Optical fibers and optical fiber cables

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SIKORA AG is a leading manufacturer and supplier of innovative online measuring, control, inspection, analysis and sorting technology for the optical fiber, wire and cable, hose and tube, sheet, metal as well as plastics industries. Worldwide, users of these measuring devices benefit from an increasing quality, profitability and efficiency. Modern laser and X-ray technologies measure product parameters such as the diameter, ovality, wall thickness and eccentricity, precisely and reliably.

Continuous control of production data helps to avoid wall thickness oversizes and leads to a more efficient material usage. The cable manufacturer consumes fewer resources and achieves a more efficient material usage. Every micrometer of material that can be saved by the use of measuring and control technology makes production more economical and saves increasingly scarce resources.

SIKORA is headquartered in Bremen, Germany. Since 1973, the high-quality devices have been developed and manufactured at this site. When it comes to service and sales, SIKORA is globally active with offices in Brazil, China, France, India, Italy, Japan, Korea, Malaysia, Mexico, Russia, Turkey, Ukraine, the United Arab Emirates and the USA. In cooperation with more than 30 local representatives worldwide, SIKORA serves all customer demands with regard to quality, productivity and cost saving. In addition, international service locations assure fast and reliable customer support on site, any time.

Since 1993, SIKORA has been certified according to DIN EN ISO 9001. The certification confirms SIKORA’s focus on continuous improvement. Customer satisfaction is SIKORA’s primary objective.

Innovation, technological know-how, quality and service are the four pillars of SIKORA’s company philosophy. A strong research and development team continuously works on the development of new technologies, enabling manufacturers of optical fibers and optical fiber cables, wires, cables, hoses, tubes, sheets as well as raw materials to increase the process reliability, efficiency and ecological balance of their production lines.

Measuring technology for the production of optical fibers and optical fiber cables

All over the world, large amounts of electronic data are transferred every day – faster and over longer distances. Data transfer is mainly via optical fibers. In order to transmit data without loss, optical fibers have to meet the highest quality requirements. SIKORA offers a complete series of measuring and control devices that are used in the drawing tower during the production of optical fibers. The FIBER Series 6000 monitors and controls the entire drawing process and optimizes productivity. SIKORA is known worldwide for its measuring devices for optical cables.

**Highlights FIBER Series 6000**

- Measurement of the diameter, position, vibration frequency, tension and spinning
- Detection of airlines and temperature measurement at the bare fiber
- Coating concentricity evaluation
- Reliable lump detection with double sensor technology and 3-axis or 6-axis measurement
1 Measuring technology for the production of optical fibers

1.1 Overview: Measuring devices for quality assurance in the drawing tower

Quality control of optical fibers in the drawing tower is realized by using innovative measuring and control technology at the crucial process phases. SIKORA’s gauge heads and processor systems of the FIBER Series 6000 measure and monitor the drawing process and increase by means of control the efficiency of the production. Hence, a constantly high quality of the optical fibers is ensured.

At the beginning of the production of an optical fiber is the preform. The preform is manufactured by means of chemical vapor deposition and is available as a glass rod with a diameter of 30 to 200 mm. In the first step, the preform in the drawing tower is heated up in an inductive furnace to a temperature of 2,100 °C. From the melted glass, the optical fiber is drawn. At this point, the fiber typically has a diameter of 125 µm. After cooling down, the optical fiber is coated with an acrylate layer that is hardened under UV light. The coating protects the optical fiber from mechanical damages and allows the fiber to be bent. For further processing, the fibers are wound onto reels.

**FIBER LASER 6003 - hot, bare position**
- Diameter
- Tension
- Ovality
- Position

**FIBER TEMP 6003 - hot position**
- Temperature

**FIBER LASER 6003 AIRLINE - cold position**
(alternatively FIBER LASER 6003)
- Diameter
- Tension
- Ovality
- Position
- Airline detection
- Spinning

**FIBER TEMP 6003 - cold position**
- Temperature

**FIBER LASER 6003 CCE - cold position**
(alternatively FIBER LASER 6003)
- Diameter
- Position
- Ovality
- Coating concentricity

**FIBER LUMP 6003 MICRO (alternatively FIBER LUMP 6003)**
- 6-axis lump detection
- alternatively: 3-axis lump detection (FIBER LUMP 6003)

**FIBER ECOCONTROL**
- Processor system for visualization and control of production data
- Interface to PLC (programmable logic controller)
1.2 FIBER LASER 6003 – Diameter measurement after the furnace, before and after the coating

The FIBER LASER 6003 is an innovative device for diameter measurement of optical fibers, directly in the drawing tower. The unique measuring principle assures an accuracy of 0.05 μm at a repeatability of 0.02 μm. 2,500 measurements per second with high single value precision and a short exposure time of 1.2 μs always guarantee the highest accuracy.

The measuring principle is based on diffraction analysis. Using this method, SIKORA has become the worldwide technology leader. The principle allows a non-contact, optical measurement of diameters without moving parts and no need for calibration.

Typically, the first gauge head is installed after the furnace to measure the diameter and position of the bare fiber and to control the process. Based on the vibration of the fiber, this gauge head calculates the tension at the bare fiber by means of a Fast Fourier Transformation (FFT). The single values of the fiber position are graphically visualized via the processor system FIBER ECOCONTROL, in the form of a scatter plot (see page 10) and are available directly at the gauge head via Ethernet.

A second gauge head, before the coating, measures the cold diameter of the fiber and provides spinning information via FFT of the ovality. The control is carried out either by the hot or cold measuring gauge head. A second diameter measurement follows the coating. At this point, the gauge head optionally provides information on the concentricity of the coating. In lines, where a second coating is applied, another gauge head is used.
1.3 FIBER LASER 6003 AIRLINE –
Diameter measurement with airline detection

Installed before the coating, the FIBER LASER 6003 provides measuring values of the diameter. Alternatively, the FIBER LASER 6003 AIRLINE detects the smallest airlines.

The FIBER LASER 6003 and FIBER LASER 6003 AIRLINE are factory calibrated and keep their absolute accuracy for the entire life-cycle.

These gauge heads can be connected via numerous interfaces to the SIKORA processor system FIBER ECOCONTROL as well as to a line computer.

**Coloring lines**
The diameter gauges of the FIBER Series 6003 are also the optimal equipment for quality control in coloring lines.

1.4 FIBER LASER 6003 CCE – Evaluation of the coating concentricity

After the coating, the FIBER LASER 6003 CCE (Coating Concentricity Evaluation) defines the coating concentricity in addition to the diameter values.

The principle is based on the evaluation of the symmetry of the intensity signal recorded by the gauge. Perfect symmetry means perfect concentricity. Increased asymmetry indicates an increased eccentricity. Tolerance levels for a warning and alarm outputs can be arbitrarily set.

As the FIBER LASER 6003 CCE replaces the FIBER LASER 6003 within the drawing tower, an additional diameter gauge head is not required at this position.
**Technical Data FIBER LASER 6003**

<table>
<thead>
<tr>
<th>Product Diameter</th>
<th>50 - 500 μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>± 0.05 μm*</td>
</tr>
<tr>
<td>Repeatability</td>
<td>0.02 μm</td>
</tr>
<tr>
<td>Exposure Time</td>
<td>1.2 μs</td>
</tr>
<tr>
<td>Measuring Rate</td>
<td>2,500/sec</td>
</tr>
<tr>
<td>Power Supply</td>
<td>100 - 240 V AC ± 10 %, 50/60 Hz</td>
</tr>
</tbody>
</table>
| Interfaces       | RS485, service interface RS232, LAN  
Optional: Industrial fieldbus (e.g. Profinet IO, EtherNet/IP, Profinet-DP, CANopen, DeviceNet), 4 analog outputs unipolar/bipolar |
| Dimensions       | 150 x 65 x 225 mm (width x height x depth) |
| Weight           | ca. 3 kg    |

* In the center of the measuring field of 3 mm ± 0.01 % of the measuring value

**FIBER LASER 6003 AIRLINE**
As FIBER LASER 6003 plus airline detection

- Feature: Airline detection
- Smallest Detectable Airline: 0.5 μm (diameter)
- Measuring Rate: 2,500 Hz
- Dimensions: 150 x 95 x 225 mm (width x height x depth)
- Weight: ca. 4 kg

**FIBER LASER 6003 CCE**
FIBER LASER 6003 plus coating concentricity evaluation

- Feature: Coating Concentricity Evaluation (CCE)
- Dimensions: 150 x 65 x 225 mm (width x height x depth)
- Weight: ca. 3 kg

**Highlights FIBER LASER 6003/ AIRLINE/ CCE**
- Highest accuracy for an optimum quality control during optical fiber production
- Diameter, position, tension, vibration frequency and spinning measurement
- Airline detection (AIRLINE option)
- Coating concentricity evaluation (CCE option)
- No moving parts, no calibration
- Availability 99.8 %

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The optical fiber is irradiated with a coherent laser beam. The incoming rays of light parallelly hit the single optical fiber layers and are refracted and reflected several times before they fall on a CCD sensor. At a symmetric optical fiber without eccentricity (see picture 1), a symmetric intensity distribution results (picture 2). On the contrary, at an eccentric optical fiber, where both coating layers in sum are eccentric to the core (picture 3), an asymmetric intensity distribution results (picture 4). From the latter, a symmetry value can be defined, which scales with the eccentricity.

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**Picture 1:** Ray tracing image of a perfect fiber due to perfectly concentric coating

**Picture 2:** Diffraction signal of a fiber with concentric coating

**Picture 3:** Ray tracing image of an eccentric fiber: cladding displaced and asymmetric primary coating

**Picture 4:** Asymmetrical diffraction signal of a fiber with eccentric coating
1.5 FIBER TEMP 6003 – Measurement of the fiber temperature

The FIBER TEMP 6003 is a standalone gauge for the measurement of the fiber temperature during the drawing process. The gauge head can be either installed at the cold (measuring range 40° to 120 °C) or at the hot end (measuring range 500° to 1,500 °C) of the fiber line. With the precise information on the optical fiber temperature, the melt temperature can be controlled or the forced cooling (e.g. helium) can be reduced to a minimum, resulting in reduced costs.

The integration of two FIBER TEMP 6003 devices at the hot respectively cold position guarantees the compliance with optimal temperatures for the highest stability of the process.

In combination with the FIBER ECOCONTROL, the temperature is displayed in real time and visualized in the trend diagram. Besides, the FIBER TEMP 6003 can be connected with the plant computer via one of the numerous interfaces.

Display of the temperature in trend diagrams on the FIBER ECOCONTROL
### Technical Data FIBER TEMP 6003

<table>
<thead>
<tr>
<th><strong>Temperature Range</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold: 40° to 120 °C</td>
<td></td>
</tr>
<tr>
<td>Hot: 500° to 1,500 °C</td>
<td></td>
</tr>
<tr>
<td><strong>Product Diameter</strong></td>
<td>100 - 500 μm</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td>± 1 °C for the cold end</td>
</tr>
<tr>
<td><strong>Measuring Rate</strong></td>
<td>100/sec</td>
</tr>
</tbody>
</table>

| **Power Supply** | 100 - 240 V AC ± 10 %, 50/60 Hz |
| **Interfaces**  | RS485, service interface RS232, LAN; Optional: Wi-Fi, analog outputs unipolar/bipolar, industrial fieldbus (e.g. Profinet IO, EtherNet/IP, Profibus-DP, CANopen, DeviceNet) |
| **Dimensions**  | 170 x 65 x 265 mm (width x height x depth) |
| **Weight**      | ca. 1 kg |

1.6 FIBER LUMP 6003/FIBER LUMP 6003 MICRO – Lump detection on the surface

In addition to diameter, tension, airline, coating concentricity and temperature measurement, lump detectors are used for a continuous quality control in drawing towers. The 3-axis testing device FIBER LUMP 6003 reliably detects the smallest lumps and neckdowns after coating with a length as small as 500 μm.

Each surface fault can be found with a report that records the length of the fiber, in which the fault had been detected. This report simultaneously includes information on the total number of faults per spool length and the exact dimensions of each fault.
For even higher quality requirements, SIKORA offers the FIBER LUMP 6003 MICRO that detects lumps and neckdowns from a length of 50 µm to 100 %. The performance is achieved by the six measuring axes. Both gauge heads detect faults as small as of 5 µm.

A guarantee for the reliable detection of lumps and neckdowns is the SIKORA double sensor technology. In general, the detection of lumps and neckdowns is based on the registration of a change in the amount of light that appears because the fault location passes the measuring plane. The FIBER lump detectors FIBER LUMP 6003 and FIBER LUMP 6003 MICRO dispose of three respectively six measuring axes for a reliable detection over the circumference of the fiber. Each of these measuring axes is equipped with a light source and two receiving sensors (double sensor technology). This system recognizes changes in the amount of light, and thus, analyzes these by means of a differential measurement.

**An example:**
An optical fiber with a lump runs through the gauge head. At the position of a lump the optical fiber is bigger. This reduces the amount of light that illuminates the first sensor. At that moment the second sensor still measures the amount of light of the perfect fiber. The differential signal of the two sensors triggers the lump alarm.

The lump detectors are available for product diameters from 100 to 500 µm and can be easily integrated into a new or already existing drawing tower. The lump detectors can be connected to the SIKORA processor system FIBER ECOCONTROL or to a line computer.

**Coloring lines**
The described lump detectors FIBER LUMP 6003 and FIBER LUMP 6003 MICRO are equally applicable in coloring lines.

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**Coloring lines**
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**Typical features FIBER LUMP 6003/ FIBER LUMP 6003 MICRO**
- Highest reliability with double sensor technology
- Detection of the smallest lumps from up to 5 µm height and 500 µm (FIBER LUMP 6003) respectively 50 µm (FIBER LUMP 6003 MICRO) length
- Reliable fault analysis regarding height, length, number and position

**Technical Data FIBER LUMP 6003/ FIBER LUMP 6003 MICRO**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>FIBER LUMP 6003</th>
<th>FIBER LUMP 6003 MICRO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product Diameter</strong></td>
<td>100 - 500 µm</td>
<td></td>
</tr>
<tr>
<td><strong>Min. Detectable Fault Height</strong></td>
<td>5 µm</td>
<td></td>
</tr>
<tr>
<td><strong>Min. Fault Length</strong></td>
<td>FIBER LUMP 6003: 500 µm</td>
<td>FIBER LUMP 6003 MICRO: 50 µm</td>
</tr>
<tr>
<td><strong>Speed</strong></td>
<td>1 to 3,000 m/min</td>
<td></td>
</tr>
<tr>
<td><strong>Power Supply</strong></td>
<td>100 - 240 V AC ± 10 %, 50/60 Hz</td>
<td></td>
</tr>
<tr>
<td><strong>Interfaces</strong></td>
<td>RS485, service interface RS232, fault contact; Optional: analog input tolerance (lump/neckdown) or alternatively industrial fieldbus (e.g. Profinet IO, EtherNet/IP, Profinet-DF, CANopen, DeviceNet)</td>
<td></td>
</tr>
<tr>
<td><strong>Dimensions</strong></td>
<td>FIBER LUMP 6003: 280 x 150 x 65 mm</td>
<td>FIBER LUMP 6003 MICRO: 420 x 274 x 80 mm (height x width x depth)</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>FIBER LUMP 6003: ca. 4 kg</td>
<td>FIBER LUMP 6003 MICRO: ca. 13 kg</td>
</tr>
</tbody>
</table>
1.7 FIBER ECOCONTROL – Premium processor system for visualization and control of production data

The FIBER ECOCONTROL is an extremely powerful display and control processor system, which clearly visualizes the measuring values of the connected measuring devices and lump detectors of the FIBER Series 6000.

The measuring values are displayed numerically and graphically on a 15” TFT monitor. In addition, it includes a time-related trend diagram of all values and a display of the distribution of single values (statistical distribution curve) and comprehensive statistics with the minimum, maximum and mean values, standard deviation, Cp and Cpk values. The operation is intuitive and menu-driven via touch screen. Data storage is available.

The FIBER ECOCONTROL is the central interface for the line control, with all signals for a control.

Display of the diameter, position, tension and temperature as well as the number of lumps, neckdowns and airlines.

Trend
Technical Data FIBER ECOCONTROL

**Display**
15" TFT touch monitor

**Display of the Following Production and Product Parameters**
- Diameter
- Ovality
- Tension
- Spinning
- Airlines
- Vibration frequency
- Concentricity
- Temperature
- Optical fiber position with scatter plot presentation
- Trend and statistics
- Number of lumps/neckdowns

**Inputs and Outputs**
Up to 4 serial interfaces RS485 for the connection of the measuring systems FIBER LASER 6003, FIBER LUMP 6003, FIBER TEMP 6003 (further interfaces optionally available)
4 analog outputs 16 Bit, unipolar 0 to 10 V or bipolar -10 to +10 V (optional)
4 contact outputs for tolerance or status messages (max. 30 V, max. 0,5 A; optionally 8 outputs available)
1 communication interface via RS232 or LAN (optional)
1 electrically isolated input for rotary pulse generators (0/15 V)
1 USB interface (included as standard) as well as USB interface for a printer (optional)
1 LAN interface (selectable OPC DA/UA/SuiteLink - optional)
Additional inputs and outputs, e.g. Profinet IO, EtherNet/IP (optional)

**Data Storage**
HDD, USB memory stick or network

**Power Supply**
100 - 240 V AC ± 10 %, 50/60 Hz
2 Measuring technology for the production of optical fiber cables in loose tubing, tight buffering and sheathing lines

2.1 LASER Series 2000/6000 – 2-axis and 3-axis diameter measurement

SIKORA’s product range also includes measuring and control technologies for the coloring of optical fibers, the loose tubing or tight buffering and extrusion of the outer sheath of optical cables.

Loose tubing lines/Tight buffering lines
For quality control during the production of loose tubes and tight buffered cables, SIKORA recommends the use of an efficient 2-axis or 3-axis diameter gauge head of the LASER Series 2000 or a superior measuring head of the LASER Series 6000 for diameter measurement with integrated lump detection.

The LASER Series 6000 has been designed under the aspect of Industry 4.0. The SIKORA App displays measuring values, trends, statistics or video signals at smartphones. The operator can easily log in via the optional Wi-Fi interface. He receives immediate production data of the particular gauge head on the smartphone, that he can forward to the quality management. In combination with the processor system ECOCONTROL 600 the measured values, trend and statistic data are directly visualized. With the efficient control module SET POINT, the connected ECOCONTROL controls the production process via line speed or extruder rpm.

Typical features LASER Series 2000
- Reliable and precise 2-axis or 3-axis diameter measurement
- No moving parts, no calibration

Typical features LASER Series 6000
- Innovative CCD line sensor technology with high pixel resolution combined with pulse controlled laser diodes
- Measuring rate of up to 5,000 measurements/sec/axis
- Detection of lumps and neckdowns
- Integrated LCD display to visualize the diameter value
- Wi-Fi interface and SIKORA App
- No moving parts, no calibration

### Technical Data LASER Series 2000/LASER Series 6000

<table>
<thead>
<tr>
<th>Gauge Head</th>
<th>Product Diameter</th>
<th>Accuracy*</th>
<th>Repeatability</th>
<th>Exposure Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>LASER 2005 XY</td>
<td>0.05 - 5 mm</td>
<td>± 0.25 μm</td>
<td>± 0.1 μm</td>
<td>0.2 μs</td>
</tr>
<tr>
<td>LASER 2010 XY/T</td>
<td>0.2 - 10 mm</td>
<td>± 0.5 μm</td>
<td>± 0.1 μm</td>
<td>0.2 μs</td>
</tr>
<tr>
<td>LASER 2025 T</td>
<td>0.2 - 25 mm</td>
<td>± 1.0 μm</td>
<td>± 0.2 μm</td>
<td>0.2 μs</td>
</tr>
<tr>
<td>LASER 2030 XY</td>
<td>0.2 - 25 mm</td>
<td>± 1.0 μm</td>
<td>± 0.2 μm</td>
<td>0.2 μs</td>
</tr>
<tr>
<td>LASER 2050 XY/T</td>
<td>0.5 - 50 mm</td>
<td>± 2.5 μm</td>
<td>± 0.5 μm</td>
<td>0.2 μs</td>
</tr>
<tr>
<td>LASER 6020 XY</td>
<td>0.2 - 18 mm</td>
<td>± 0.2 μm</td>
<td>± 0.1 μm</td>
<td>0.2 μs</td>
</tr>
<tr>
<td>LASER 6040 XY</td>
<td>0.5 - 38 mm</td>
<td>± 0.5 μm</td>
<td>± 0.2 μm</td>
<td>0.2 μs</td>
</tr>
<tr>
<td>LASER 6080 XY</td>
<td>1.0 - 78 mm</td>
<td>± 1.0 μm</td>
<td>± 0.5 μm</td>
<td>0.2 μs</td>
</tr>
</tbody>
</table>

**LASER Series 2000**
**LASER Series 6000**

### Measuring Rate
500/sec/axis up to 5,000/sec/axis (LASER 6020 XY)
(higher measuring rates on demand)

### Power Supply
100 - 240 V AC ± 10 %, 50/60 Hz

### Interfaces
Serial interface RS485, setup and diagnosis interface RS232
Optional: Wi-Fi (only at LASER Series 6000), analog output or alternatively industrial fieldbus
(e.g. Profinet IO, EtherNet/IP, Profibus-DP, CANopen, DeviceNet, OPC UA)

* ± 0.01 % of the measured value
2.2 X-RAY 6000/6000 PRO –
Eccentricity, wall thickness and diameter measurement

Sheathing lines
Optical fiber cables of high quality require the latest measuring technology during the manufacturing process. Thereby, the X-ray technology used in the X-RAY 6000/X-RAY 6000 PRO is by far the most interesting option.

The devices measure the diameter, wall thickness and eccentricity during the extrusion process and ensure a reduction of material usage, an optimal line productivity and an online quality control by automatically controlling the wall thickness.

The X-RAY 6000 is specifically designed for single layer products* and equipped with an integrated 7” monitor for the graphical and numerical display of the measured values. This operation is intuitively carried out via a touch screen. The high-performance model X-RAY 6000 PRO measures up to three material layers and provides impressive accuracy.

Included within the delivery of the X-RAY 6000 PRO is the processor system ECOCONTROL 6000 (optionally available for X-RAY 6000) for an automatic control of the line speed or extruder rpm. Brilliantly, the ECOCONTROL 6000 visualizes the measuring values graphically and numerically. It provides trend, statistical data and data storage of all measuring values.

Measurement of the average wall thickness according to the differential measuring method
Sheathing lines, for which only a limited budget is available, are controlled conventionally without taking into account the eccentricity. For this, a diameter gauge head is installed before and after the crosshead and the average wall thickness is determined by calculating the difference of the diameter measuring values. Similar to the X-RAY 6000 systems, the control is carried out via one of the processor systems ECOCONTROL 6000/1000. Depending on the requirements, diameter measuring gauge heads of the LASER Series 2000 or LASER Series 6000 may be used.

Hot/Cold Module HC 2000
In combination with an additional diameter gauge head, that is used after the cooling section, a Hot-Cold-Control module continuously calculates the material shrinkage for final quality control and considers it for the control of the diameter. For this method, the hot and cold measuring values of the diameter are compared by a speed controlled delay time memory.

* Alternatively, the XRAY 6000 can also measure the total wall thickness of multi-layer products
Technical Data X-RAY 6000/6000 PRO

<table>
<thead>
<tr>
<th>Measuring Principle</th>
<th>Non-contact with state-of-the-art X-ray technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application*</td>
<td>Insulation, tight buffer, loose tube and sheathing lines, coax and RF cables</td>
</tr>
<tr>
<td>Material</td>
<td>PE, PVC, HDPE, foamed plastic, all typical polymers, nylon, silicone and many others</td>
</tr>
</tbody>
</table>
| Wall Thickness      | ≥ 0.3 - 30 mm for PE, HPDE  
|                     | ≥ 0.3 - 2 mm for PVC**  
|                     | 1) Products with PVC wall thickness ≥ 2 mm and a diameter > 50 mm require a higher X-ray power |
| Calibration         | The X-RAY 6000/6000 PRO requires no calibration |
| Safety (Radiation)  | Radiation measurements by independent experts have revealed that the radiation of the X-RAY 6000/6000 PRO is far below limiting values of all international regulations |

Measuring rate

<table>
<thead>
<tr>
<th>X-RAY 6000 PRO:</th>
<th>1 to 3 Hz (optional 10 Hz/25** Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-RAY 6000:</td>
<td>1 to 3 Hz</td>
</tr>
</tbody>
</table>

Power Supply

100 - 240 V AC ± 10 %, 50/60 Hz, 1,200 VA

Permissible Temperature

+ 5 to + 45 °C

Interfaces

** X-RAY 6000 PRO for multi-layer products/X-RAY 6000 for single layer products and total wall thickness measurement of multi-layer products

** For X-RAY 6035 PRO and X-RAY 6070 PRO

*** Expanded measuring range up to 110 mm on request

<table>
<thead>
<tr>
<th>X-RAY 6000 PRO:</th>
<th>X-RAY 6035</th>
<th>X-RAY 6070</th>
<th>X-RAY 6120</th>
</tr>
</thead>
</table>
| Diameter          | 0.65 - 15 mm  
| min. wall: 0.1 mm |            | 5 - 30 mm  
|                   |            | 6 - 65 mm  
|                   |            | 10 - 100 mm** |
| Accuracy          | 5 μm       
| X-RAY 6000 PRO    | 5 μm       
| X-RAY 6070        | 10 μm      
| X-RAY 6120        | 10 μm      
| Sight field       | 20 mm      
| Opening           | 25 mm      
|                   | 35 mm      
|                   | 70 mm      
|                   | 120 mm     
|                   | 25 mm      
|                   | 100 mm     
|                   | 100 mm     
|                   | 180 mm     |

* X-RAY 6000 PRO for multi-layer products/X-RAY 6000 for single layer products and total wall thickness measurement of multi-layer products

** For X-RAY 6035 PRO and X-RAY 6070 PRO

*** Expanded measuring range up to 110 mm on request
2.3 LUMP 2000 – 2-axis and 3-axis lump detection

Loose tubing/Tight buffering lines
For reliable lump detection in loose tubing or tight buffering lines, 2-axis lump detectors from the LUMP 2000 XY series are available as well as 3-axis lump detectors from the LUMP 2000 T series. The 3-axis measuring principle is focused on the detection of punctual faults with a constantly high detection probability. The 2-axis lump detectors are perfect for the detection of larger faults and so-called bamboo rings.

Sheathing lines
In sheathing lines, the detection of surface faults by lump detectors are equally important as well.

Typical features LUMP 2000
- Detection of lumps and neckdowns in two or three planes
- Fault analysis regarding type, dimension, length, number and position
- Highest reliability due to double sensor technology*
- Elimination of “ghost faults”**

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Product Diameter</th>
<th>Min. Detectable Height Lumps/Neckdowns</th>
<th>Min. Fault Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>LUMP 2010 XY</td>
<td>0.5 - 10 mm</td>
<td>0.01 mm</td>
<td>0.5 mm</td>
</tr>
<tr>
<td>LUMP 2025 XY</td>
<td>0.5 - 25 mm</td>
<td>0.01 mm</td>
<td>0.5 mm</td>
</tr>
<tr>
<td>LUMP 2010 T</td>
<td>0.25 - 10 mm</td>
<td>0.02 mm</td>
<td>0.5 mm</td>
</tr>
<tr>
<td>LUMP 2035 T</td>
<td>0.5 - 35 mm</td>
<td>0.02 mm</td>
<td>0.5 mm</td>
</tr>
</tbody>
</table>

Line Speed
up to 3,000 m/min

Power Supply
100 - 240 V AC ± 10 %, 50/60 Hz

Interfaces
Serial interface RS485, setup and diagnosis interface RS232, fault contact
Optional: analog input for tolerance (lump/neckdown) or alternatively industrial fieldbus (e.g. Profinet IO, EtherNet/IP, Profinbus-DP, CANopen, DeviceNet)

* See explanation on page 9
** “Ghost faults” are caused by light fluctuations from the outside, and thus, are no real faults
2.4 ECOCONTROL 6000/1000/600 – Premium processor systems for visualization and control of production data

Premium processor systems with 22”, 15” or 8.4” TFT color monitor and touch screen operation

Three ECOCONTROL processor systems form the SIKORA premium segment of display and control devices. Intelligent software technology, clear arrangements, intuitive structure and usability are their convincing characteristics.

Choose the extremely innovative and powerful ECOCONTROL 6000, the unique ECOCONTROL 1000 or the smart ECOCONTROL 600. Each of these display and control systems exceeds all expectations in their class.

The innovative display of the line including pictograms of the connected devices provides a unique overview, while the numeric and graphic display of the measuring values, trend diagrams and statistics fulfill every wish regarding process visualization.

The 22”, 15” and 8.4” TFT monitors and the intuitive touch screen control of the ECOCONTROL 6000, 1000 and 600 processor systems represent an intelligent and cutting edge technology.

Advanced software (optional)

Automatic diameter/wall thickness control
In combination with the control module SET POINT, the ECOCONTROL systems deliver quality assurance and cost reduction. They ensure a continuous, automatic control of the diameter or wall thickness to the nominal value by controlling either the line speed or the extruder rpm.

Hot/Cold Module HC 2000 (ECOCONTROL 6000/1000)
With the Hot/Cold Module HC 2000, the material shrinkage is continuously calculated and considered automatically for the control of the diameter and/or wall thickness.

FFT analysis
Optionally, the ECOCONTROL 6000 visualizes periodical variations of the product parameter from an FFT analysis of the measuring values. This software package was developed with the support of competent partners within the industry. The FFT analysis leads to transparency of the processes, shows risks, that are caused e.g. by variations of the diameter, and indicates potential causes.
Data storage
The data storage on a hard disk is a standard for the ECOCONTROL 6000. For the ECOCONTROL 1000, this feature is optionally available. For the ECOCONTROL 600, an external storage (USB, LAN) is available upon request. Time, length or reel related production reports are available for each of the three ECOCONTROL devices (6000, 1000 and 600).

VIRTUAL 2000 – Intelligent software concept
The virtual gauge technology is suitable for all applications, which require a fast wall thickness control, but due to line configuration or the product structure, a diameter or wall thickness measurement directly after the extruder is not possible. Only after the cooling section, that is to say in greater distance from the cross head, the real measurement is done by this technology.

Technical Data ECOCONTROL

<table>
<thead>
<tr>
<th>Display</th>
<th>6000</th>
<th>1000</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFT color monitor</td>
<td>22&quot; (vertical)</td>
<td>15&quot;</td>
<td>8.4&quot;</td>
</tr>
<tr>
<td>(alternatively 15&quot;, horizontal)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inputs/Outputs</th>
<th>6000</th>
<th>1000</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial interface RS485 for the connection to measuring devices</td>
<td>8*</td>
<td>4*</td>
<td>1</td>
</tr>
<tr>
<td>Electrically isolated digital inputs for the connection to testing devices</td>
<td>8*</td>
<td>4*</td>
<td>4*</td>
</tr>
<tr>
<td>Analog inputs 16 Bit, ± 10 V (bipolar)</td>
<td>8*</td>
<td>4*</td>
<td>-</td>
</tr>
<tr>
<td>Analog outputs 16 Bit, ± 10 V (bipolar)</td>
<td>8*</td>
<td>4*</td>
<td>-</td>
</tr>
<tr>
<td>Contact outputs for tolerance and status messages</td>
<td>8*</td>
<td>4*</td>
<td>4*</td>
</tr>
<tr>
<td>(max. 30 V, max. 0.5 A)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication interface via RS232 or LAN</td>
<td>1*</td>
<td>1*</td>
<td>1*</td>
</tr>
<tr>
<td>Interface for printer</td>
<td>1*</td>
<td>1*</td>
<td>1*</td>
</tr>
<tr>
<td>Electrically isolated input for rotary pulse generators (0/15 V)</td>
<td>1</td>
<td>1*</td>
<td>1*</td>
</tr>
<tr>
<td>Electrically isolated interface module for control of the diameter (HC 2000)</td>
<td>1*</td>
<td>1*</td>
<td>-</td>
</tr>
<tr>
<td>USB customer interface</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Industrial fieldbus (e.g. Profinet IO, EtherNet/IP, Profibus-DP, CANopen, DeviceNet)</td>
<td>Yes*</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>LAN interface (selectable OPC DA/UA/SuiteLink)</td>
<td>1*</td>
<td>1*</td>
<td>1*</td>
</tr>
<tr>
<td>(only OPC DA/SuiteLink)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wi-Fi</td>
<td>1*</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Data Storage

<table>
<thead>
<tr>
<th>Power Supply</th>
<th>6000</th>
<th>1000</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard disk</td>
<td></td>
<td>Hard disk (optional)</td>
<td>External media (optional)</td>
</tr>
<tr>
<td>100 - 240 V AC ± 10 %, 50/60 Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Depending on the equipment