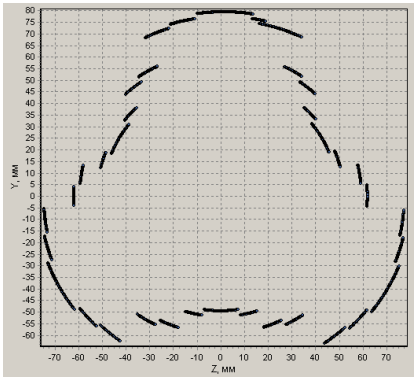


Figure. The example of a profile (the caliber)

AREA	FIELDS/BUTTONS	FUNCTION
SECTION PROFILE		The area for showing the profile of a section
PROFILE MEASUREMENT		The area for showing the parameters of a section
Fields:	Inner diameter	The inner diameter in current section
	Rifling diameter	The rifling diameter in current section
	Inner ovality	The inner ovality in current section
	Rifling ovality	The rifling ovality in current section
	Gap width	The gap width in current section
	Rifling width	The rifling width in current section
Buttons:	Start measure	To measure in current section (manual mode)
	Stop measure	To stop measuring
	Save result	Profiles saving into the file

	Protocol	To open the protocol form
	Calibrate	To open the calibration form
VIDEO INSPECTION		
Lightning		
Buttons:	Load preset	To load preset from the internal controller
	Save to preset	To save preset to the internal controller
	Channel 1/2/3	Fine and Rough tunes for lighting (separately for each from three channels)
Video inspection	Connect video	To connect a video camera.
	Screenshot	To save a current shot to a database
	Capture	To start video capturing
	Full screen	Switch to full screen mode
	Exposure ROI	To change exposure
PARAMETERS		
Buttons:	Connect	To connect with the probe
	Main on	To switch all the sensors on
	Exit	To exit from the program
PROBE CONNECTION		
Fields:	Bore #	Number of the barrel
	Bore type	Type of the barrel
Buttons:	Bore type edit	To open “Bore type” library
	Section step edit	To open “Section step” form
PROBE POSITIONING		
Fields:	Next section	Indication of next section position
	Probe position	Indication of current probe position
	Probe angle	Indication of current section angle
Buttons:	Next section	To choose the next section in a manual mode
	Previous section	To choose the previous section in a manual mode
	Set Zero	To set logical O for OZ axis

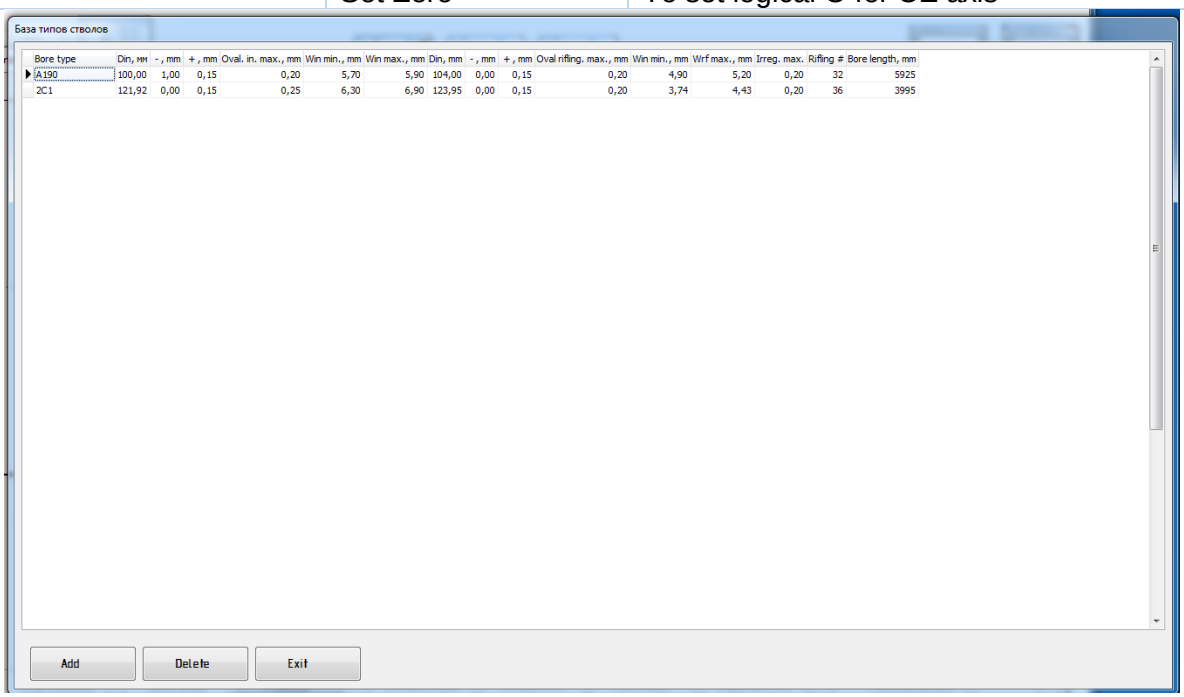


Figure. “Bore type” library

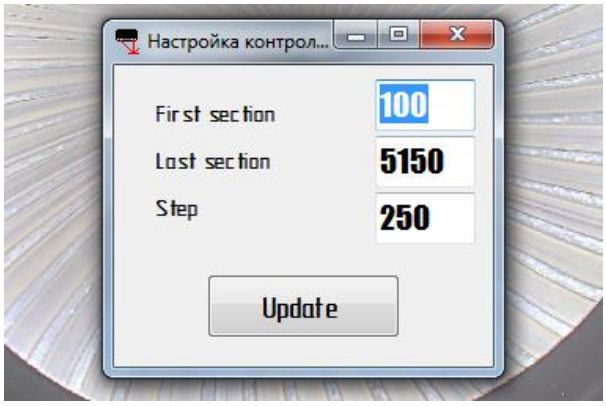


Figure. The "Section step" form

AREA	FIELDS/BUTTONS	FUNCTION
SECTION STEP		The form for determination of macros in automatic mode
Fields:	First section	The first section to measure, mm
	Last section	The last section to measure, mm
	Step	The step between sections, mm
Buttons:	Update	To update the macros

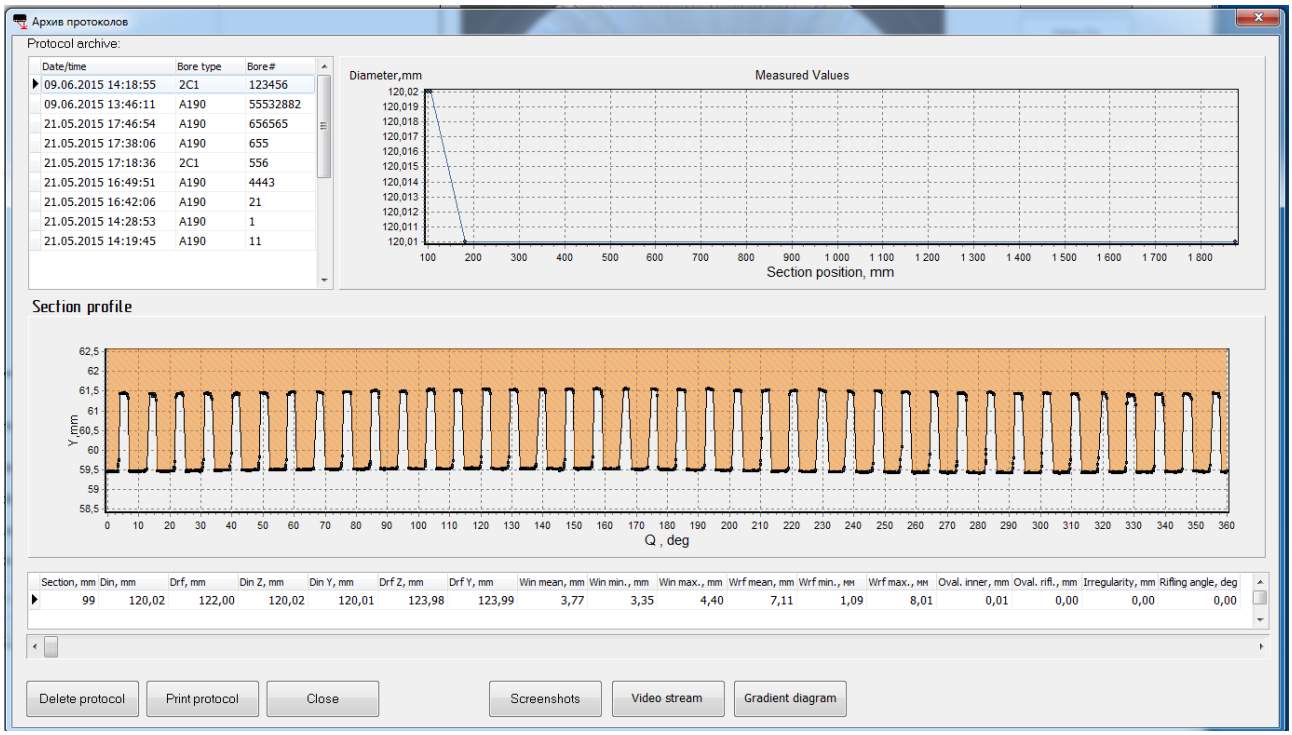


Figure. The protocol form

AREA	FIELDS/BUTTONS	FUNCTION
PROTOCOL ARCHIVE		The list of all saved protocols
MEASURED VALUES		A chart showing an inner diameter for all the length of the barrel
SECTION PROFILE		A chart showing a barrel profile in the selected section (User can switch a circle chart as well)
	The table below	Showing all parameters of the barrel in selected section
BUTTONS BELOW		

	Delete protocol	To delete the selected protocol
	Print protocol	To print the selected protocol out
	Close	To close the form
	Screenshot	To show/print out a screenshot for the selected section
	Video stream	To play a video stream
	Gradient diagram	To show/print out a gradient diagram for the selected protocol

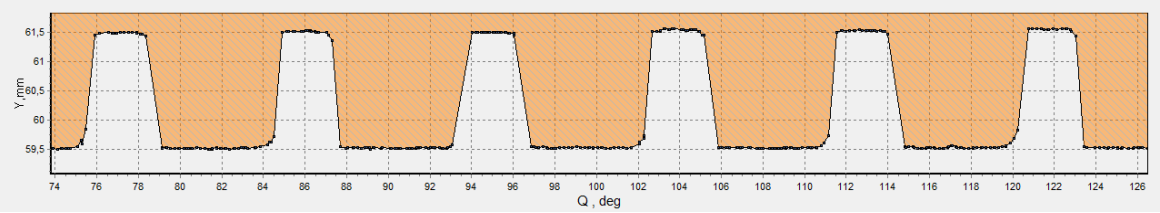


Figure. The protocol form (Zoom mode)

Measurement result

The measurement result also can be displayed as:

- 2D cross section;
- linear un-warped display;
- gradient diagram;
- tables;
- graphs.

The measurement result is stored in the database and can be opened and printed in any time.

The form of the protocol (a visualization of the result) might be changed according to customer requirements.

Measuring channels

Video inspection channel

Video inspection channel is switched on immediately after plugging in the probe. The user can manage lighting via special form in software "**Brightness**". Using this form the operator can reach quality lighting on all parts of the pipe. It is possible to adjust three channel of light module separately in order to eliminate reflections, highlights etc.

The picture from the camera can be present as a small video area inside the main form and as full-screen picture. Switching between these modes is by pushing "**Fullscreen**" button. The button "Save image" allows saving JPEG on hard disk. The button "**Save movie**" activates a video capture mode. The filename is formed of the number of the pipe, the current date and the current probe position in the tube.

The system uses ultra-wide lenses (similar with a fish-eye lens) and HDR camera. Special algorithm eliminates circular distortions and converts o-shaped "fish-eye" picture into usual flat image. See the Figure below.

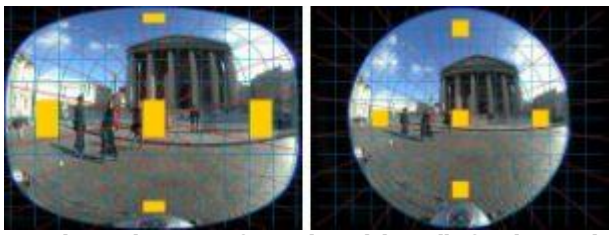


Figure. Comparing picture after algorithm (left picture) and before.

Rotating laser triangulation scanner

The rotating laser triangulation scanner consists of two or four laser triangulation sensors. Operation of the sensors is based on the principle of optical triangulation. The radiation of a semiconductor laser is focused by a lens onto an object. The radiation reflected by the object is collected by a lens onto a linear CCD-array. A signal processor calculates the distance to the object from the position of the light spot on the array.

Each sensor of the scanner covers its own range of diameter. All sensors summary cover all the range of pipes.

Non-straightness (warpage) PSD sensor

The non-straightness (warpage) channel consists of a PSD matrix and stabilized laser source.

The laser source is placed at one end of the tube. The laser beam emits through the pipe. The radiation of a semiconductor laser is focused onto PSD matrix located inside the self-moving probe.

A position of the laser point on the matrix is determined permanently and allows calculating an offset between the probe and the laser beam. Since the probe is centered in the pipe and follows the profile of the pipe during measuring, the system can measure the non-straightness (warpage) using the position of laser point on the PSD matrix.

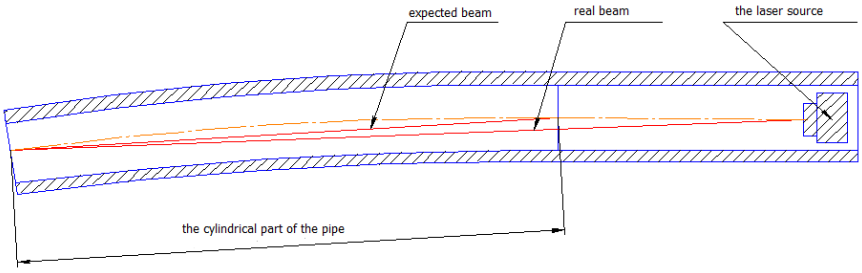


Figure. The Principle of non-straightness measurement.

Temperature sensor

The temperature sensor is designed to compensate for the distortion of the system readings relating to changes in ambient temperature. This makes it possible to achieve high accuracy over a wide temperature range.

Inclinometer

The inclinometer is intended to compensate for the distortion of the system readings relating to possible spin or tilt of the probe.

Laser distance sensor

The laser distance sensor is located on the rear unit of the probe and intended to determine a position of the probe inside the pipe (distance between the edge of the pipe and the probe).

The laser distance sensor allow measuring a distance in the range from 50 to 20000 mm with linearity +/-1 mm. Measurement frequency is 2 Hz.

Calibration

The first calibration is done by the manufacture. All parts of the system contain special features for self-diagnostic. However, the operator should do a periodic calibration once a year or more often if it is required.

The system includes special calibration block, which allows checking instrument's accuracy anytime and fixing calibration table if it is necessary. The calibration takes 10-15 minutes. All calibration processes are automatic.

Figure. The caliber for PS-57/120 and PS-120/159

The calibration block contains a caliber (see pictures), which is used to correlate the readings of the system with factory values in order to check the system's accuracy. The inner surface of the caliber emulates a plenty of pipes with different diameters in all working range.

In order to calibrate, the probe should be inserted into the calibration block as it is showed on the picture below. The calibration starts automatically after pushing “Calibration” button.

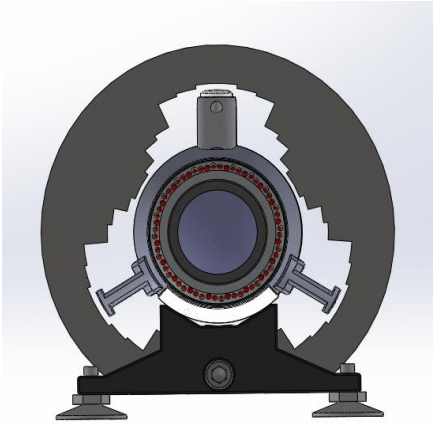


Figure. The PS-57/120 probe inside the caliber

In order to calibrate non-straightness (warpage) channel, the operator mounts 2-axis motorized positioner to the calibration block. The laser source is located in the centre of the positioner. Using special module in **Software** the system provides an automatic calibration in all the range. A calibration table is uploaded to system's controller.

Warranty policy

The factory guarantees a normal system condition within 2 years from the date of manufacturing.