


iNOEX


INSPIRE BEYOND MEASUREMENT

Precise, intuitive and safe **X-RAY TECHNOLOGY** for pipe and tube measurement



Your guide to technology assessment and implementation

 Process and quality data for single and multi-layer products

 X-ray technology reduces your material consumption by up to 5 %

An Overview

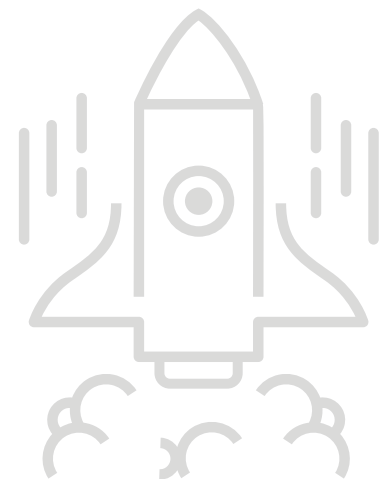
State-of-the-art, high-precision X-ray technology that is safe and easy to use

CHALLENGES

- » Increasingly complex documentation requirements for process and product data
- » Diversification of the product portfolio and more complex products
- » Shortage of skilled labour reduces process knowledge in production operations
- » Rising material prices and strict sustainability targets
- » Digitalisation of the production environment

In addition to global challenges in the area of international supply chains and the overall economic development, the challenges mentioned above are currently decisive for a large part of the plastics processing industry and therefore also for the production of pipes, tubes and cables.

To master these challenges, it is essential to be able to react flexibly to changes in the market and at the same time meet the highest standards of product quality, precision and documentation. Key to achieve this are the following parameters: transparency regarding wall/layer thickness distribution, compliance with limit values for ovality and eccentricity, user-friendliness when it comes to adjusting varying product parameters, as well as the robustness and durability of the installed components.



This is precisely the promise of our iXRAY system as well as of iNOEX as a solution provider in the extrusion industry. X-ray technology thus complements the existing product portfolio. Particularly in combination with gravimetric systems, iXRAY offers various control options to ensure a consistently high product quality. The collected process and quality data form the data basis for automation. Realized material savings and drastically reduced quality assurance and documentation costs guarantee a rapid return on investment. Likewise, in times of growing shortage of skilled labour, dependency on plant operators' many years of personal process knowledge is reduced.

This white paper discusses the areas of application best suited for X-ray technology in pipe, tube and cable extrusion and examines the following topics in detail:

- ***How state-of-the-art X-ray technology adds value to the extrusion process***
- ***Applications for which X-ray technology offers the greatest advantages***
- ***How to successfully integrate iXRAY X-ray technology into your production process***
- ***Where X-ray measuring systems are used successfully today***

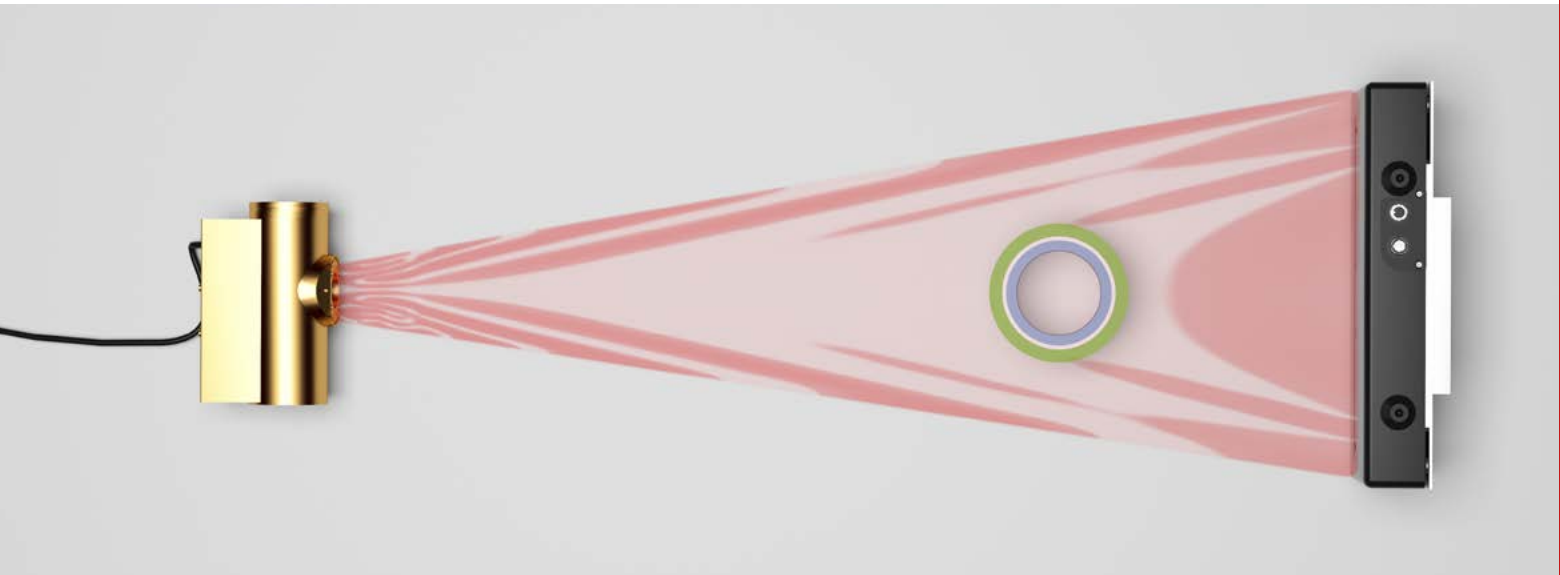
X-ray technology

How X-ray technology works and how it is classified

Sustainability and material savings are closely linked in pipe, tube and cable extrusion. The aim of every modern extrusion line is to deliver the highest and most consistent product quality while utilizing materials efficiently. Depending on the product, compliance with the minimum wall thickness defined in the specification, the exact diameter narrow ovality limits or the individual layer thicknesses can be crucial.

A variety of measurement technologies are available for measuring these products. In addition to the X-ray technology discussed in in this white paper, ultrasound or radar-based measuring systems can also be used for measurement. The measuring systems are suitable for various product categories due to their specific advantages and areas of application.

X-ray technology is ideal for measuring multi-layered products. These include aluminium composite pipes, pressure tubes with fabric inserts, microducts and other tubes, elastomer products, pipes and cables. To measure these products, a fan-shaped X-ray beam is emitted and narrowed by means of an aperture. This beam hits a detector where it is converted into visible light. If a pipe or cable to be measured is located in the beam's path, the X-ray radiation is partially absorbed by the object to be measured and the product is precisely visualized.



Here are the most important facts about X-ray technology:

- It measures the product in the **micrometer range**, **contact-free** and **non-destructively**.
- The radiation is partially absorbed in the material and thus enables an **overall wall thickness measurement** as well as material-dependent **single layer thickness measurements**.
- In combination with gravimetry, you can upgrade the iXRAY to a **measurement and control system**.
- Our X-ray systems are equipped with the required safety features to ensure **safe operation**.

ADVANTAGES OF MEASUREMENT

Advantages of measurement

Intuitive, versatile and precise

Transparency

iXRAY technology measures **crucial product features** such as total wall thickness, layer thickness, diameter, ovality and eccentricity. The result is a comprehensive assessment of your product. **Real-time data** from both the production process and the **production history** of the last two hours are graphically illustrated. The **measuring accuracy** and **reproducibility** of this technology lies in the **micrometer range**.

Plug & Play

User-friendliness and **ease of use** of the systems are more important today than ever. You can create your product recipes yourself or draw on our expertise in the creation of technical recipes. The **intuitive user interface** allows you to have all the information you need at a glance at all times during production. Another positive aspect for the operating personnel is the **simple integration** into the user interface of your production line.

Quality enhancement

Constantly **increasing demands on component quality**, process efficiency and the **documentation** of process and quality data make it important to reduce manual quality assurance processes and to push ahead with the process of **digitalisation**. The high **precision** and **robustness** of X-ray-based measurement technology makes a key contribution to this, as products can be measured automatically without a high level of labour input.

Material savings

Gain transparency on local discrepancies in wall thickness and take targeted countermeasures. An unevenly distributed wall thickness or increased layer thicknesses, often of expensive functional materials, reduce productivity. Wall thickness gauges contribute to make the **best possible use of resources**. Especially in combination with gravimetric weighing, you will be able to **save up to 5 % of material**. Sustainability increases and energy and material costs will be reduced. Alternatively, the output of the productionline could be increased to the same extent, thus **increasing productivity**.

Full automation

With the help of the recorded quality data, you not only provide evidence of the high quality of your products, you can also automate and control the manufacturing process. In **combination with gravimetry**, various **automation steps** are available. Typical control options include mass throughput, weight per meter and thin point control.

YOUR SOLUTION IN DETAIL

Your solution in detail

Three options for your application

iNOEX iXRAY utilises X-ray radiation with state-of-the-art X-ray detectors and proven long-life X-ray tubes for dimensional measurement and data acquisition. The system is available in three different types and covers a diameter range from 1 to 63 mm.

Ideally suited for elastomer and fluoropolymer tubing in the diameter range from 1 to 16 mm, the iXRAY 16 offers a very high repeat accuracy of up to $\pm 3 \mu\text{m}$. To avoid the effect of vibrations when measuring these small tubes, the iXRAY 16 can be set to a short exposure time starting from 5 ms.

With a standard working range of 5 to 32 mm the iXRAY 32 offers a repeatability of $\pm 5 \mu\text{m}$. iXRAY 63 measures pipes, hoses and cables in a diameter range from 6 to 63 mm with a repeat accuracy of typically $\pm 10 \mu\text{m}$. The repeat accuracy depends largely on the material being processed.

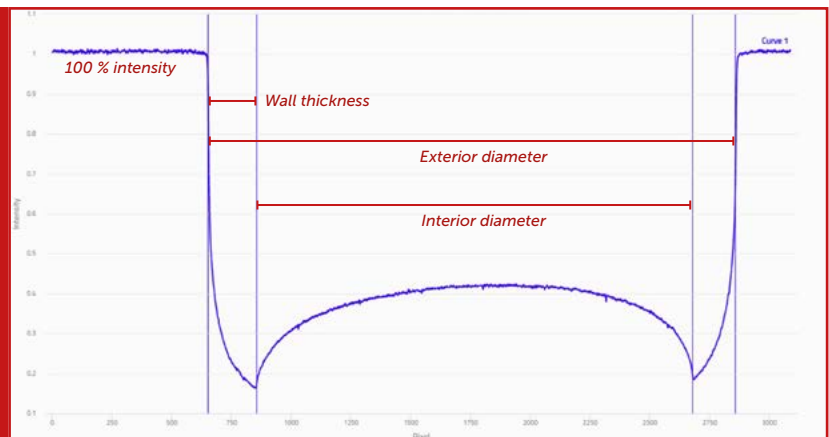


The measuring principle

To measure the products, a fanned X-ray beam is generated and narrowed by an aperture. This beam passes through the object to be measured and then hits the scintillation layer of the detector. In this scintillation layer, the rays are absorbed and converted into visible light. The photosensitive chip underneath detects the light intensity. If there is no measuring object between the X-ray tube and the detector, the full light intensity is transmitted to the detector. The transmission curve equal 100 % and has the shape of a straight line.

The typical transmission curve of a single-layer product in the beam path has an intensity of 100 % on the left and right sides.

In the area where the measurement object is located, the intensity drops sharply on both sides. The lowest intensity value on the transmission curve is reached on the inner wall of the measuring object, as this is where the highest amount of material has to be penetrated.



YOUR SOLUTION IN THREE OPTIONS FOR

Your solution in detail - Three

The characteristic points of the product to be measured appear as a discontinuity (sharp bend) in the transmission curve. These characteristic points are used to derive the geometrical data (wall thickness, diameter) from the transmission curve. The outer diameter corresponds to the distance between the two outer kink points. The inner diameter is marked by the two inner kink points. To determine the wall thicknesses, the corresponding distances between the outer and inner bend on the transmission curve are analyzed.

The measurement method is the same for multi-layer products. The changes in the absorption behavior of the individual layers result in the characteristic bends. An example of a multilayer product can be found in the application example for aluminium composite pipes on page 10.

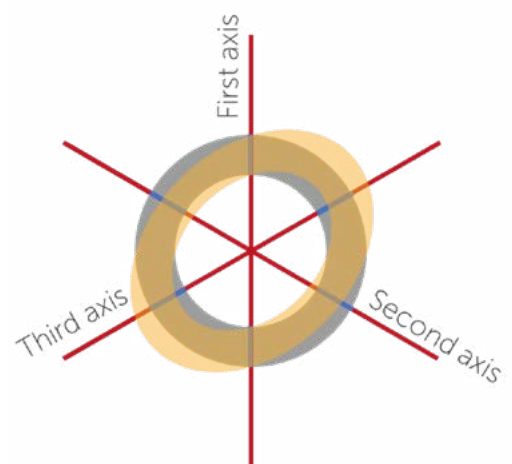
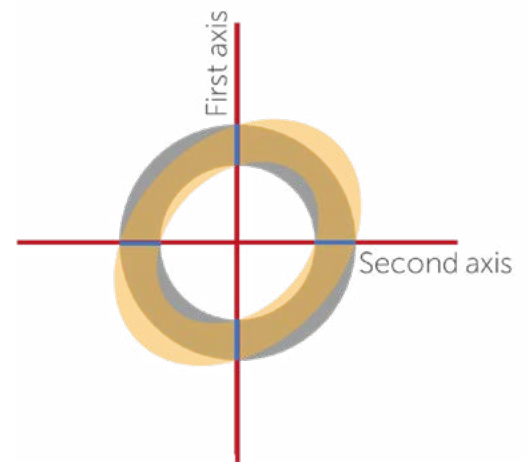
Why a 3-axis measuring system?

Pipes and hoses manufactured in the extrusion process are not perfectly round, but usually have an elliptical shape and can vary in wall thickness along the circumference. The high quality requirements on the diameter and wall thickness of the products are largely based on the data provided by the measuring system. In some applications, such as in the field of underfloor heating pipes, there are also strict ovality requirements.

If the requirements are not met, the fittings do not fit perfectly with the pipe. Localised wall thickness under-runs (total wall thickness or individual layer thickness) or excessive use of material lead to increased rejects or a loss in economic efficiency in your production. The number of quality data points available is therefore a crucial factor.

““ **The 3-axis iXRAY is able to analyze twice the measuring points of a 2-axis X-ray system.**

The iXRAY system is characterized by its ability to carry out measurements independent of the scale factor. Thanks to the triple measuring axis configuration, exact geometry measurement and the precise coordination of all system components is achieved. This means that even the complex, often elliptical, shapes of extruded pipes and tubes can be captured.



The graphic shows the difference in ovality analysis between a 2-axis and a 3-axis measuring system. Each X-ray source provides two wall thickness and diameter values. Ovality is determined by comparing these values. In this case, only the 3-axis system detects the quality deficiency of the product.

options for your application

By determining the centre of the ellipse and then calculating its tangents the actual shape of the object can be analysed with extraordinary precision. A model tailored to the X-rays, object geometry and the material permits identification of the optimum edge position, by placing the model perfectly over the measured data. The detector technology with more than three thousand pixels, in combination with the calculated model allows measurements to sub-pixel accuracy.

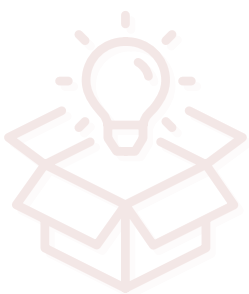
The iXRAY system thus combines maximum precision with an intelligent solution for the challenges in modern measurement technology. It is perfect for demanding applications in quality assurance and production monitoring.



Smart safety aspects

iXRAY places the greatest emphasis on X-ray safety. The X-rays do not present any danger to the operator as the radiation output is below the legally permitted limits. Additional safety features also ensure safe use.

- ***The hinged radiation protection tubes can be opened on both sides to facilitate introduction of the product on both sides. The safety switch, in conjunction with the safety PLC, switches off the radiation when opening so that no radiation is emitted to the outside.***
- ***An aperture directly on the X-ray tube ensures a narrow X-ray fan. This reduces the volume of X-rays passing through the tube, which has a direct influence on stray radiation. Thanks to the aperture, the stray radiation is reduced to a minimum.***



The iXRAY also has other features, such as optimum pipe guidance thanks to double, manually adjustable guide rollers. The pipe is guided through the centre which minimises pipe movement and increases the measurement quality.

Further useful additional equipment options are available.



Foldable radiation protection tubes

Modern user interface and easy in

In times of increasing automation and digitalisation of the production environment, plant operators often have to record and process information from several lines and intervene in the production process if necessary. These increasing demands on operators are a particular challenge in times of a growing shortage of skilled labour. An intuitive, clear and straightforward presentation of all the required information is therefore essential.

The iXRAY's integrated user interface includes a standardized OPC UA process data interface and can therefore be easily integrated into the line. The intuitive operation of the WebIQ user interface is operated intuitively via a pop-up menu.

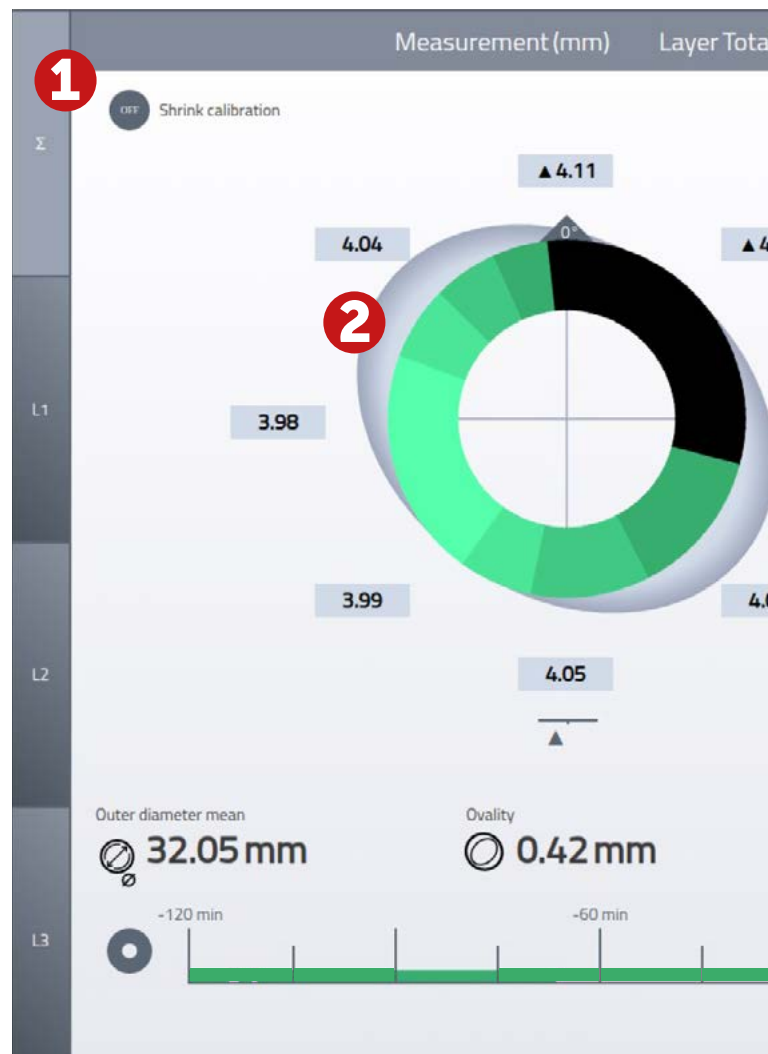
The pie chart shows all important production parameters at a glance. Minimum, maximum and average values are displayed, as is the wall thickness distribution over the circumference. In addition, a 2-hour measuring history is displayed, summarising the process and quality data of the line.

The display of the centering aid can be intuitively adjusted for the operator. This provides a clearer visualization of the eccentricity. In addition the transmission curves can be monitored and the 3-axis measurement is visualized. Under the menu item "Recipe management" there is a material database that facilitates the product-specific creation of the recipe for the customer. In addition, the technical recipe is created specifically by iNOEX.

Integration of the statistics module

The new statistics module extends the iXRAY system's functionality with decisive analysis functions. It enables the display of up to three process values in a histogram, which provides a visual interpretation of the measurement data and their distribution over time. This visualization is most useful for detecting trends, assessing process stability and to identify potential quality problems.

One of the key functions is the automatic transfer of tolerance values from the pipe, tube or cable recipe. This integration simplifies the set-up of the measuring system and ensures seamless adaptation of quality control to the specific requirements of every product. The automatic monitoring of tolerances ensures that production remains consistent within the specified quality standards and minimizes the risk of rejects.



INTERFACE EASY INTEGRATION

- 1 Layers:** Display the layer-specific quality data.
- 2 Circular graphic:** Intuitive visualization of your product including ovality and tolerances.
- 3 Measurement history:** Navigate easily through the the measurement data of the last 120 minutes.
- 4 Trends display:** This gives you a direct overview of the wall thickness distribution including tolerances.
- 5 Product characteristics:** A summary of the most important key data on your product.



Arno Neumeister, Product Manager X-ray Technology, explains the iXRAY user interface. [Click on the image to watch the video.](#)

4.14

▲ 4.11

Eccentricity
🕒 0.18mm

Now
Live

Cross section

4

Angle [°]	Wall Thickness [mm]
0	4.11
30	4.12
60	4.13
90	4.10
120	4.08
150	4.06
180	4.04
210	4.02
240	3.98
270	4.00
300	4.02
330	4.04
360	4.06

5

Statistic table

Outer diameter	Inner diameter	Wall thickness	Eccentricity
🕒	🕒	📏	🕒
MIN 31.86	MIN 23.57	MIN 3.96	
Ø 32.05	Ø 23.88	Ø 4.06	Ø 0.18
MAX 32.28	MAX 24.17	MAX 4.14	

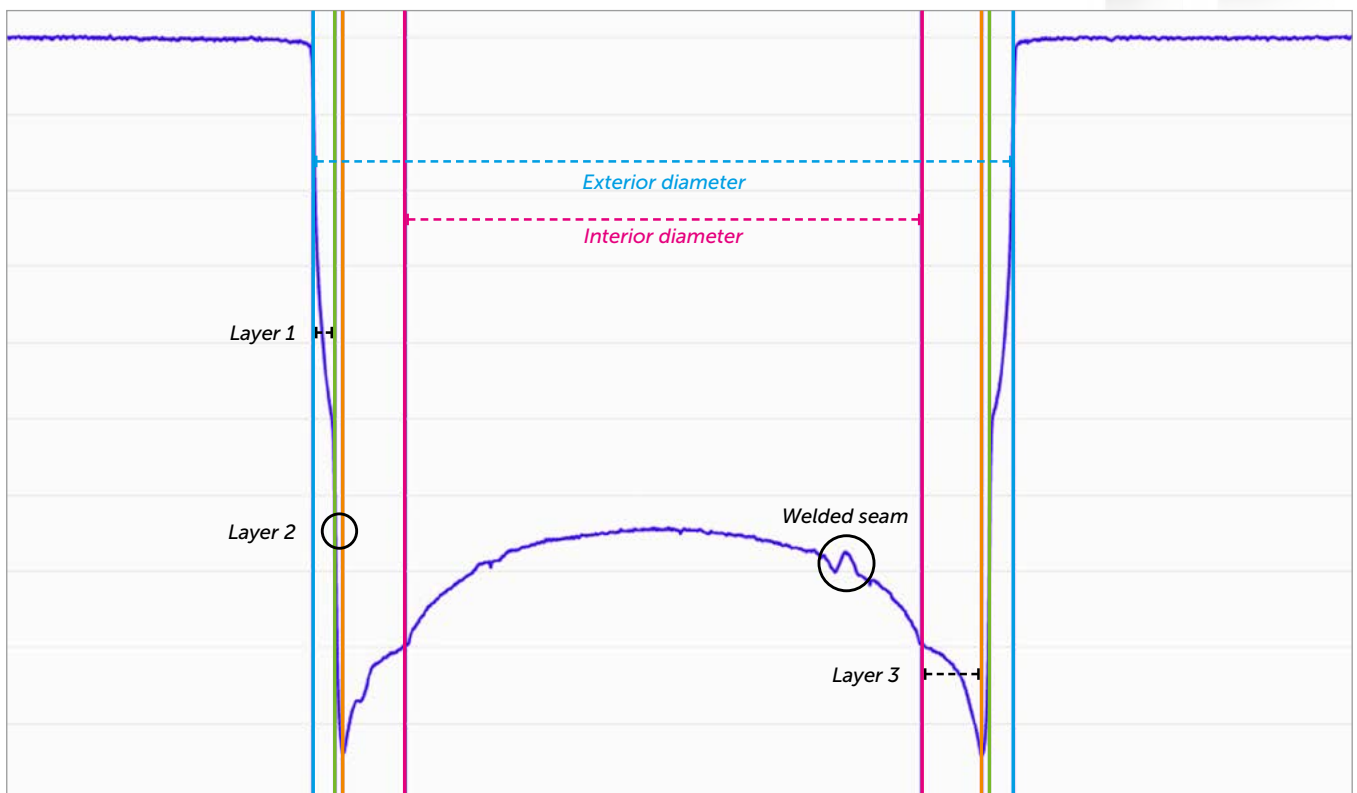
MEASUREMENT TECH FOR A WIDE RANG

Measurement technology for a

1 APPLICATION: Aluminium composite pipes

The production of overlapping and butt-welded aluminium composite pipes combines the advantages of plastic and aluminium. It combines the corrosion resistance of plastic with the strength and dimensional stability of aluminium. Typical areas of application are heating and cooling, in particular underfloor heating systems, drinking water installations, gas supplies, industrial applications and compressed air systems. A decisive factor is the compatibility of the pipes with the corresponding fittings, which is why the geometric dimensions such as diameter, ovality and eccentricity are of the utmost importance.

Manual measuring methods are time-consuming, cost-intensive and error-prone. Faulty productions (also known as "scrap") are associated with time-consuming and cost-intensive recycling of aluminium composite tubes. iXRAY allows precise measurement of the different pipe layers and their geometric dimensions in order to minimise scrap production and ensure compatibility with the fittings.



The iXRAY system can be easily integrated into the production line and offers an unmatched level of measurement accuracy, minimising enabling production deviations to be detected and minimized at an early stage.

INOLOGY

a wide range of applications

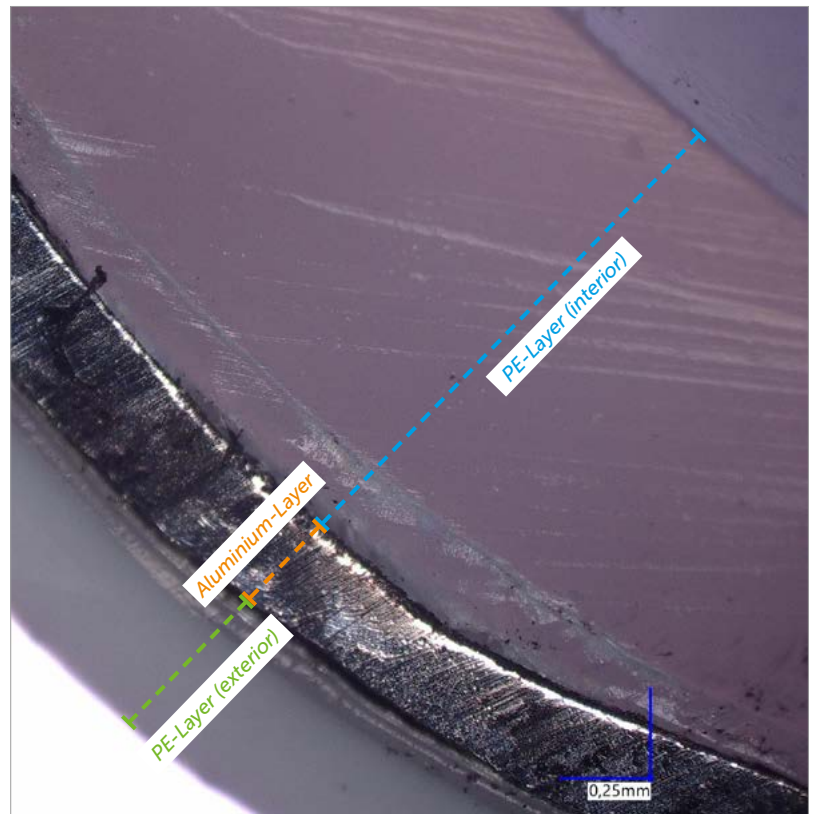
RESULTS

- » Precise layer measurement and geometric control ensure compatibility with the fittings
- » Reduced scrap and recycling costs
- » Consistent product quality thanks to quality assurance during extrusion
- » Significant reduction in material costs
- » Time and resource efficiency thanks to the elimination of manual measurements

The iXRAY wall thickness measuring system offers a full overview of the wall thickness distribution, eccentricity and ovality thanks to its three measuring axes and a total of 6 wall thickness values. This allows precise measurement of the combined PE outer layer (often containing titanium dioxide) and the adhesive agent, the individually measurable aluminium layer and the combined inner layer of adhesive agent and PE.

In the microscopic image shown here the various functional layers are easily recognizable. The inner, 1.51 mm thick PE layer guarantees corrosion resistance. In the centre is the 0.28 mm thick aluminium layer. This ensures the good installation properties and the low thermal expansion of the aluminium composite pipe. The PE outer layer (0.49 mm) protects the aluminium from environmental influences and provides the required colour.

For producers of overlapping and butt-welded aluminium composite pipes, the 3-axis iXRAY measuring system is an indispensable tool. It not only guarantees minimized rejects and reduced recycling costs, but also ensures that the pipes are compatible with the corresponding fittings. It sets standards in precision and efficiency for modern and competitive production processes.



The microscopic image shows the cross-section of an aluminium composite tube with its three different functional layers.

Other applications

Versatile, precise and customized to your needs

2 APPLICATION: Fluoropolymer hoses

Fluoropolymer hoses, made from materials such as PTFE, FEP and PFA, are very popular due to their excellent properties such as chemical resistance, thermal stability and purity. With expensive fluoropolymers, an optimized extrusion process is crucial to avoid material waste. Due to the sometimes complex rheology, precise coordination of all steps in the extrusion process is required.

CHALLENGE:

It is necessary to ensure that exact measurements and controls are carried out to fulfil the high quality standards. Traditional measurement methods can be time consuming and costly and do not always provide the required precision.

iXRAY ADVANTAGES

- » Continuous and accurate measurements to meet high industry standards and to avoid problems such as thermal degradation
- » Reduced need for manual measurements and increased production efficiency
- » Cost reduction through fewer production errors and minimized material waste
- » Better control and optimization of the complex extrusion process of fluoropolymers

3 APPLICATION: PE-Xa pipes for underfloor heating

PE-Xa pipes, produced by peroxide cross-linking of polyethylene, are valued in the heating and air conditioning industry for their flexibility, durability and resistance to high temperatures and pressures. In production, precise adherence to the dimensions is crucial for compatibility with the matching fittings.

CHALLENGE:

Production requires precise control of the extrusion process to ensure correct dimensions and minimise waste. Deviations can lead to installation problems, system failure and non-recyclable production waste.

iXRAY ADVANTAGES

- » The produced PE-Xa pipes comply with industry standards
- » Precise monitoring and control minimise production waste, reduce costs and environmental impact
- » High customer satisfaction thanks to perfectly matched fittings
- » Consistent quality and maximum precision of PE-Xa pipes

Success Story**iXRAY inline Measurement**

*Monitoring the production process of PE-Xa pipes,
to ensure the highest quality standards*



i B A
CONSULTANCY FOR THE EXTRUSION INDUSTRY

**The iXRAY system
plays a key role in
our production.**

**It enables us to
accurately measure
ovality, eccentricity
and wall thickness
during the extrusion
process and has
become the industry
standard for us.**

Martin Deters

Managing Director
iBA GmbH

Solution: X-ray technology

iBA GmbH uses iXRAY systems in its PE-Xa lines to monitor the production process in order to ensure the highest quality standards. Martin Deters, Managing Director of iBA GmbH, emphasises the importance of absolute measurement and precise measurement processing that the iXRAY offers.

PE-Xa pipes produced by iBA GmbH are manufactured in a high-precision and technically stable process that has been refined through decades of research. As PE-Xa pipes are often used for underfloor heating, their ovality is of the greatest importance for compatibility with various fitting systems and global standards. The 3-axis measurement in particular ensures that the ovality of the pipe is accurate.

iXRAY is not only extremely accurate, but can also be easily integrated into the production line. The simple and intuitive plug-and-play solution is a huge advantage explains Martin Deters. In addition, the iXRAY has an easy-to-use user interface that clearly presents all the key process data.

Via the VNC connection, the iXRAY system can be easily integrated into the extruder control system. The pie chart gives the line operator an overview of the wall thickness of the wall thickness distribution. In addition, all other essential quality data, such as trend data and eccentricity view, are directly visible on the terminal. Based on the measured values, the operator can immediately carry out the necessary adjustments, such as the centering of the pipe.

About iBA GmbH

As the world's leading PE-Xa specialist, iBA GmbH specialises in sustainable consulting. Since 1984 the company has been the technology and engineering partner for customers of the extrusion industry worldwide. The company develops and researches safe compounds as well as high-quality and durable extrusion systems.

iBA GmbH stands for future-proof processes, to offer customers the perfect solution for their needs.

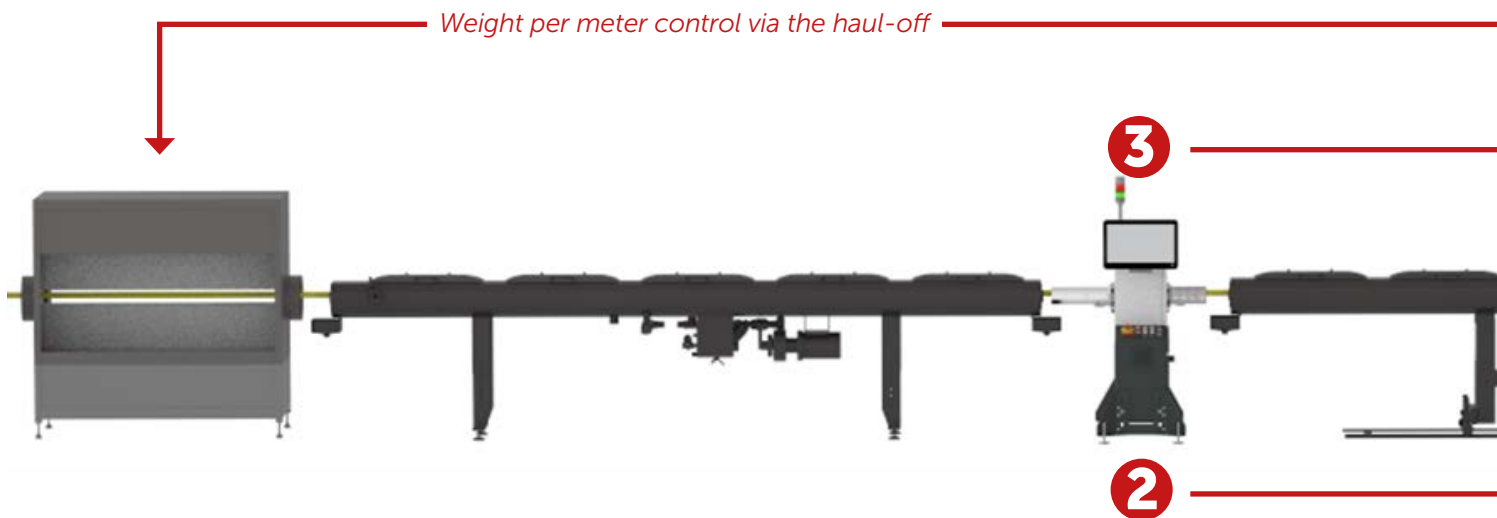
TURN YOUR MEASURING

Turn your measuring system in

Customized process control with iXRAY

Increasing quality and product standards combined with a shortage of skilled labour are the main challenges in many industrial sectors today. **Increased efficiency** and maximum precision **cannot be achieved without consistent automation.**

As a solution provider for the pipe extrusion industry, automation is therefore our main focus: **The interplay of gravimetry, wall thickness measurement systems and control technology is the key to increasing productivity**, significantly reducing costs and at the same time ensure the highest quality. In addition, the more efficient utilisation of the raw materials used contributes to increasing the sustainability of your production and thus secures your competitive strength in the future.



1 CONTRIBUTION OF GRAVIMETRY

Every raw material is subject to fluctuations in bulk density. Gravimetric weighing allows the resulting fluctuations in mass throughput to be recorded and automatically balanced out. In principle, the use of gravimetry opens up two control options: Mass throughput control and meter weight control.

Mass throughput control: With mass throughput control, the extruder speed is adjusted depending on the material feed into the extruder.

Weight per meter control: The haul-off speed is controlled depending on the amount of material fed into the extruder. This keeps the weight per meter constant and eliminates fluctuations in wall thickness in the direction of extrusion. The smaller fluctuations, also reduce the target wall thickness, which saves material. The increase in productivity is proportional to the material savings.

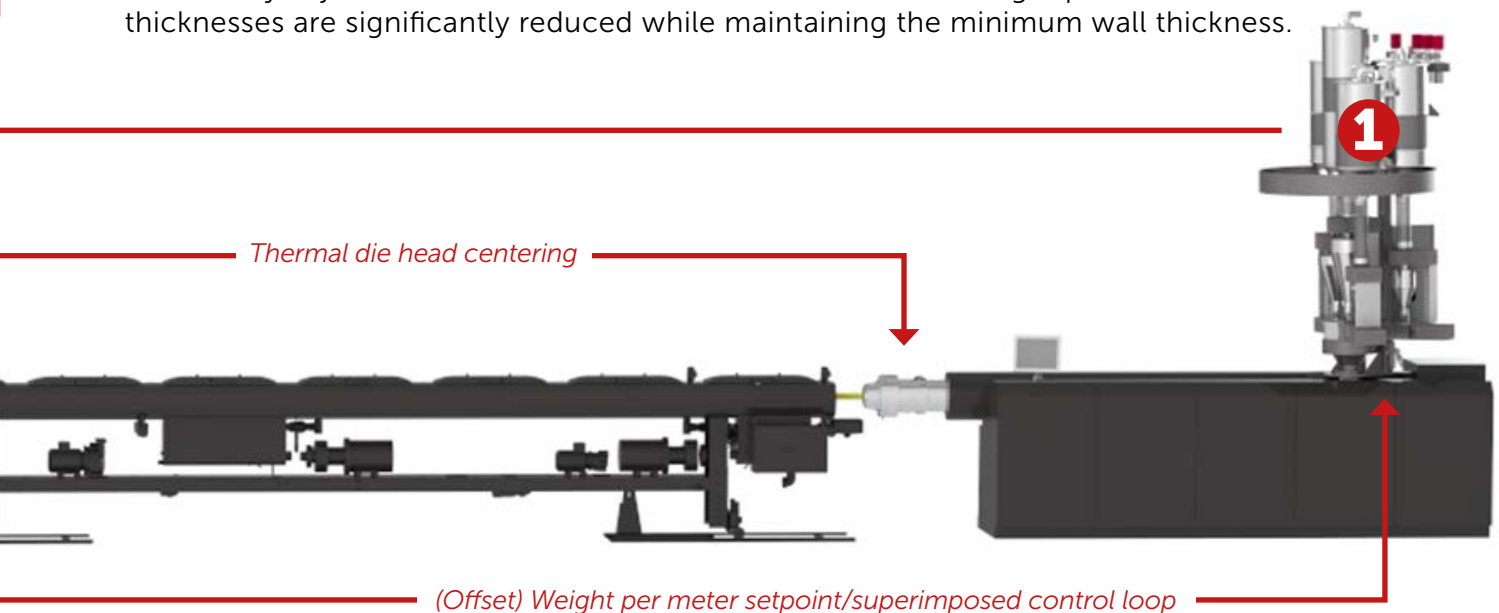
SYSTEM into a control tool

2 CONTRIBUTION OF THE WALL THICKNESS MEASURING SYSTEM

The wall thickness measuring system is integrated into the production line and offers additional control options in the extrusion process. The system enables measurements of important parameters such as diameter, wall thickness, ovality and eccentricity.

Thin point control: In thin point control, the pipe or tube is first measured. The thinnest point defines the control section. The control system then calculates the new target value for the weight per meter and then adjusts the haul-off speed, which also changes the wall thickness.

As a result, the fluctuations in the mass throughput and the wall thickness are recorded and individually adjusted. This ensures a further reduction in the weight per meter. The wall thicknesses are significantly reduced while maintaining the minimum wall thickness.



3 FURTHER CONTROL OPTIONS

Thermal die head centering: Thermal pipe head centering for PVC pipes is a further control step in the automation of extrusion lines and enables additional material savings. The measurement data from the measuring system can be used as a starting point for manual pipe centering. The wall thickness distribution and pipe geometry are recorded by the measuring system and temperature adjustments are then made according to the optimum wall thickness and pipe geometry.

For this purpose, new target values are defined and set for the temperature zones. The resulting change in melting speed in the heating zone reduces the eccentricity. This leads to a further reduction in the weight per meter, an increase in potential savings and perfect end products.

LEARN MORE ABOUT THE ADVANTAGES OF iXRAY TECHNOLOGY



Our cooperation is characterized by a clear mission statement and a focus on customer needs. This is based on our values and principles. Every day, we work with enthusiasm and passion on our claim to "inspire beyond measurement".

Vision

We are the most innovative solution provider for measurement technology in the plastics industry. Today and in the future.

Mission

As both pioneers and experts we offer our customers added value in the pipe, hose, film, cable blow molding and profile extrusion industries.

Our high quality products are user-friendly, intelligent and innovative solutions that are key factors for sustainable success.



iNOEX

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