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WHITEPAPER

RAYEX® S Advanced X-Ray Measurement for Automative Tube Manufacturing

Executive Summary

Automotive tubes require extremely tight dimensional tolerances and real-time dimensional control to meet OEM standards. **RAYEX® S** delivers a highly stable, dual-axis x-ray measurement system capable of analysing **outer diameter (OD), inner diameter (ID), wall thickness, eccentricity, ovality, and all of up to four co-extruded layers simultaneously**. With high-frequency data capture and closed-loop extruder control, RAYEX® S ensures stable layer distribution, reduced material waste, and superior end product quality.

Problem Statement

Automotive tube manufacturers face critical challenges in achieving precision and efficiency:

- Maintaining uniformity in **multi-layer extrusion lines**
- Detecting **thin spots** early
- Reducing **startup scrap** and avoiding numerous late **die-centering adjustments**
- Ensuring consistent extruder output despite **material inconsistencies**
- Meeting **tight tolerance demands** and providing **full SPC traceability**
- Measuring **corrugated, reinforced, or composite tubes** where optical or ultrasonic systems struggle

RAYEX® S: Real-Time X-Ray Measurement & Closed-Loop Control

RAYEX® S addresses these challenges through advanced x-ray technology and integrated process control:

- **Dual x-ray scanning at 90°** for complete geometric reconstruction
- **Simultaneous measurement** of all extruded layers
- **Real-time, independent closed-loop correction** for each extruder
- **High-frequency dimensional sampling** (1–15 scans per second)
- **Pin-hole and defect detection** via micro-absorption anomaly analysis
- **High-speed host output** up to 20 updates per second
- **Long x-ray tube life** (4–5 years) with near-zero maintenance
- **User-driven recipe creation** for in-house customization

Deep Technical Explanation

Principle of Operation

RAYEX® S employs two static, x-ray sources positioned at 90° from each other. Each source emits a narrow, high-energy photon beam that penetrates the tube. Photon attenuation follows the **Beer–Lambert absorption principle**, where intensity decreases based on material density and thickness.

Key factors influencing attenuation:

- Density variations across layers
- Material composition (rubber, adhesive, reinforcement)
- Layer thickness differences

Detection & Analysis

High-resolution CCD detectors capture intensity profiles with extremely fine spatial resolution. Advanced algorithms reconstruct the tube geometry by analysing absorption gradients:

- **Inner diameter (ID)** from the first absorption boundary
- **Layer interfaces (L1/L2/L3)** from abrupt absorption slope transitions
- **Outer diameter (OD)** from final attenuation drop
- **Wall thickness uniformity** around the circumference
- **Eccentricity** from centroid shifts of layer boundaries
- **Ovality** from OD measurements at multiple angles

Because RAYEX® S collects more attenuation points per second, it can detect extremely small layer instabilities, such as localized thinning - events invisible to optical systems. The optimized x-ray spectrum for polymers and rubber ensures precise detection of each layer, even with different densities. The CCD array's high dynamic range resolves subtle attenuation differences. This is especially important for automotive tubes where inner and outer layers may use similar compounds but require independent measurement and tolerancing.

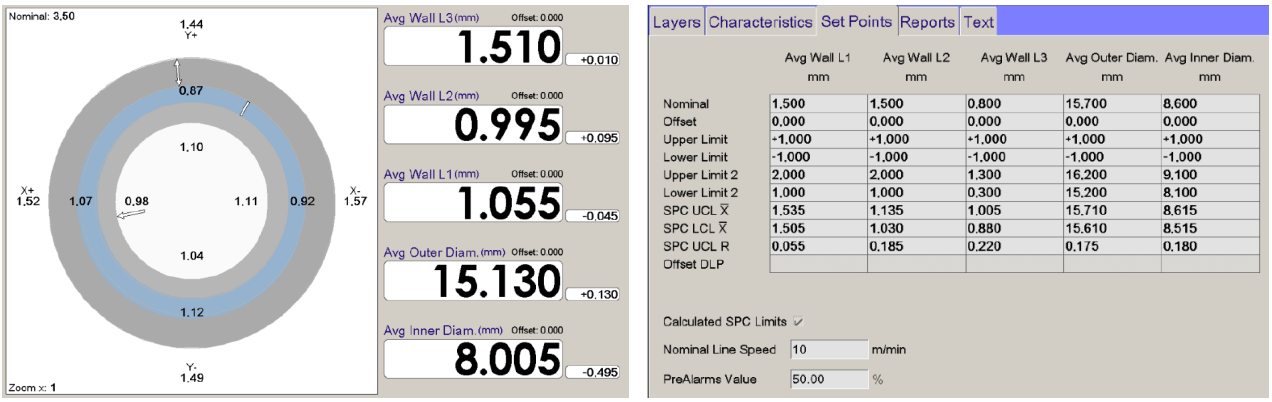
High-resolution layer boundary detection and dimensional analysis

Closed-Loop Extrusion Control

RAYEX® S integrates seamlessly with extrusion control systems, enabling real-time corrections:

- **Inner layer extruder** optimizes ID and inner wall thickness, affecting by default any outer layer thicknesses
- **Middle layer extruder** optimizes middle layer thickness, counteracting any control influences from inner layer adaptations, affects by default any outer layer thicknesses
- **Outer layer extruder** controls final OD and final layer thickness, counteracts any affects from inner layer adaptations

This automation optimizes simultaneously all layer thicknesses, reduces material drift, accelerates startup stabilization (up to **40% faster** than manual operation), and eliminates over-extrusion.



RAYEX® S real-time closed-loop control interface for multilayer extrusion

Technical Strengths

- Full multilayer measurement **without calibration or material lookup tables**
- **Static architecture**: no moving parts, zero mechanical drift
- Immune to **vibration, moisture, heat, steam, die drool, or extrudate shine**
- Flexible geometry: horizontal, vertical, or angled for complex processes
- Measurement range: **2 mm (micro-tubing) to 100 mm (large automotive hoses)**
- Long-term accuracy with **high x-ray stability**
- Operates in **harsh environments** (high temperature, humidity)
- Extended capability for **corrugated, reinforced, or multi-layer composite structures**

ROI & Operational Gains

- **20–40% reduction in startup scrap** via rapid die-centralization
- **1–3% material savings** by prevention of over-extrusion
- Reduced manual QC and destructive testing requirements
- Early defect detection reduces customer rejection rates
- Full SPC data highlights specification compliance and process capability

Typical ROI achieved by automotive hose factories: **9–14 months**, depending on production throughput.

Conclusion

RAYEX® S sets the benchmark for x-ray dimensional control in automotive tubing. Its advanced measurement systems, robust hardware, and high scanning frequency deliver unmatched accuracy, process stability, and waste reduction. For manufacturers seeking world-class tolerance control and quality assurance, RAYEX® S is the definitive solution.