

Fischerscope

THE HELMUT FISCHER CUSTOMER MAGAZINE OF MEASUREMENT TECHNOLOGY

**GETTING READY FOR THE FUTURE
FROM FACTORY TO MODERN
PRODUCTION PLANT**



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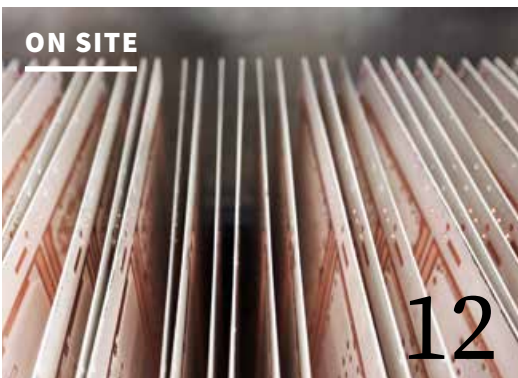
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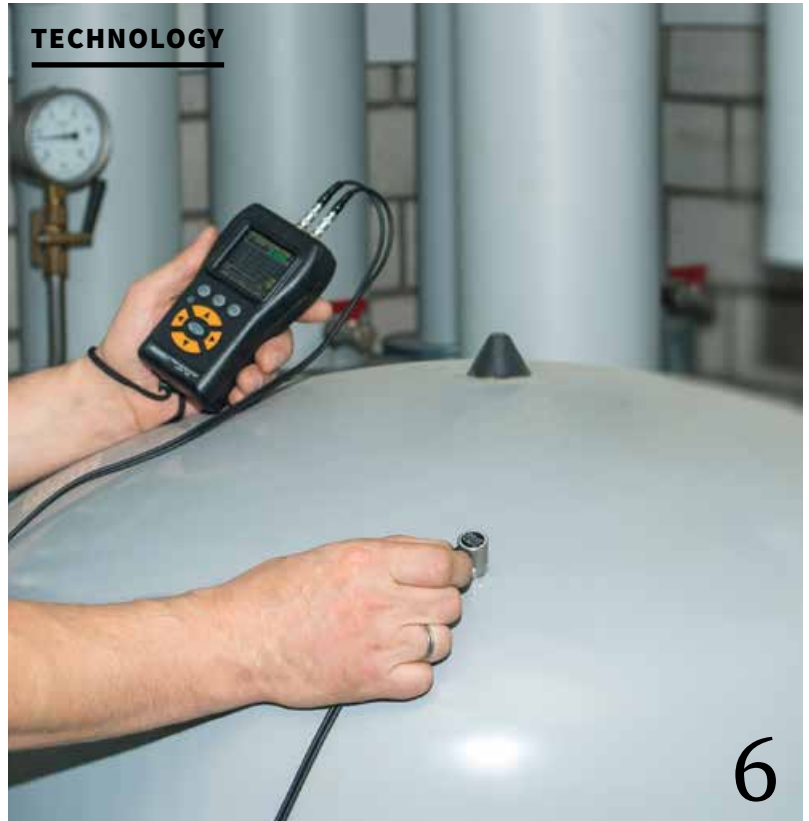
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Editorial staff

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DEAR READER,

In 1953 – at just 22 years old – Helmut Fischer opened his first business in Stuttgart, launching a career as pioneer and trailblazer in the field of measurement technology. In his small workshop, he built highly sensitive measurement instruments by hand. 60 years and a long string of patents later, Fischer has set many milestones in the field of measurement technology and material analysis. What was once a two-man operation is now a global player with over 600 employees worldwide.

Today, the Fischer headquarters are located in Sindelfingen. As an organization certified according to ISO 9001:2015, we attach great importance to our process-oriented company structure. In order to turn a factory into a modern production plant, we've realigned our processes around the principles of lean management. This enables the quick turnaround of individual customer requirements. I invite you to take a look behind the scenes on page 16.

Helmut Fischer's goal was and still is, to create sustainable added value for our customers. That's why Fischer solutions are always the result of close collaboration between the company and its customers – across industries and across the globe. A good example of this are the special devices we have for the electronics industry. You'll find a case study from Graphic Plc on page 12.

I hope you enjoy reading the new Fischerscope!

A handwritten signature in blue ink that reads "Wolfgang Babel". The signature is fluid and cursive, with the first name "Wolfgang" written in a larger, more prominent script than the last name "Babel".

Dr. Wolfgang Babel
CEO / Managing Director

Measure according to standards

If they're going to serve the general public, standards must be based on proven results from science and technology. That's why Fischer also contributes its expertise in metrology to a host of standardization bodies.

In November 2017, Fischer collaborated in publication of the DIN 50994 standard, which, for the first time, regulates the use of the phase-sensitive eddy current method to measure the conductivity of metallic layers non-destructively. In addition to the methodology thereof, the standard also describes typical fields of application.

Conductivity is more than just an electrical property of a given material: It provides information about a substance's hardness, the structural stability of alloys and layer stresses. Even heat damage and material fatigue can be determined via this method.

The Fischer SIGMASCOPE® SMP350 can be used for all these diverse applications. With the three probes of the FS40 series, you can always measure in compliance with standards, despite different penetration depths and sample geometries.

Currently, DIN 50994 is only obligatory in Germany. However, since there is no international counterpart, it's being tested by the International Organization for Standardization as an ISO standard.



Coating thickness measurement? There's an app for that

The pen-like PHASCOPE® PAINT is Fischer's newest mobile measurement instrument. This handy device is designed for fast and easy coating thickness measurement. Thanks to the very large measuring range up to 3000 μm , it is particularly well-suited for very thick coatings. Additionally, it takes advantage of the computing power already in your pocket: the readings are analyzed and reported using a simple app for smartphone or tablet.

Application in the field requires flexibility, as many different coatings need to be tested. That's why the PHASCOPE PAINT relies on the versatile eddy current method. For example, paint coatings can be measured on magnetizable substrates such as steel or iron, as well as on non-magnetic metals such as aluminum – without the need to switch the device or the probe.

When testing on samples of different aluminum alloys, the different conductivities of the metal can have an effect on the measurement of the coating thickness. That's why the PHASCOPE PAINT has a conductivity compensation feature, which ensures accurate measurement results.

This versatility allows for a wide variety of applications, from the automotive industry to heavy corrosion protection.

Dynamic mode – the flexible side of nanoindentation

In material testing, the dynamic method has increasingly come to complement classic nanoindentation. Analogous to dynamic-mechanical analysis (DMA), it allows investigation of the visco-elastic properties of substances and depth-dependent determination of their modulus of indentation.

With the new HT measuring heads for Fischer's nanoindentation systems, properties such as the elastic modulus and the storage and loss moduli can be determined quickly and easily. While DMA focuses on solid materials testing, Fischer's dynamic mode also allows for the characterization of materials on much smaller scales, e.g. coatings like car paints. To accomplish this, an indenter is pressed into the surface with sinusoidally increasing and decreasing force – all with an amplitude of just a few nanometers.

Another field of application for Fischer's dynamic mode is the characterization of polymers at different temperatures. To this end, the automated HM500 and HM2000 systems can be further equipped with the SHS200 heating table, which – using sensors both in the table and directly on the sample – always ensures the right measuring conditions.



TECHNOLOGY



Ultrasound – reveals what's hidden

Metal frameworks form the backbone of our modern cities. Metal sub-structures hold houses and skyscrapers together. Steel-and-concrete bridges connect metropolises. And metal aqueducts and pipelines are like the blood vessels of this giant organism. If any of these parts fail, it puts the whole system at risk.

In order for these vital "organs" to continue to serve reliably for decades and to withstand the seasons, they must be maintained and regularly checked. Fields as diverse as medicine and heavy corrosion protection rely on the same gentle method: ultrasonic testing.



A wide span of applications ...

Ultrasound refers to acoustic waves with frequencies between 20 kHz and 1 GHz, which puts it above the range that humans can hear. Ultrasound was used technically for the first time over 100 years ago: Shortly after the sinking of the Titanic, attempts were made to use it for locating icebergs. Today, the ultrasound method has conquered a wide range of industries, from medical imaging to non-destructive materials testing.

How well the waves propagate in a medium depends primarily on the nature of the material: The stiffer the substance – that is, the higher the impedance –, the faster the wave propagates. For this reason, air and other gases transmit sound far less effectively than a solid matter like steel.

It is precisely these differences that form the basis for Fischer's UMP series, which measures wall thickness non-destructively. At the transitions between materials, for example between the steel wall of a tank and the liquid inside, the impedance changes. This leads to the ultrasound being partially reflected at this interface – an echo. Using the speed of sound in the material, the UMP calculates the wall thickness based on the time elapsed between the emission of the signal and the return of its echo.

In addition to impedance, there are several other factors that affect the propagation of sound: temperature, for example. A deviation of just a few degrees can already distort the

measurement result. Therefore, the device must always be calibrated under actual measuring conditions.

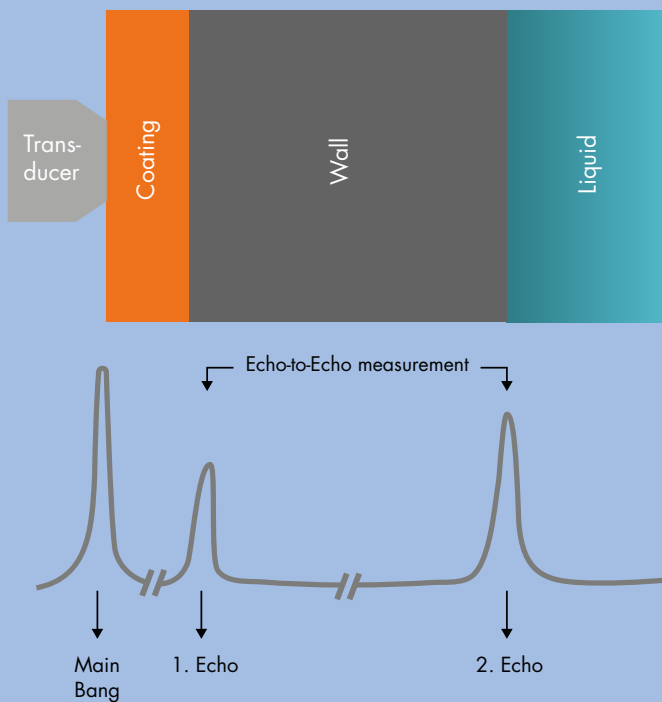
... from light bulbs ...

Ultrasonic testing is very flexible: From ultra-fine measurements on glass to analyzing heavily corroded steel tanks, a wide variety of applications are possible. In order to meet the many requirements, the units of the UMP series use two fundamentally different types of transducers: single- and dual-element.

The UMP 150 uses single-element transducers. Here, the piezoelectric element that generates the ultrasonic pulse is simultaneously the receiver of the echo. This allows for very fine thickness determination with a resolution of just 1 micron (0.0001 "). These devices are most frequently used in quality assurance, in production or in incoming goods inspection. For example, in automotive manufacturing, the engine blocks can be inspected ultrasonically. Especially in applications such as cylinder walls, where a precise wall thickness is critical for part fit.

But with the UMP 150, one can test not only metals but nearly any kind of processed solid, including plastic and glass. For very thin samples, such as light bulbs, the interval between signal and echo is very short. However, the probe needs some time to "recover" after transmitting the signal before it





The A-Scan displays all returning echoes. Selecting empty times (blank) allows the irrelevant echoes to be filtered out

Echo-to-echo measurement

Some applications, such as painted steel structures or tanks, require that one ignore surface coatings when determining the thickness of a metal wall. Since the speed of sound in paint is much slower than it is in steel, even a relatively thin layer can seriously distort the measurement result.

To measure only the thickness of the metal and ignore the finish, the units of the UMP series are equipped with an echo-to-echo mode. As with classical thickness measurement, the transducer emits an ultrasonic pulse that is reflected – but in this case, multiple times. The first echo arises at the transition between the paint and the metal. The second echo is then generated at the interface between the back of the metal wall and whatever lies behind it. In echo-to-echo mode, the UMP registers both reflections so it can subtract the thickness of the coating from the overall thickness.

can "hear" the echo. In such cases, one can use a delay line. This attachment increases the physical distance between the piezo element and the sample, which delays the echo just long enough that the probe is ready to receive it by the time it comes back.

... to shipping containers

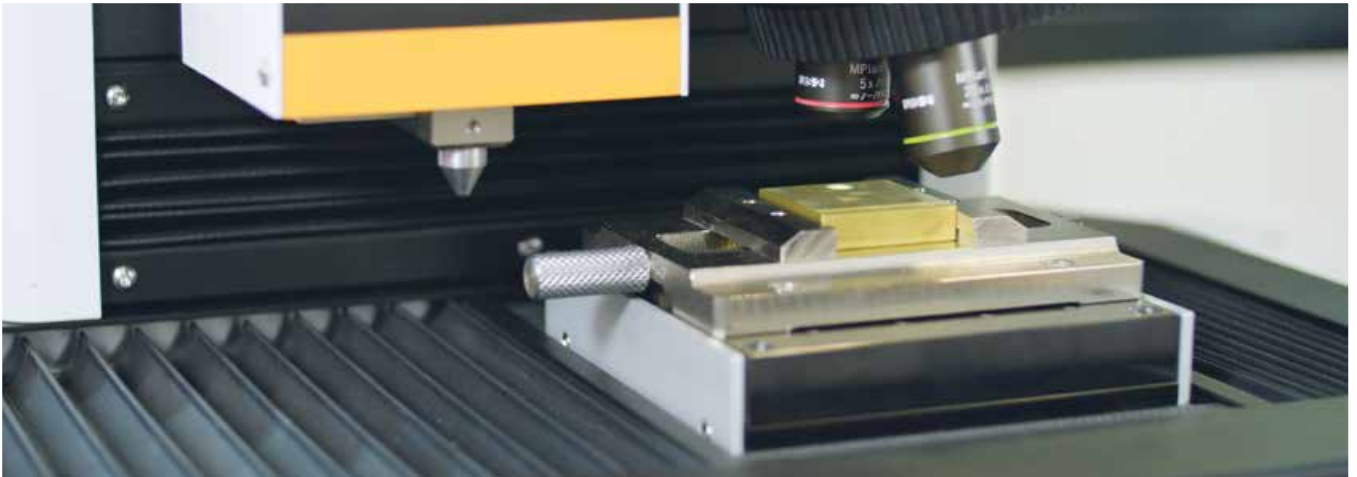
The single-element transducers need smooth, parallel surfaces in order to measure accurately. When the back wall is uneven, the sound waves that arrive vertically are scattered in all directions, making for a noisy signal. This happens especially when the inner walls of tanks and pipes are corroded. To address this problem, Fischer recommends and offers dual-element transducers for rough surfaces.

On a dual-element transducer, there are two piezo elements. The transmitter and the receiver are tilted towards each other, forming an angle to the test surface. Due to the inclination of the transmitter, the sound waves tend to be concentrated and are therefore better reflected back to the receiver.

Such transducers are used by the UMP series 20 to 100, which was designed especially for testing corrosion protection. These units make it possible to determine the thickness of just the walls – even on severely pitted, rusty and uneven surfaces – and to ensure that steel girders, bridges, tanks and pipelines have not lost any of their stability.

Always the right choice

Besides these examples, the UMP series offers the right solution for many applications, as well as for every budget. The smallest full-featured device on the market, it is still extremely easy to use. Intuitive menu guidance and acoustic alarms make it easy even for non-technical personnel to get the right results. And if your measurement tasks change over time, you can easily upgrade the instruments. Many software options and measurement modes can be activated directly via the device's keyboard. Thus, Fischer's UMP series gauges offer all the professional powerful thickness measurement capabilities in an easy to use, compact package.



Scratches, cracks, chips

Hard material coatings in a scratch test

[B]uy cheap, buy twice: that's especially true for tools. With a cheap drill bit, the tip can be completely worn out after drilling just a few holes. To prevent this, high-quality, professional-grade cutting tools are coated with hard materials. Checking such coatings is a job for the scratch tester.

Whether the functional coating on a drill bit lasts a long time or a gold-plated watch is still shiny years later, depends on the adhesive and cohesive properties of the coating. For example, if a paint wears off, the problem may be with the coating material itself. Cracks and damage frequently occurs at the interface between the coating and the base materials.

The scratch test is a widely used method of simulating in a laboratory, the stresses that a coating undergoes in everyday use. A diamond indenter with a rounded tip (Rockwell) is pulled across the sample at a constant speed. The resulting scratch on the surface provides information about how the coating will behave in real life.

Testing various substances

The FISCHERSCOPE® ST 200 is the first scratch tester from Fischer. The instrument offers several different measurement modes. This allows the test force that the indenter exerts on the surface to remain constant or to be increased.

A scratch test applied with constant force is typically used to determine the scratch hardness or scratch resistance. More often, the progressive mode is employed. In this case, the force acting on the surface is increased either incrementally or linearly.

Starting out with an initially very low load, the indenter is moved across the coating. As the force increases, it gradually penetrates into the layer. As the penetration depth increases, so does the material stress, until a certain force – the critical load L_c – is reached, which is the force that causes material failure: Cracks form and the coating chips off.

For the test to be meaningful, the load must be chosen correctly: If too low, the coating is hardly stressed at all; but at very high loads, the indenter can penetrate through to the substrate and be damaged.

With hard material layers such as titanium nitride or diamond like carbon (DLC), test loads higher than 30 – 50 N are often necessary to trigger large-scale chips. Softer materials like paints, on the other hand, require low test forces, since the coating usually fails much sooner.

To cope with such diverse coatings, the ST 200 offers a wide range of possible test loads: from 0.1 to 200 N. That makes it ideally suited for measurements on hard coatings, while still allowing for the testing of thicker paint layers.

Evaluation: a trained eye needed

The scratch test is a comparative procedure that relies on reference measurements. Initial evaluations are always performed visually. Under a high-resolution microscope, the examiner determines at which force the first cracks formed, or when the coating chipped off.

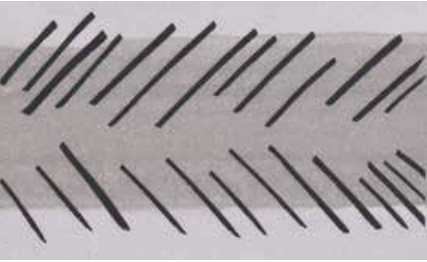


In addition to the microscopic evaluation, the ST 200 can also record acoustic emissions, i.e. the scratching noise, as well as the tangential force, i.e. the resistance that the material exerts against the indenter. Did the scratching get louder? Or did the diamond tip suddenly start dragging through the coating? Both are signs of material failure.

The intuitive user interface of the WinSCU software summarizes all three parameters in a single evaluation step: the microscopic image, the acoustic signal and the change in tangential force. The critical loads are thus defined in just a few mouse clicks.

More scratch testers planned

The ST 200 rounds out our portfolio for the tools industry. Together with our nanoindentation systems and the X-ray fluorescence instrument XDAL, Fischer offers a total quality assurance solution for TiN and DLC coatings.

For measurements on soft materials like polymers and plastics, another scratch tester is already in development. The FISCHERSCOPE ST 30 will be presented in the middle of this year!

DLC	TiN	Car paint
		
<p>Typical layer thickness: 1 – 5 µm on steel, other metals and semiconductors</p>	<p>Typical layer thickness: 1 – 5 µm on various kinds of steel</p>	<p>Typical layer thickness: 50 µm, with several superimposed layers of paint on fillers and autobody</p>
<p>L_{Ci}: First cracks usually occur at forces between 10 and 15 N</p>	<p>L_{Ci}: First cracks usually occur at forces around 8 N</p>	<p>L_{Ci}: First cracks usually occur at forces between 5 and 10 N</p>
<p>Frequent patterns of damage: The cracks develop at the edge of the scratch track and point mostly inwards</p>	<p>Frequent patterns of damage: The cracks develop at the edge of the scratch track and point mostly outwards</p>	<p>Frequent patterns of damage: The cracks run along the scratch track and are shaped like a pine tree.</p>

ON SITE





Circuit boards – printed progress

[C]omputers with more processing power than those used for the mission to the moon – back then, behemoths that filled multiple rooms – now fit neatly into your pocket: today's smartphones. However, the science of miniaturization is nearly as old as the field of electronics itself. And in no small way, it owes its success to the availability of ever-shrinking circuit boards.

One of the oldest and still active PCB manufacturers in the world is Graphic Plc. The company was founded by Rex Rozario, a protégé of Paul Eisler, the inventor of the circuit board. Over the past 50 years, Graphic Plc has witnessed – and helped shape – the industry's evolution from the early single-sided PCBs to today's high-density interconnect technology: the ultra-compact PCB.

These multilayer PCBs from Devon, in southern England, are at work today controlling power plants, saving lives in medical equipment and connecting millions of people around the world via satellites. Graphic Plc has made a name for itself producing such mission-critical circuit

boards, and its customers are mostly high-end users. One industry particularly dependent on highly reliable electronics is aviation, which is why several major aircraft manufacturers are supplied by Graphic Plc.

If it happens mid-flight, a fault in the electronics can cost lives. For this reason, high-end PCBs require high-end coatings. Here, Graphic Plc relies on the ENIG process (Electroless Nickel Immersion Gold), in which the copper conductor paths are chemically plated with a 3–6 µm thick layer of nickel; on top of that, a 50–100 nm coating of gold is deposited through an immersion process. PCBs coated in this way have excellent conductive properties and long shelf lives before assembly.

Even better results are achieved with an intermediate layer of palladium between the nickel and the gold: ENEPIG (Electroless Nickel Electroless Palladium Immersion Gold). This advanced finish produces a contact surface ideally suited for high-reliability gold and aluminum wire bonds.

The changing face of quality assurance

To guarantee reliable solder joints and to insure good storage properties, the thicknesses of the different material layers must be perfectly coordinated. Graphic Plc is a well-known manufacturer of mission-critical PCBs. That means the quality expectations are correspondingly high. "Fischer supplies measuring technology with the precision we need to guarantee that our products are of the finest quality," says Paul Comer, Technical Director at Graphic Plc.

Graphic Plc also values the reliability of Fischer instruments. For the past 20 years, there has been an XDL® system in use at the company headquarters in Devon. And with good maintenance, it would have continued to provide excellent service in quality assurance. But now the norms have changed.

The high-end users not only need very reliable PCBs but also very homogeneous ones. In order to for all subsequent steps to run as smoothly as possible, the printed circuit boards should be as similar as possible. That's why in 2017 the new IPC standard 4552 regulated the ENIG process very strictly: The gold layer may only be between 40 and 100 nm thick.

Only under such strict conditions does it become clear how important powerful measuring technology is.

To ensure that the specified norm limits of 40 and 100 nm are met at all times, the coating process aims at even narrower limits, e.g. 55 and 85 nm. The width of this "safety distance" depends on how consistent the coating process is. The more the coating thickness varies, the larger the safety distance must be to ensure, that the norm specifications are observed. As a rule, a distance of 3 standard deviations is selected.

However, the measured standard deviation does not only depend on the coating process itself – the measurement technology plays a critical role as well. If a device is not sufficiently precise, the standard deviation will be high even with a very consistent coating process.

For this reason, the new norm makes it necessary to monitor the quality of printed circuit boards with X-ray fluorescence

“ At Fischer, the customer relationship doesn't end with the sale of an instrument – that's only when it begins! ”

Paul Comer, Technical Director at Graphic Plc



devices with semiconductor detectors such as the silicon drift detector (SDD). The previously-common proportional counter tubes are no longer accurate enough for monitoring this strictly regulated coating process.

Tailored to the industry

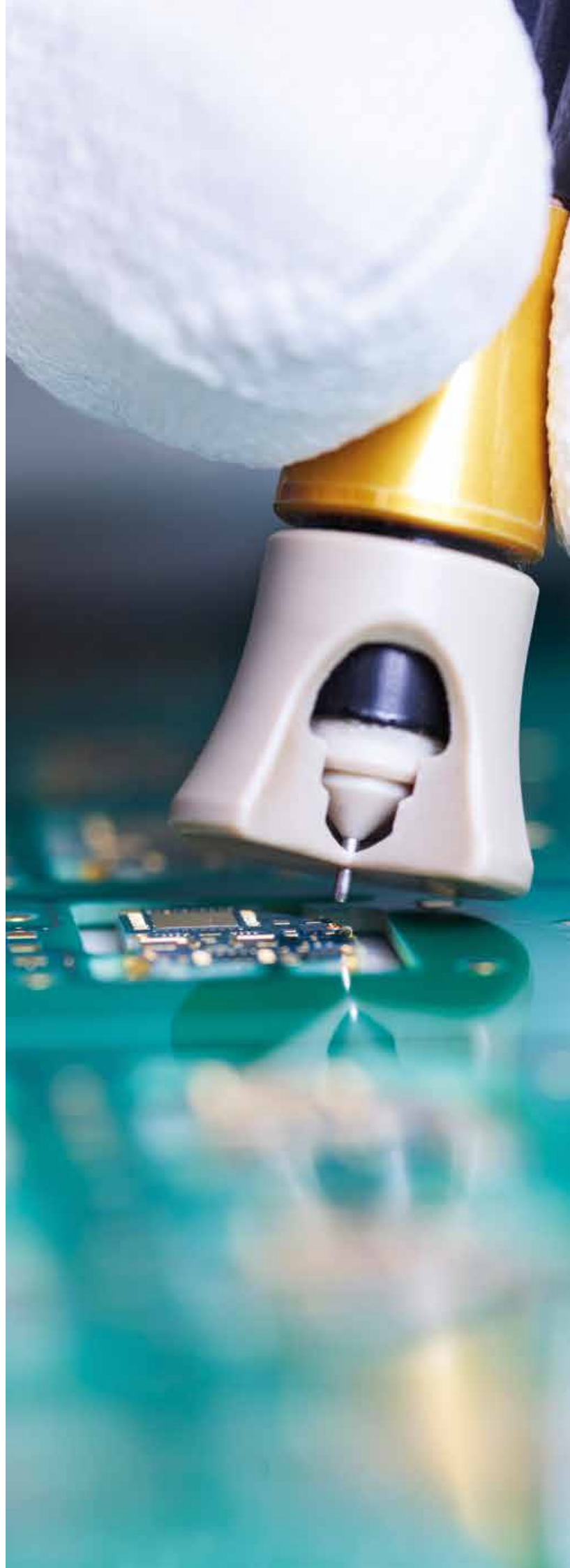
Mindful of this update to the standard, Fischer developed its newest X-ray fluorescence device, the XDAL® 237 SDD, which was launched in late 2016. This SDD version of the tried-and-true instrument makes handling large and flexible circuit boards both simple and easy, and it allows for the analysis of layers just 100 nm thick.

One of the first devices of the new series was put into operation by Graphic Plc in December 2016. Before delivery, the system was pre-set and customized. Thanks to Fischer's long experience with Graphic's applications and products, it was an immediate match. "This tailor-made instrument fits perfectly into our quality assurance process and helps us to optimize our production," explains Paul Comer.

But although the implementation is complete, Graphic Plc and Fischer are still working closely together. Paul Cave, Senior Application Manager at Fischer, continues to support Graphic Plc with their measurement tasks. The common goal is to keep pace with the changing requirements for the future.



In addition to its X-ray devices, Fischer also offers other special instruments for the printed circuit board industry. The various layers of multilayer PCBs are connected via through-holes. Here, Graphic Plc uses the PHASCOPE® to test the coating.



From factory to modern production plant

Fischer is readying itself for the future

[B]ut we've always done it that way!" Doesn't it just make you want to roll your eyes? Yes, tradition is important. But in a changing world, it can become a problem if one doesn't question existing methods from time to time. That's why Fischer is retooling its manufacturing processes and outfitting itself for the decades to come.

The numbers look good, the course is set for growth – and Fischer is expanding its production capacity. This is why the past year was all about transformation.

As a classic manufacturer, Fischer made instruments according to the “push” principle. Devices were built, put into stock and sold off successively. The result: changeable delivery times and large stocks. Since 2017, however, the “pull” principle rules: Devices and components are made to order. Goods flow is now controlled by a Kanban system. If parts start running out somewhere, empty containers move to the upstream department to initiate a re-stocking.

To facilitate the work, we've also optimized the workspaces. In a “cardboard-box” workshop, employees have tables and shelves redesigned according to 5S rules to ensure optimal working conditions.

8 months

Whether for X-ray fluorescence, nanoindentation or electromagnetic devices, there was room for improvement in all the production lines. One of the first projects that Fischer tackled was manufacturing of the probe system carriers.

The system carrier is the place where the electronic heart of the probe and the mechanical tip come together. To achieve the best results, the tip is crafted – in a series of over 20 consecutive work-steps – out of PERMENORM and carbide.

Previously, the various operations were performed in separate workshops: Annealing in the hardening shop, cleaning in the washing room, and then the parts were sent out for polishing. This resulted in long distances and many handovers of responsibility. Some departments didn't really understand all the dependencies of the next step.

And the different stations also processed other orders. In the end, every step contributed to the delays: here a few days, there a week. Overall, more than 100 days of inactivity. It often took as many as 250 days to finish a batch of system carriers – over 8 months!

The Heijunka board helps to keep track of all current orders and to plan the resources. Red cards indicate which tasks are in the queue, the green ones are for tasks already in process.

20 days

It just had to go faster! So, Fischer undertook some changes and established a cell manufacturing practice: all previously disjoint operations were united in one room and under the management of Andreas Rauthe.

The risk was that some processes could interfere with others. For example, the annealing furnace and the washing machine generate heat and steam, which makes a delicate job like soldering in the immediate vicinity nearly impossible. But with powerful ventilation, a good working climate was created nonetheless.

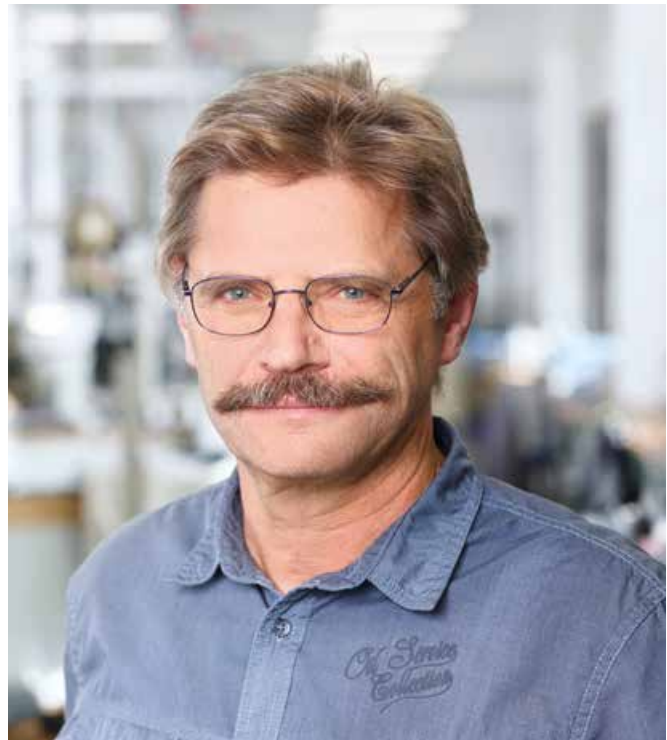
And the external supplier also plays a major role in the timeline. That's why a firm delivery schedule was agreed upon. So, instead of on an as-needed basis like before, Fischer now sends small batches at regular intervals – and gets them back within a week. That's six times faster! For everyone, it means more planning security.

The investment in the remodeling is already paying off: There are no more idle times, and management has a complete overview. Today, 6 months after the project began, it only takes 20 days to manufacture a probe tip – an improvement of some 90%.

THE 5S RULES

The 5S rules are a lean management tool for creating safe and easy-to-understand workspaces.

- Seiri:** Sort out everything that isn't immediately needed
- Seiton:** Set everything neatly into its marked and pre-defined place
- Seiso:** Shine up your work area and utensils, check them for deficits
- Seiketsu:** Standardize processes and utilize consistent identifiers
- Shitsuke:** Strive for self-discipline and continuous improvement (Kaizen)



Andreas Rauthe, Head of the cell manufacturing at Fischer

“ Changing old thought patterns and completely rebuilding the production – that was a team effort. ”

15 projects

To date, Fischer has implemented 15 such optimization projects in various departments: in production, order processing and logistics. Many more are planned for the coming year. Our ambitious goal is to optimize the entire value chain according to the methods of lean management.

An important step will be to extend the Kanban system to the rest of production and to implement a just-in-sequence strategy for incoming materials. That, in turn, will enable the quick turnaround of individual customer requirements.

When everyone pulls together, a scheduled plan works well. That's why Fischer also attaches great importance to training employees. The optimal processes are developed collaboratively in workshops where the principles of lean management are exercised.

However, lean production doesn't start with assembly, but rather at the beginning of product development. For this reason, during the development phase of a given instrument, Fischer pays close attention to how easy it is to build and maintain.

The most important statistics terminology

[N]o matter whether you're measuring layer thickness, electrical conductivity or the composition of a material – there are always fluctuations. Therefore, no single reading can fully reflect reality. It takes several measurements, which must be evaluated statistically. With Fischer devices, analyses of this kind are no problem, because the work is performed by powerful software. Here's a summary of the most important statistical parameters.

[Mean] The mean \bar{x} is an average of the different readings. The simplest way to calculate a mean is to add all the values together and then divide that sum by the number of values. This is called the arithmetic mean. There are other ways to calculate a mean, but they're seldom used.

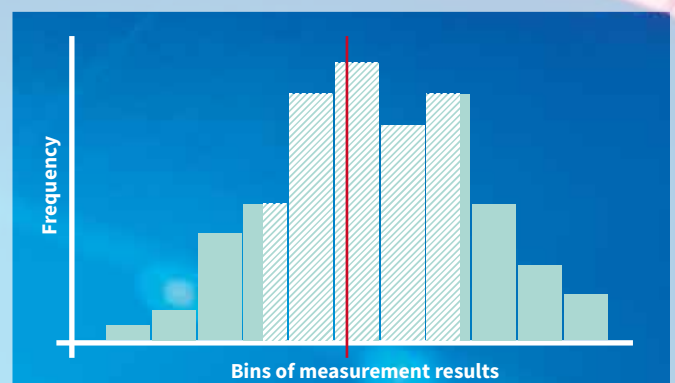
[Range] The range R shows how far apart the smallest measured value is from the largest. To calculate the range, simply subtract the lowest measured value from the largest one. The range can be greatly distorted by outliers and is therefore only useful if you have just a few readings. For larger quantities of data, the standard deviation is more meaningful.

[Standard deviation] The standard deviation σ indicates how widely scattered or clumped together the readings are around the mean. A high standard deviation indicates that the measured values differ greatly from each other. But if the values are all close to the mean, the standard deviation is small. How well the mean and the standard deviation describe the reality depends, among other things, on the number of measurements: the more measurement points, the more meaningful the metrics.

In two measurement series you get the values [1, 2, 3] and [1.5, 2, 2.5]. In both cases, the mean is 2. However, the standard deviations are different: In the first case it's 1, in the second it's 0.5. The standard deviation makes clear that the values in the second case are more similar to each other.

[Coefficient of variation] The magnitude of the standard deviation depends not only on the variance among the readings but also on the size of the values: A higher average automatically leads to a higher standard deviation. To address this problem, the relative standard deviation – that is, the coefficient of variation V – is often given as a percentage. For that, the standard deviation is divided by the arithmetic mean. As with the standard deviation, higher values indicate that the measured values are more widely scattered.

You measure a thin and a thick coating. The thin paint is uneven and has, for its average depth of 10 microns, a standard deviation of about 1 micron. That corresponds to a coefficient of variation of 10%. The thicker coating is more even and, for its depth of 100 μm , also has a standard deviation of 1 μm . But here, the coefficient of variation is 1%. In this case, the coefficient of variation expresses the differences in the coating quality much better than the standard deviation does.



A histogram shows how often certain values were measured. The red line shows the mean of the distribution, while the shaded area spans two standard deviations, i.e. about 68% of all the measured values.

EVENTS

Germany

17th – 20th April 2018

PaintExpo, Karlsruhe

International trade fair for industrial painting technology
www.paintexpo.de/en/

24th – 27th April 2018

Control, Stuttgart

International trade fair for quality assurance, coating thickness measurement, material analysis and nanoindentation
www.control-messe.de/en

India

12th August 2018

IIJS, Mumbai

International jewellery show
www.iijs.org/

USA

4th – 6th June 2018

SUR/FIN, Cleveland, OH

sShow dedicated specifically to the surface technology
<http://www.nasfsurfin.com/>

6th – 8th November 2018

FABTECH, Atlanta, GA

Event for Metal Forming, Fabricating, Welding and Finishing
www.iijs.org/

Japan

6th – 8th June 2018

JPCA, Tokyo

Total solution exhibition for electronic equipment
www.jpccashow.com/show2018/en/

5th – 7th December 2018

Metal Japan, Tokyo

Show for highly-functional metal materials, processing and analysis equipment
www.metal-japan.jp/en/Home/

China

4th – 6th December 2018

SF China, Guangzhou

A Professional Finishing Show
www.sfchina.net/

Global Sales Global Application Global Service



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