Mastering Coating Control in Metal Packaging

(3PC CANMAKING)

innovative sensors for canmaking

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I. INTRODUCTION

Coating control is a critical yet often overlooked aspect of metal packaging. Proper coating application plays a crucial role in ensuring product safety, performance, corrosion resistance, and shelf appeal.

This whitepaper outlines insights and practical principles on how coating thickness impacts quality, how to measure it effectively, and how to use data for continuous process improvement.

II. FUNDAMENTALS OF QUALITY

Question: Who wants to create bad cans?

The rhetorical question underscores a simple truth: **no one** aims to produce defective cans.

However, defective cans are not the result of one single mistake—they arise from subtle deviations across multiple quality parameters.

Producing good cans is not about perfection but about consistency within **acceptable limits** across several elements such as **dimensional accuracy, mechanical strength, print quality and coating performance**—the latter being a critical focus for maintaining product integrity.

In coating control, several variables come into play: the **weight** of the coating, its **distribution** across the surface, and its **adhesion** to the substrate. Each must be optimized to achieve the desired protection and finish. When paired with strong mechanical properties, these factors ensure that every can meets both functional and aesthetic expectations—consistently, efficiently, and cost-effectively.

III. STATISTICAL PROCESS CONTROL (SPC)

Producing a high-quality can comes down to three essential factors: the **equipment used**, the **tools applied to monitor the process**, and the **procedures that guide production**.

Among these, one of the most powerful tools for maintaining consistency is **Statistical Process Control (SPC)**.

The concept is much like conducting an election survey: by analyzing a small, representative sample, manufacturers can draw accurate conclusions about the quality of the whole batch. This data-driven approach allows production teams to detect variations early, make timely adjustments, and ensure that every can leaving the line meets defined quality standards.

Through consistent monitoring and disciplined process control, canmakers can move beyond guesswork—achieving measurable, repeatable quality with every batch.
To achieve consistent can quality, manufacturers rely on Statistical Process Control (SPC)—a method that uses data to monitor, analyze, and improve production performance.

Within SPC, two key tools play a vital role in understanding process behavior: the **histogram** and **process capability analysis**.

IV. COATING THICKNESS & DISTRIBUTION

One of the most fundamental tools in Statistical Process Control (SPC) is the histogram—a simple yet powerful way to visualize how consistent a process truly is.

Consider a batch of metal sheets, each designed to have a coating weight of 10 grams per square meter. In practice, not every sheet will weigh exactly 10 grams. Some will be slightly heavier, others slightly lighter. This natural variation is part of every manufacturing process.

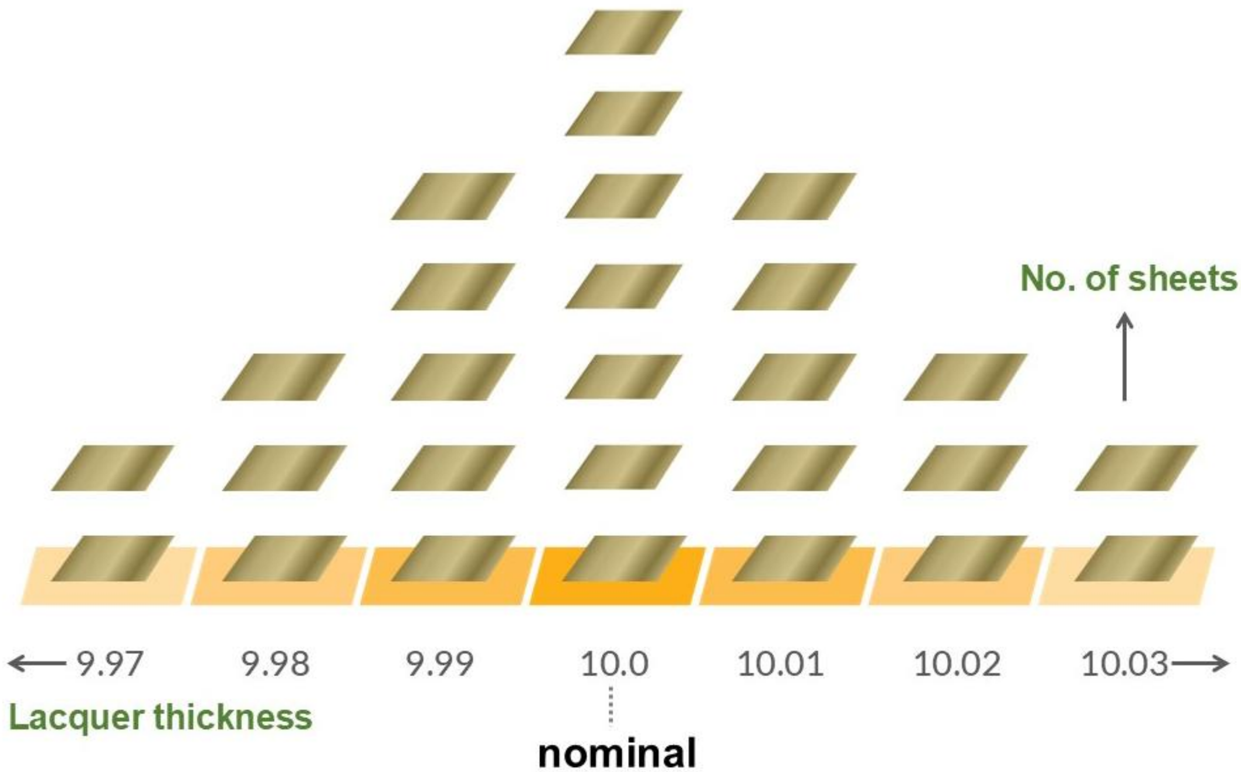


Image 1: Visual representation of sheets being categorized by their coating weight

A histogram organizes these measurements into groups based on their coating weights. Imagine marking squares on the floor: sheets measuring exactly 10 grams are placed in the center, while the slightly heavier ones are stacked to one side and the slightly lighter ones to the other.

As more data is added, these stacks form a pattern—typically a **bell-shaped curve**, also known as a **normal distribution**. A well-centered, narrow distribution indicates stability; skewed or wide distributions signal potential issues such as equipment misalignment or inconsistent lacquer application.

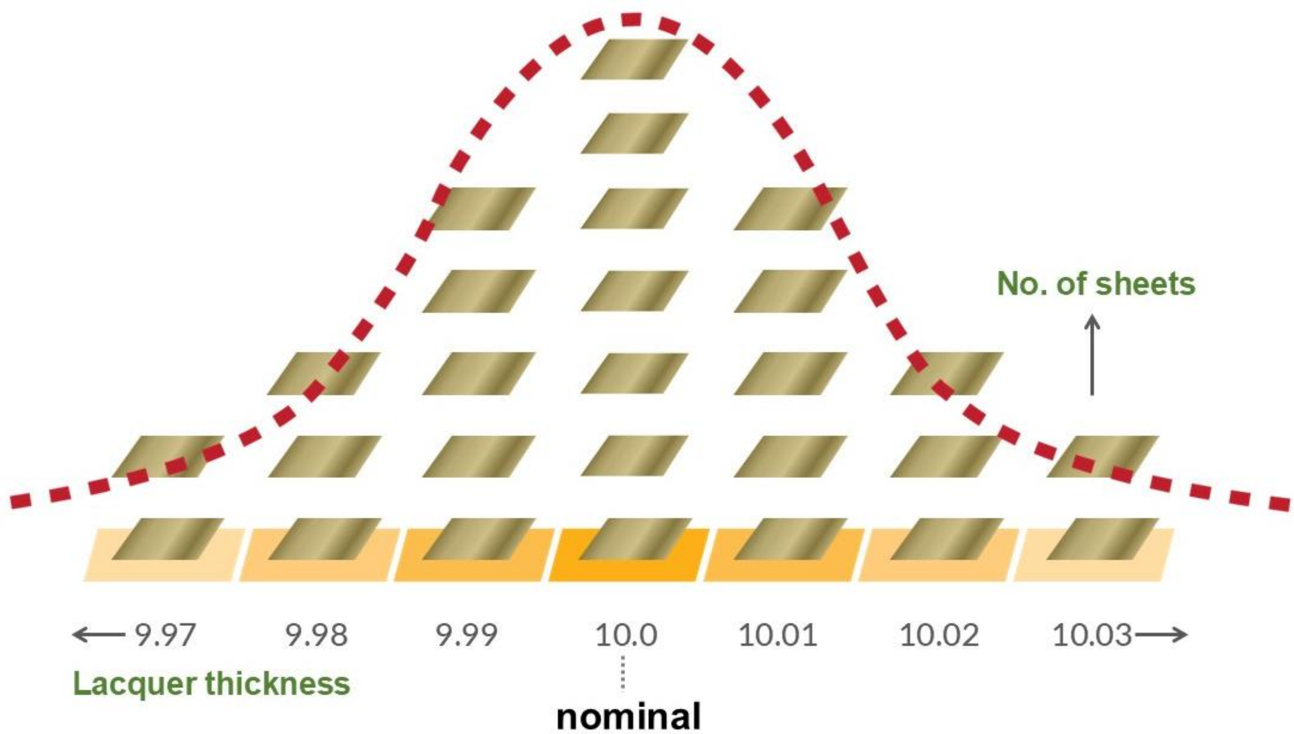


Image 2: Visual representation of sheets being categorized by their coating weight

By studying this distribution, canmakers gain powerful insights into how their production behaves—turning simple data into a clear picture of performance and control.

V. THE GAUSSIAN DISTRIBUTION & STANDARD DEVIATION

The Gaussian, or bell curve, describes how natural variation behaves in stable processes: most measurements cluster around an average, with fewer occurring as values move away from the mean. Introduced by mathematician Johann Carl Friedrich Gauss, this distribution became fundamental to modern quality control. It enables manufacturers to quantify variation, detect trends, and define meaningful quality limits—transforming random fluctuations into actionable insights for better process management.

Image 3: Johann Carl Friedrich Gauss 1777-1855

Behind every bell curve lies a powerful mathematical concept known as standard deviation, symbolized by the Greek letter sigma (σ). In simple terms, standard deviation measures **how tightly data points cluster around the average**.

By drawing two lines around the average and adjusting them until **68% of all measurements** fall within that range, manufacturers define **±1 standard deviation**. Depending on the measurement system, this range can be expressed in **grams per square meter**, **microns**, or **milligrams per square inch**.

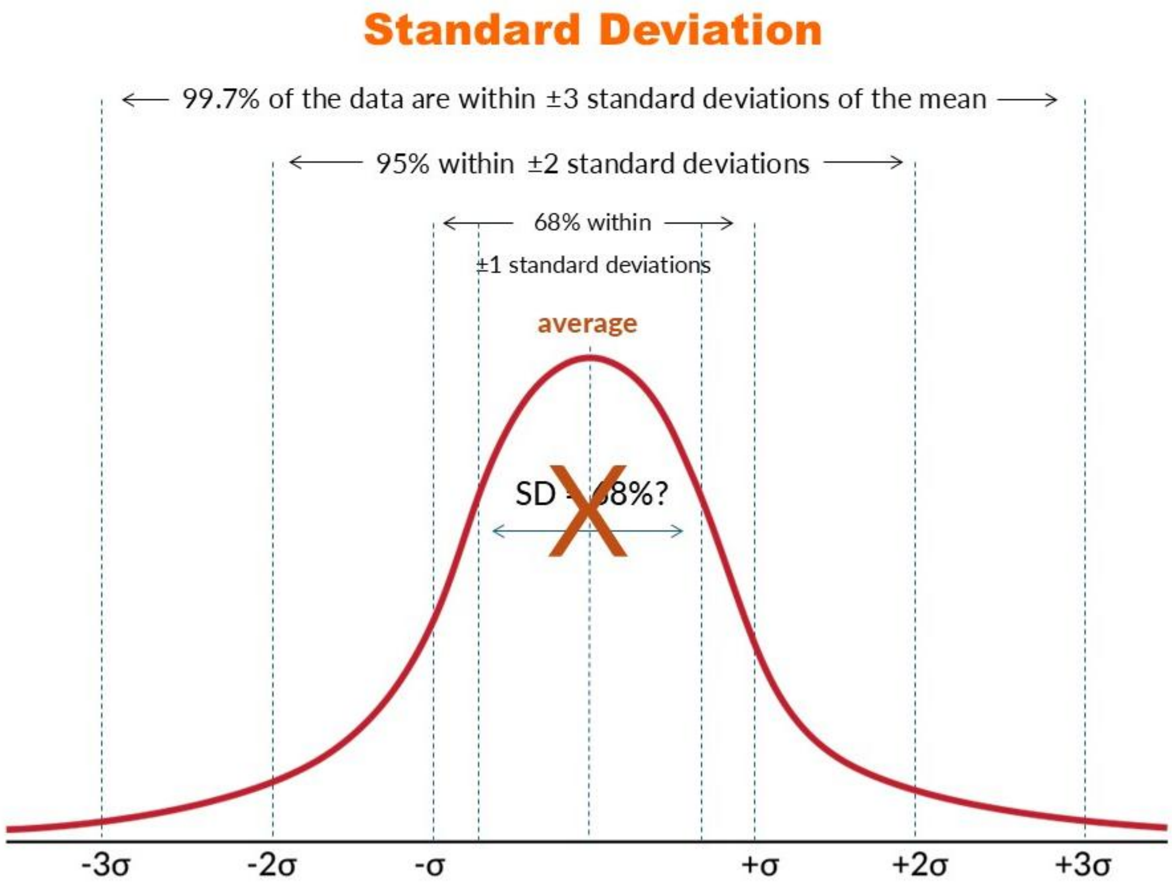


Image 4: Standard Deviation

What makes standard deviation so powerful is its predictability:
±1σ covers approximately **68%** of production
±2σ covers about **95%**
±3σ covers nearly **99.7%**

These predictable ranges help manufacturers evaluate consistency, identify deviations early, and determine whether corrective adjustments are necessary. By applying standard deviation analysis, canmakers gain a clearer understanding of process behavior and can more effectively maintain coating uniformity and overall product quality.

Gauss's discovery of the bell curve is more than just an academic milestone—it's a practical tool for understanding real-world production behavior. In coating control, the **shape of the bell curve** reveals how consistent or variable a process truly is.

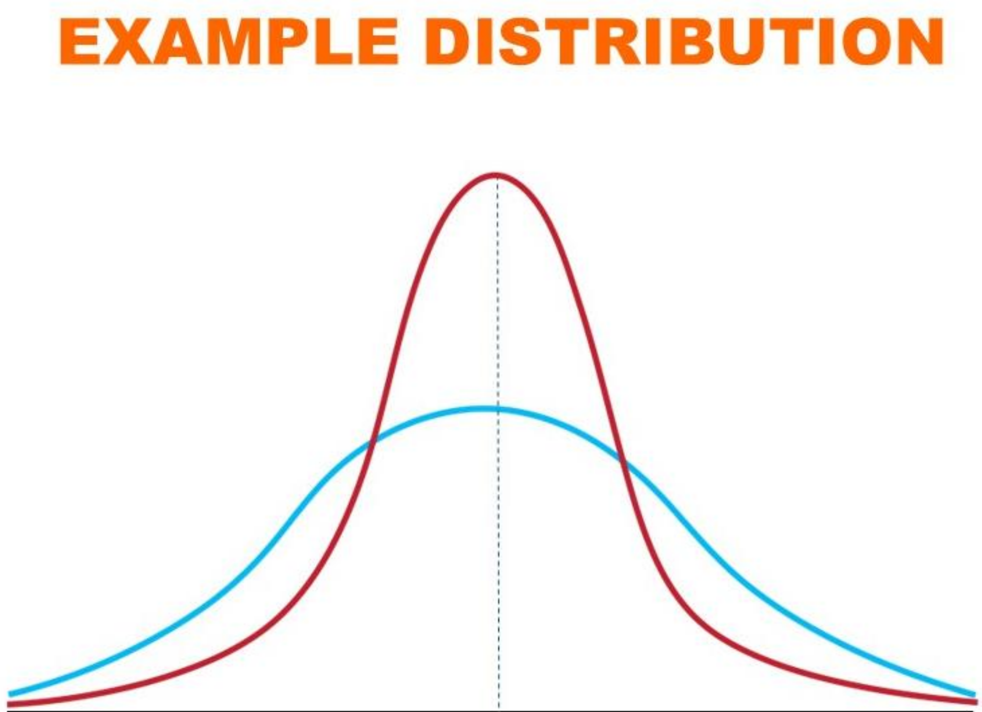


Image 5: Different types of bell curve distribution

When plotted, not all bell curves look the same. A **steep, narrow curve** indicates that most sheets fall very close to the target coating weight, suggesting a **stable, well-controlled process**. In contrast, a **flatter, wider curve** shows that more sheets deviate toward the extremes—either heavier or lighter than the desired value—signaling **greater variation** and potential quality concerns.

A **narrow distribution** is the ultimate goal: it means the process is precise, predictable, and capable of producing a consistently high-quality batch. By monitoring the shape of the bell curve, canmakers can quickly assess whether their coating process is performing optimally or if adjustments are needed to bring production back into control.

VI. PROCESS CAPABILITY

Once variation is understood through the bell curve, the next step in process control is setting clear **specification limits**—the boundaries that define acceptable product quality. In coating control, these are known as the **Lower Specification Limit (LSL)** and the **Upper Specification Limit (USL)**.

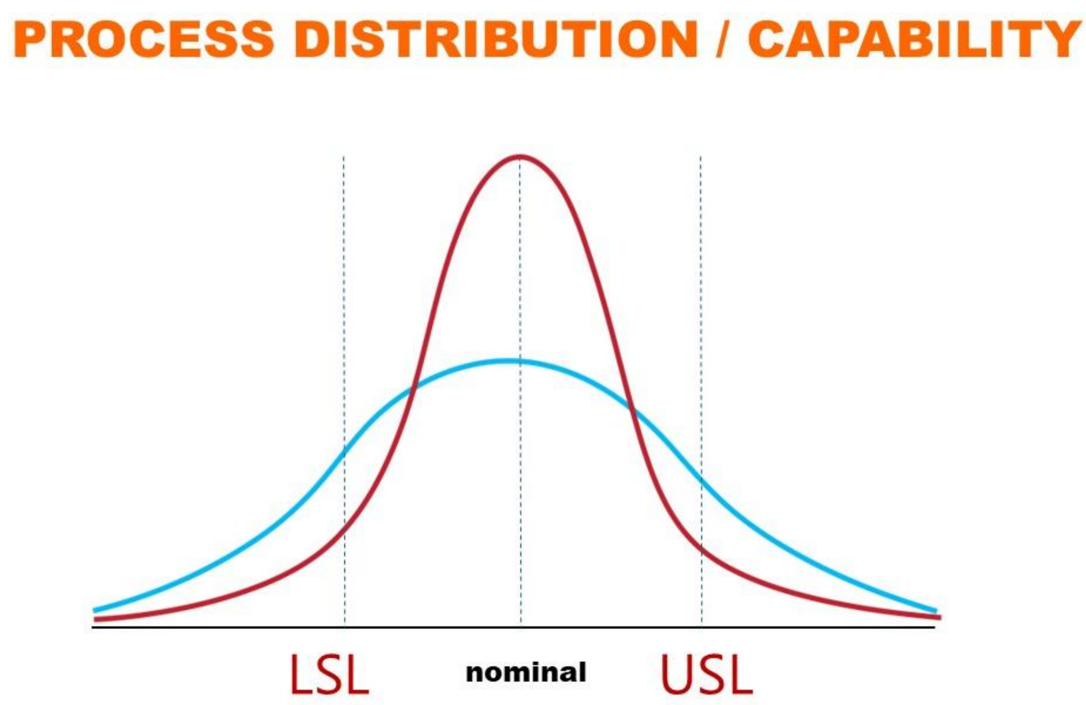


Image 6: The nominal, lower specification limit (LSL) and upper specification limit (USL)

The LSL represents the minimum coating thickness agreed upon with the customer—no sheet should fall below this value. The USL, on the other hand, defines the maximum acceptable thickness beyond which the coating may be considered excessive or noncompliant. Even in a stable process represented by a **narrow red curve**, a few sheets may still fall outside these limits. These are out-of-spec and should never be delivered to customers. In contrast, a **flatter blue curve** indicates a wider spread of results, meaning a higher proportion of sheets will fall beyond the acceptable range. The outcome is more rejects, higher waste, and ultimately, greater production cost.

In other words, a narrow distribution ensures most results fall within LSL–USL. A wide distribution increases rejects, waste, and cost.

VII. MEASUREMENT SYSTEMS

To keep coating thickness within specification limits, manufacturers rely on precise **measurement systems** that monitor sheet performance in real time. In three-piece can production—where coating is applied to metal sheets before forming—accurate measurement is essential for maintaining uniformity and minimizing waste.

Non-contact Systems:

- Spectrophotometric
- Interferometric

Advantages: highly accurate

Disadvantages: expensive

Use: real-time feedback, ideal during startup

In a typical setup, non-contact systems scan **strips along the right and left sides of each sheet**. To eliminate signal noise—small fluctuations that could distort readings—they average results across multiple sheets. This produces a **stable, reliable indication of coating weight** on each side.

Though they come at a higher cost, these systems perform exceptionally well, making them an ideal choice for operations where precision and process stability are top priorities.

While non-contact systems offer precision, many manufacturers continue to rely on **contact measurement systems**—trusted, cost-effective tools that have proven reliable across decades of production. Each type of contact system comes with distinct advantages and trade-offs, depending on the coating process and production needs.

Contact Systems:

- Gravimetric (accurate but destructive)
- Capacitive (industry standard, non-destructive, cost-effective)
- Ultrasonic (poor R&R for thin coatings)

Ultimately, choosing the right measurement system is about finding the right balance between **precision, practicality, and cost-effectiveness**—ensuring that quality assurance remains both accurate and sustainable.

VIII. IMPORTANCE OF R&R

R&R (Repeatability and Reproducibility) is a critical indicator of how much variation comes from the measurement system rather than the coating process itself. Repeatability measures consistency when the same operator repeats the same measurement under identical conditions, while reproducibility reflects how consistent results remain across different operators, instruments, or environments.

If R&R performance is poor, measurement data becomes unreliable, leading to incorrect process adjustments, increased variation, and loss of control. For coating control—where tolerances are often tight—measurement error must be significantly smaller than the allowed coating thickness range. This ensures that any variation detected reflects real changes in coating application, not measurement noise.

R&R is expressed as a percentage of the process range:

<10% → Excellent measurement system

10–30% → May be acceptable depending on use and tolerance levels

>30% → Not acceptable; system cannot support reliable coating control

In flat-sheet coating operations, both non-contact and capacitive gauges typically achieve strong R&R, making them suitable for monitoring fine coating variations. Strong R&R performance in coating control ensures that thickness measurements accurately represent true sheet conditions, enabling canmakers to make precise adjustments, reduce waste, and maintain consistent product quality.

IX. CAPACITIVE MEASUREMENT

To explain what capacitive measurement is we will use the Hoverprobe™ II as an example. The Hoverprobe™ II is equipped with a **rubber probe tip** that gently presses down on the coated metal sheet. The **lacquer layer** between the probe and the metal acts as a **dielectric**, creating two conductive surfaces separated by an insulating layer—essentially forming the two plates of a **capacitor**.

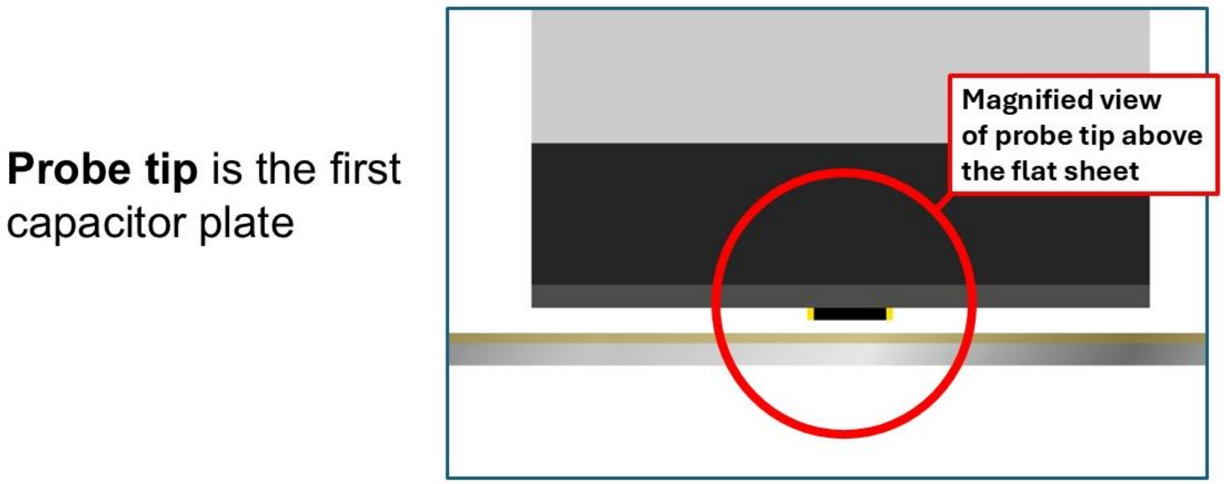
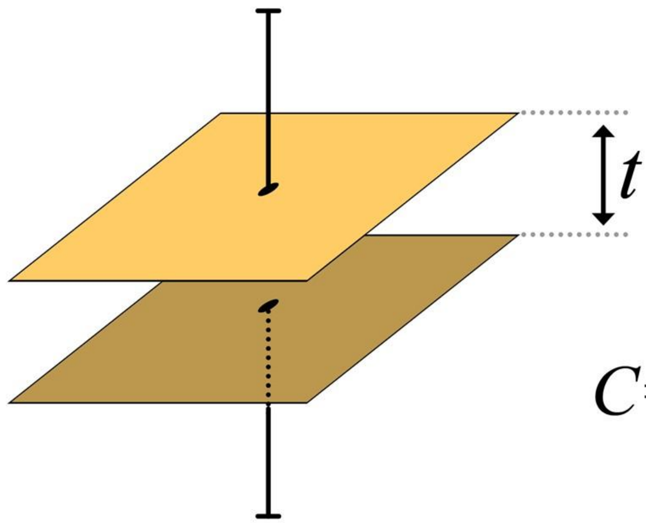


Image 6: Close-up illustration of the Hoverprobe™ II on a flat metal sheet.

As the thickness of the coating changes, so does the **capacitance**, or the ability of this miniature capacitor to store an electric charge. By detecting and calculating these changes, the system determines the **coating thickness** with high precision.

This non-destructive method allows canmakers to measure coating consistency quickly and accurately, ensuring that every sheet meets specification. Simple in concept yet highly effective in application, capacitive measurement remains one of the most practical and reliable techniques for quality assurance in metal packaging.

Capacitive measurement is grounded in a straightforward electrical principle. The **capacitance (C)** between the probe tip and the metal sheet is defined by the formula:



$$C = \varepsilon \cdot \frac{A}{t}$$

where:
C is the capacitance,
ε is the dielectric constant,
A is the surface area of the probe tip, and
t is the thickness of the lacquer layer between the probe and the metal substrate.

During calibration, the **dielectric constant** and **surface area** are determined and stored as fixed values in the gauge. Once these are set, measuring capacitance allows the system to accurately calculate the **coating thickness**. To maintain precision, the **surface area of the probe tip must remain consistent**. Any wear, deformation, or residue buildup can alter the area, affecting readings. Consistent probe maintenance and calibration are therefore critical to ensuring reliable, repeatable measurements.

WHAT AFFECTS CAPACITIVE MEASUREMENT?

For capacitive measurement systems to deliver precise and repeatable results, several key factors must be carefully controlled. Even small variations in probe handling or environmental conditions can significantly impact data accuracy.

1. Probe Tip Condition
The condition of the **rubber probe tip** is one of the most critical elements. It should always be kept **clean**, checked regularly for **wear**, and allowed to **deform properly** during use.

Over time, the probe tip gradually takes on a slightly flattened or “mushroom” shape—a normal part of the process that ensures consistent contact with the coated surface. When a **new probe tip** is installed, it must be placed on a **solid surface for at least 30 minutes before calibration**. This allows the rubber to stabilize and reach its natural deformation. Skipping this step can cause the tip to continue changing shape during measurement, leading to drift and inaccurate readings.

2. Humidity
Environmental **humidity** can also affect capacitance readings. Moisture in the air changes the dielectric properties of both the probe and the coating layer, subtly influencing the measurement. Maintaining stable humidity conditions—or compensating for them during calibration—helps ensure consistent results.

3. Calibration Method
Accurate calibration is essential. Using **multiple calibration points** across the sheet, rather than relying on a single reference point, greatly enhances precision by accounting for small variations across the surface.

4. Handling and Surface Contact
Finally, the way the probe is handled between measurements matters. A common mistake is leaving the **Hoverprobe™ II** resting on a soft surface, such as a computer mouse pad. This causes continued relaxation of the probe tip, which can distort readings. The probe should always rest on a **firm, stable surface** when not in use to maintain consistent geometry.
Attention to these details—probe care, environmental control, and proper calibration—ensures the capacitive measurement system operates at peak accuracy, providing dependable data for coating control and process optimization.

X. SYSTEMS FOR COATING CONTROL

HOVERPROBE™ II IS9651

One of the most widely used systems for coating thickness measurement is the Hoverprobe™ II, a trusted tool found in factories around the world. With a legacy spanning more than 25 years, the Hoverprobe™ II has become a standard in quality assurance for three-piece canmaking.

Image 7: The Hoverprobe™ II IS9651

The latest version, the **Hoverprobe™ II**, incorporates key design improvements that make it both safer and more efficient. Unlike earlier models, this upgraded system **no longer requires the use of a crocodile clip**, eliminating the risk of scratching or damaging metal sheets during measurement. Another valuable advantage is its **non-destructive testing capability**.

When production standards permit, measured sheets can be safely **returned to the production line** after testing—an important feature that helps **reduce material waste and save costs** without compromising quality. Durable, dependable, and easy to use, the Hoverprobe™ II continues to set the benchmark for accuracy and practicality in coating control across the global metal packaging industry.

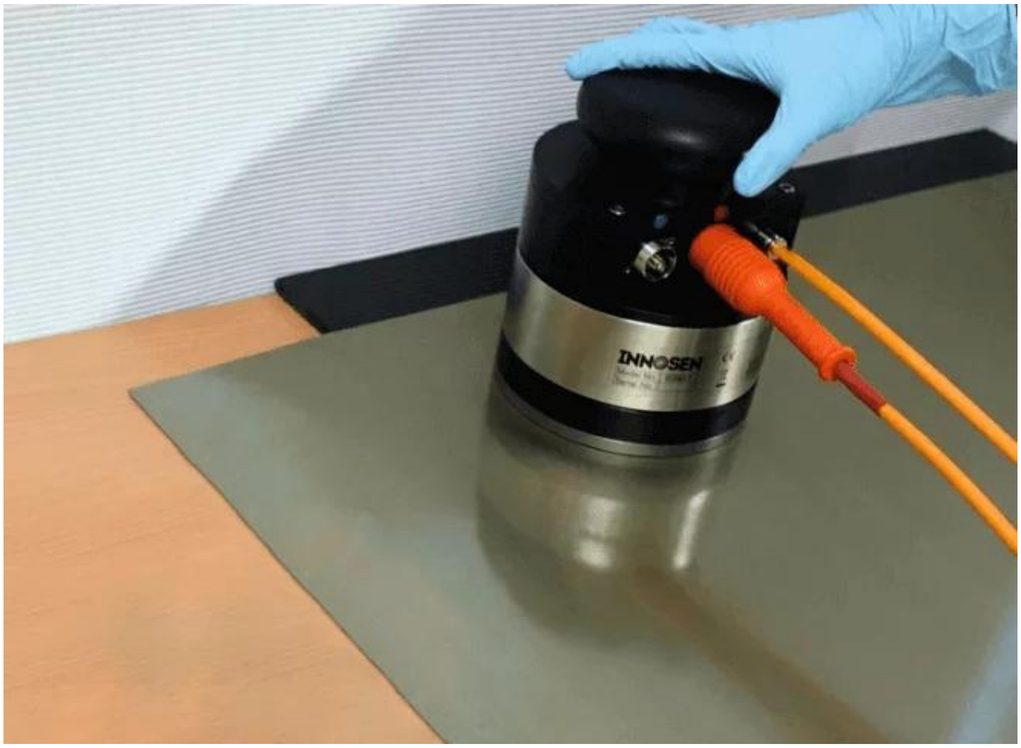


Image 7: Coating thickness measurement probe

One of the key advantages of the **Hoverprobe™ II** is its ability to perform **nondestructive measurements**, allowing operators to reuse tested sheets— provided company standards and customer requirements permit it. This simple improvement can have a **significant impact on cost efficiency**. Consider a typical production environment running **1,000 hours of operation**, with one sheet measured every **20 minutes**.

Over time, that equates to roughly **3,000 sheets** used purely for testing. By allowing those sheets to be safely returned to the production line, manufacturers can dramatically **reduce material waste and testing costs** while maintaining strict quality assurance.

It's a small operational detail that delivers measurable savings—reinforcing why the Hoverprobe™ II remains one of the most practical and cost-effective tools for coating control in modern canmaking.

TUBE PROBE IS9561

Expanding beyond flat sheet applications, Innosen also developed a specialized **Tube Probe system** designed to measure coating thickness of **aluminium tubes** and **severely necked-in monobloc cans**.

Like the Hoverprobe™ II , this system uses **capacitive technology** to deliver accurate, repeatable measurements—even in complex or hard-to-reach geometries. Its precision and reliability make it an invaluable tool for manufacturers producing collapsible tubes, aerosol cans, or other cylindrical packaging that demands consistent internal and external coating performance.

By bringing the proven advantages of capacitive measurement to more challenging shapes, the Tube Probe ensures that coating integrity can be verified across a wider range of metal packaging applications.

Image 8: The Tube Probe IS9561 with a sample aluminium collapsible tube

INNOLYTIX™ IS1100

In today's production environments, modern gauges and inspection systems generate **vast amounts of data** every day. But having data alone isn't enough— the real value lies in how it's used.

Too often, manufacturers collect endless measurement readings that are never analyzed or applied. In one memorable case, a factory produced nearly **a cubic meter of paper reports every week**—a mountain of information that no one had the time to review, let alone interpret for process improvements. Even today, many facilities still rely on **manual data recording**, storing results in binders that gather dust on shelves, with no meaningful impact on production.

The lesson is simple yet vital: **you don't need data—you need information.** Raw numbers only become valuable when they're transformed into insights that drive smarter decisions and more stable processes.

To meet this need, Innosen developed **Innolytix**, an advanced software solution that **analyzes measurement data and converts it into actionable intelligence**. By turning complex datasets into clear, visual summaries, Innolytix empowers quality teams to spot trends, make timely adjustments, and continuously improve coating control. This approach bridges the gap between measurement and management—helping canmakers move from reactive data collection to **proactive process optimization**.

The **Innolytix software** was designed to bridge the gap between measurement and process control, transforming raw data into clear, actionable insights. Currently compatible with the **Sencon filmweight gauge**, Innolytix gives canmakers a powerful platform to visualize, analyze, and respond to coating data in real time.

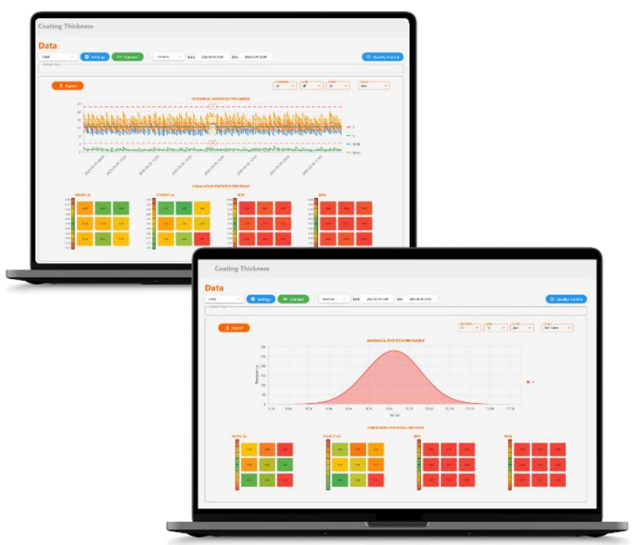


Image 9: Innolytix™ IS1100

Once connected, the software automatically **displays measurement data in easy-to-read graphs**, allowing users to analyze results by **operator, shift, channel number, lacquer type, or job**. This flexibility makes it simple to pinpoint where variations occur and trace them back to specific conditions or team members.

For **quality assurance and safety**, Innolytix provides immediate visual alerts: if measurements exceed **Upper or Lower Specification Limits (USL or LSL)**, the screen **flashes red**, signaling that production should stop or hold for inspection.

If results fall **outside control limits** but still within specifications, the display **flashes yellow**, prompting operators to take corrective action before defects occur.

Each measurement is automatically **time-stamped and linked to the operator** who performed it, ensuring full traceability. This makes it easy to review performance, confirm corrective actions, and maintain accountability across shifts.

With intuitive visuals, clear alerts, and instant data access, Innolytix helps canmakers move from data collection to **data-driven decision-making**—enabling faster responses, improved quality control, and smarter production management.

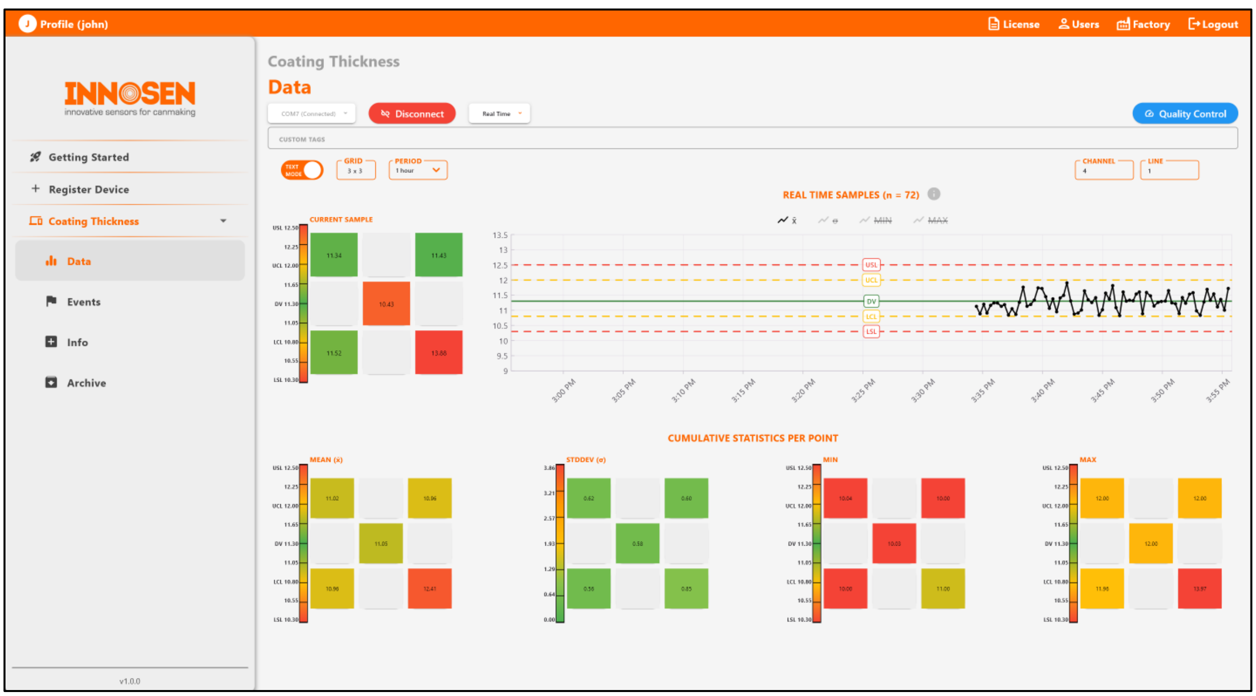


Image 10: Real Time Data for 5-Point Sheets in Coating Thickness Measurement.

One of the most powerful aspects of **Innolytix** is its ability to transform live measurement data into meaningful, actionable insights. The software displays **real-time process data** using a series of dotted lines—where the **outer lines** represent the **specification limits** and the **inner lines** indicate the **control limits**.

When measurements begin to approach or exceed the control limits, it's a signal for operators to take notice and prepare for corrective action. If readings move beyond specification limits, immediate intervention is required to prevent defective production. This clear visual feedback ensures that quality issues can be identified and addressed **before** they escalate.

Beyond live monitoring, Innolytix offers advanced tools for **in-depth data analysis**. Each sheet is measured at maximum **nine distinct points**, allowing users to track both **average coating thickness** and **variation** across the entire surface. The software first calculates the **mean coating thickness** at each point over many sheets. If one area—such as the right side—consistently shows heavier readings, this may indicate a systematic imbalance. However, a single deviation doesn't necessarily warrant adjustment; only consistent trends over time suggest that mechanical fine-tuning is needed.

Innolytix also analyzes **standard deviation per point**, providing deeper insight into process stability. For example, if the standard deviation is low on the left side but high on the right, it could signal a **mechanical issue**, such as a **roller bearing problem** or **uneven pressure distribution** during coating. In these cases, the roller may be lifted slightly by the lacquer layer, causing more fluctuation on one side.

By visualizing and analyzing this data, Innolytix empowers engineers to go beyond simple measurements—helping them diagnose root causes, verify machine alignment, and make informed, data-driven adjustments that enhance coating uniformity and overall process control.

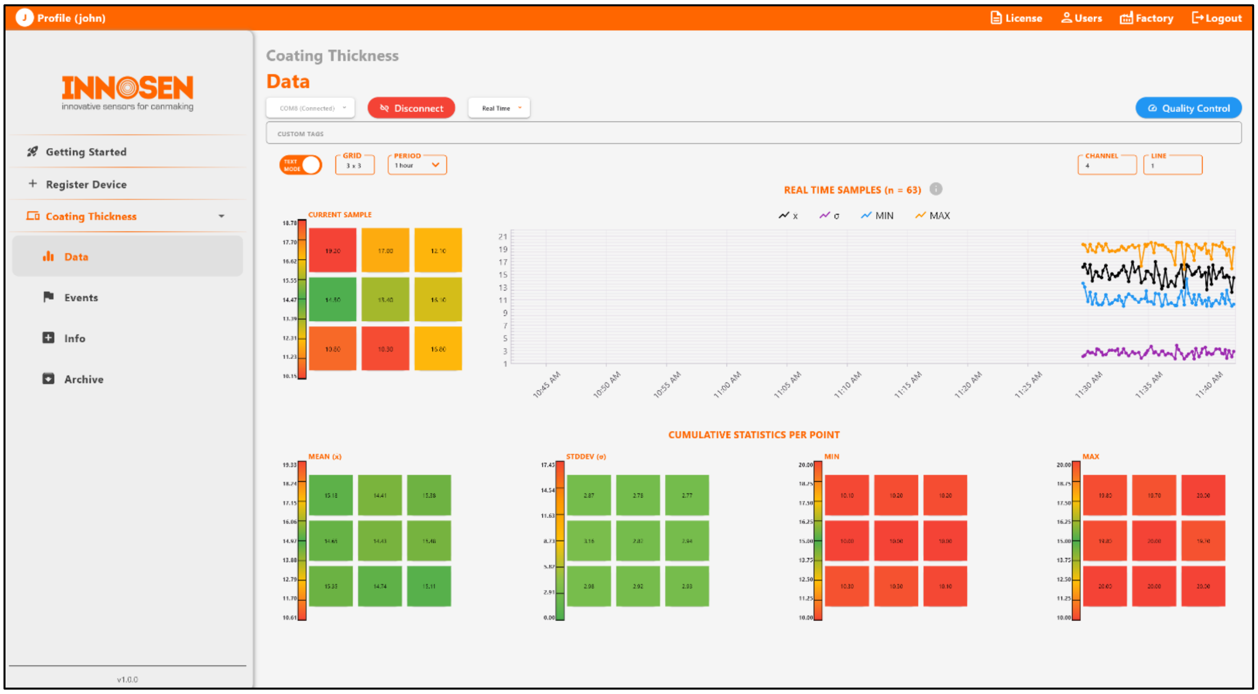


Image 10: Real Time Data for 9-Point Sheets in Coating Thickness Measurement.

Beyond real-time monitoring and statistical analysis, **Innolytix** offers a suite of intelligent features designed to help manufacturers take full control of their coating processes.

Operators and engineers can **analyze data by shift**, making it easier to identify trends tied to specific production periods or teams. The ability to **review historical data** also proves invaluable when investigating **customer feedback or complaints**, enabling manufacturers to trace issues with precision and accountability.

The software further allows users to **create custom tags** tailored to their factory's unique requirements—whether that's specific coating types, line identifiers, or job references—ensuring that data remains organized and relevant. All critical information is **comprehensively recorded and tracked**, giving teams immediate access to insights that were once buried in paper logs or spreadsheets.

With every key function—from data capture to visualization—built directly into the platform, Innolytix provides a **complete, user-friendly solution** for coating process control. By turning raw measurements into actionable knowledge, it empowers canmakers to enhance consistency, minimize waste, and maintain the highest standards of quality assurance.

Building on its analytical capabilities, **Innolytix** also provides a detailed visual representation of coating data across every measured point on the sheet. This expanded view displays key statistical indicators—**mean**, **standard deviation**, **minimum**, and **maximum** values—allowing engineers to assess process consistency and performance at a glance.

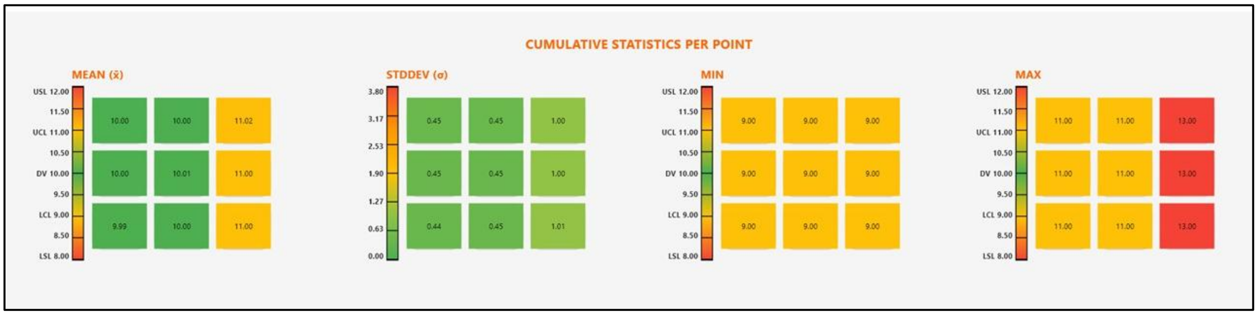


Image 11: Visual Representation of the 9-point Grid Measured in a Flat Sheet

Each parameter is **color-coded** for quick and intuitive interpretation. With this feature, users can instantly identify coating areas that are stable, variable, or trending toward specification limits. This makes it easier to spot irregularities, confirm process balance, and ensure coating uniformity across every batch.

By transforming complex measurements into a clear, color-based visualization, **Innolytix** turns data into an accessible, practical tool for continuous process improvement.

Among the many visualization tools in **Innolytix**, two metrics stand out as the most critical for process control: the **mean** and the **standard deviation**. Together, these values provide a powerful snapshot of coating performance—showing not only the average coating thickness but also how consistent it is across production.

What sets Innolytix apart is the way it presents this information. The software translates complex coating data into an intuitive, visual format that enables users to instantly understand and act on trends. With this level of clarity, manufacturers can bring their coating processes under control faster, maintain consistency across batches, and make data-driven improvements with confidence.

Innolytix can also generate a **Bell Curve,** which can help visualize and compare your measurement against the control limits.

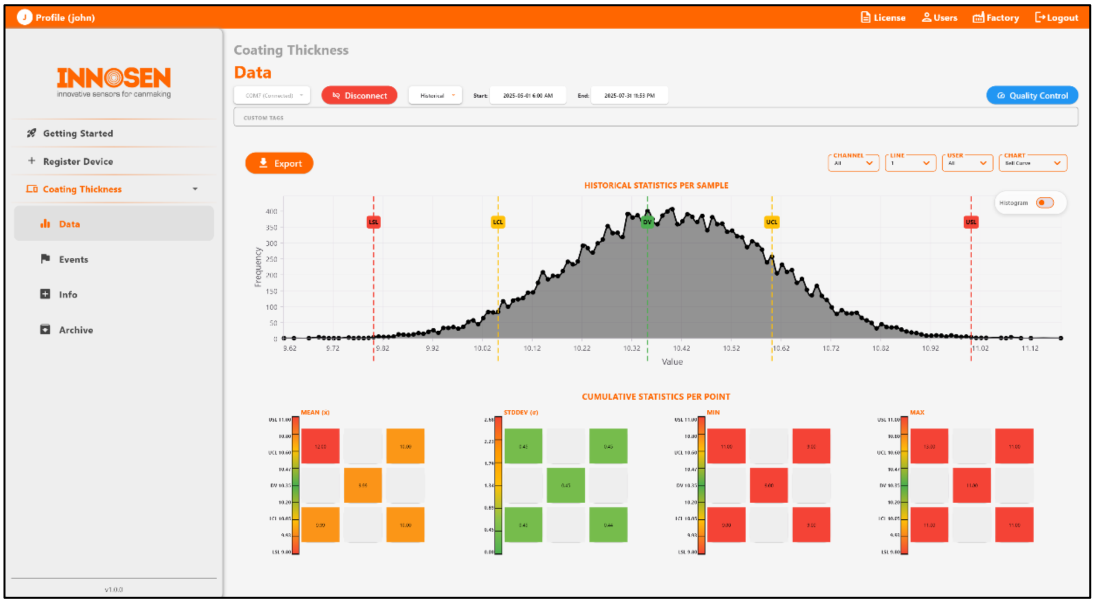


Image 12: Bell Curve with Control Limits in Historical Data for Coating Thickness

It can generate a **box-and-whisker plot** to see if there are **outliers** and show how big they are. It is typically a **comprehensive SPC (Statistical Process Control) program**.

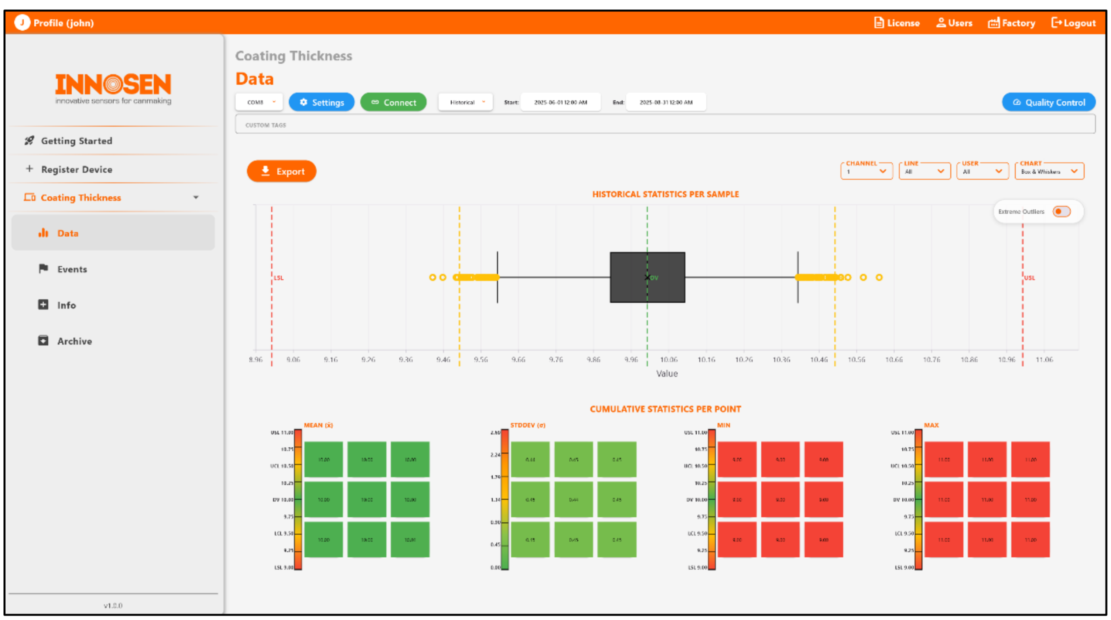


Image 13: Box and Whiskers Used to See the Outliers in the Measurement

XI. CONCLUSION

Effective coating control begins with **reliable measurement equipment** and a **robust process monitoring system**. To achieve consistent quality, manufacturers must ensure that their measurement tools deliver **high repeatability and reproducibility (R&R)**—a critical factor for making accurate, data-driven adjustments.

Ideally, coating thickness should be measured at **multiple points across each sheet**, rather than just on the left and right sides. Limiting measurement to two edges can overlook key variations in coating distribution, leading to inaccurate conclusions about process performance.

While **non-contact systems** are capable of multi-point measurement, they are often not optimized for that purpose. In contrast, **capacitive systems**—known for their strong R&R performance and cost efficiency—are particularly wellsuited for detailed, point-by-point coating analysis.

When combined, **Innosen's Hoverprobe™ II** and **Innolytix™ software** form a powerful solution for comprehensive process control. Together, they enable canmakers to capture accurate data, visualize results intuitively, and make timely adjustments that enhance coating consistency, reduce waste, and ensure every can meets the highest quality standards.