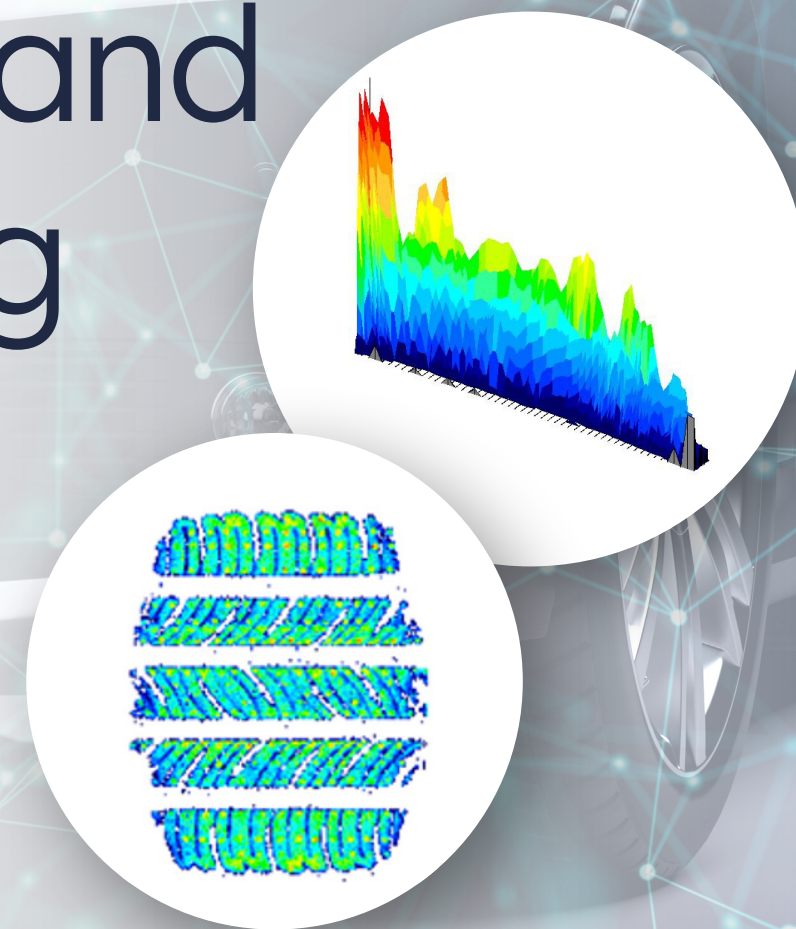




Optimize Automotive Design with Pressure and Temperature Mapping

Surface Sensing Insight Drives Better Performance, Safety, and Comfort

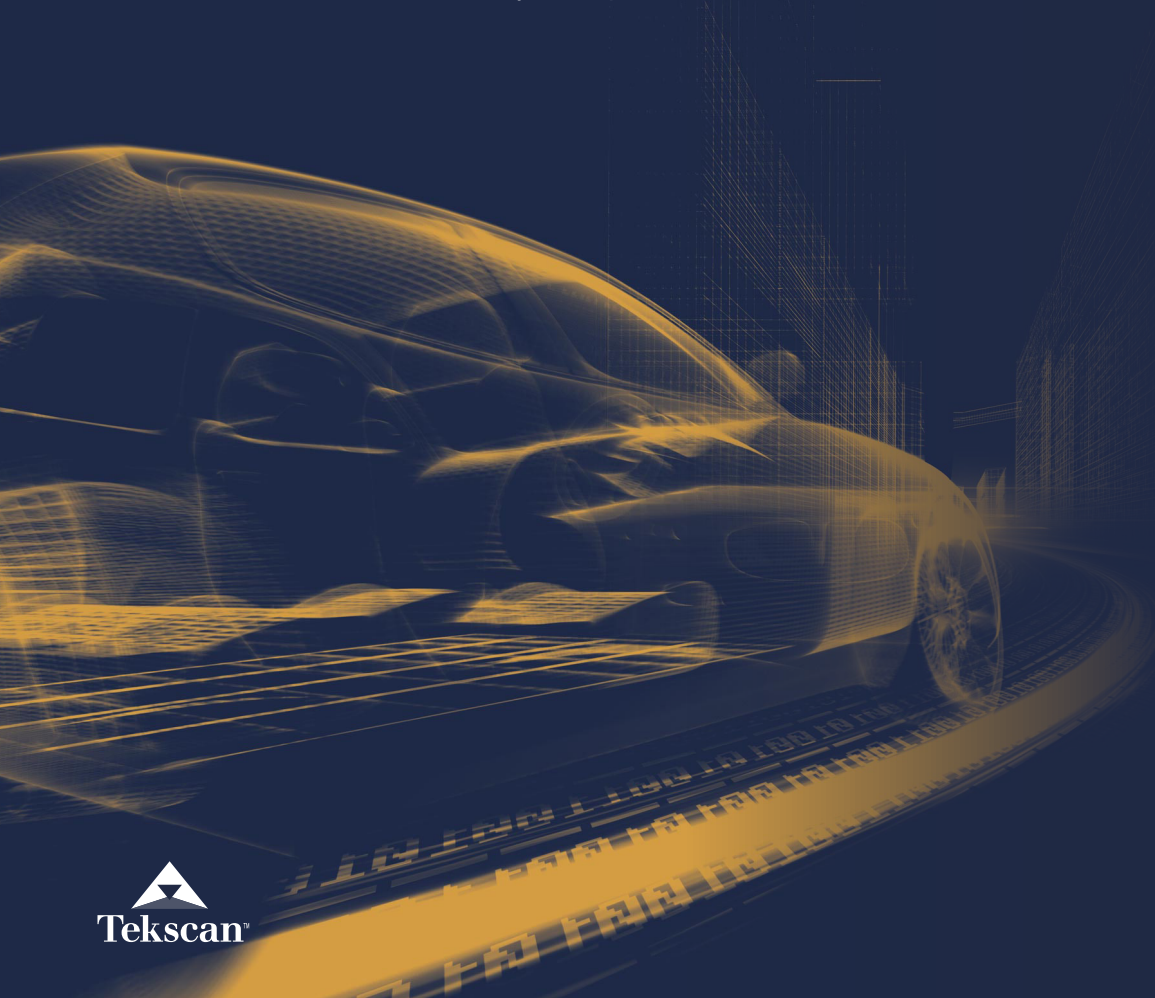


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Introduction

In a highly competitive and rapidly evolving global marketplace, automotive design engineers and researchers must relentlessly pursue enhancements in performance, quality, efficiency, and safety. A deeper understanding of contact pressure is crucial for driving these enhancements. Today, engineers are also turning to temperature mapping to visualize temperature propagation across critical contact areas. Combining pressure and temperature data enables deeper insight into material behavior, safety, and performance.



Key challenges engineers face include:

Identifying Failure Modes:	Detecting mechanical pressure concentrations, or "hot spots," which can lead to product failure.
Ensuring Proper Sealing and Fit:	Verifying the effectiveness of seals in doors, trunks, and dashboard mountings, or the precision of snap-fit designs.
Understanding Force Distribution:	Analyzing the distribution of force between two load-bearing surfaces to optimize design.
Validating Design Integrity:	Confirming the structural integrity of lighter, fuel-efficient, cost-saving components.
Optimizing Manufacturing Processes:	Refining processes to enhance efficiency, such as calibrating the alignment of nips/rollers, presses, or nozzle spray patterns.
Improving Yields and Reducing Downtime:	Enhancing production yield and minimizing operational interruptions.
Comparing Manufacturing Methods:	Evaluating products made from different materials or processes, such as robotic frame assembly, to determine the best approach.
Benchmarking Competitors:	Assessing and comparing your products against competitive offerings.

Evaluating interface pressure can offer key insights and critical data to tackle these challenges effectively.

What is Pressure Mapping?

Even between relatively flat surfaces, the interface pressure distribution is often not uniform, with localized areas of peak pressure. Pressure mapping technology provides insight into areas that may impact design and quality.

Pressure mapping systems consist of 3 components – **sensors, scanning electronics and software** – to deliver real-time, actionable data, in ways other methods cannot.

1. The sensor transforms compressive pressure loads to a change in resistance.
2. The scanning electronics collect analog data from the sensor and convert the data to a digital signal.
3. The software displays real-time activity of the sensor area, allowing the user to see force, pressure, contact area, and timing data.

Now Available:

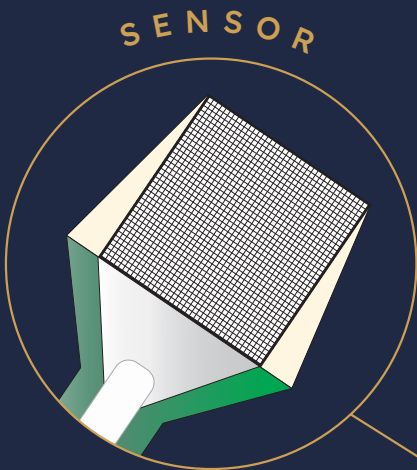
Temperature Mapping

Tekscan now offers a thin-film temperature mapping solution that integrates with I-Scan, enabling users to collect thermal data, and in some cases, thermal and pressure data simultaneously.

Explore the Possibilities



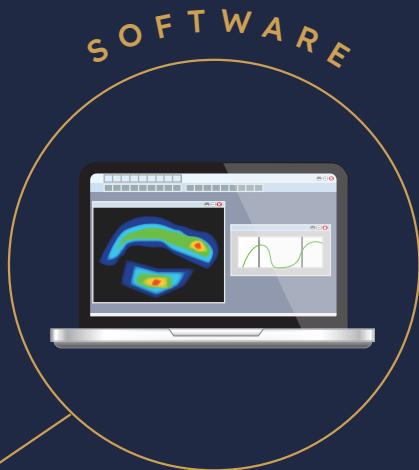
Components of a Tekscan Surface Sensing System



- Minimally invasive
- High resolution
- Thin & flexible
- Reusable
- Trimmable
- Multiple pressure ranges and form factors



- Scan thousands of sensing points within each sensor
- Instant data relay to PC via USB or WiFi



- Display data in multiple formats for superior analysis
- 2D & 3D graph display
- Capture peak pressures and center of force in real time
- Video playback

Technology Comparison

Below are technologies to consider when trying to measure force or interface pressures. While there is some overlap with the information each sensing technology provides, they each present a unique value in the problem-solving process.

White Paper

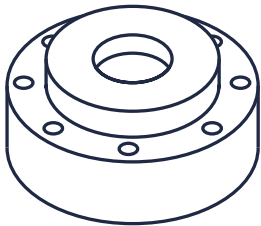
Comparison of Interface Pressure Measurement Options

Free Download →

Pressure Mapping

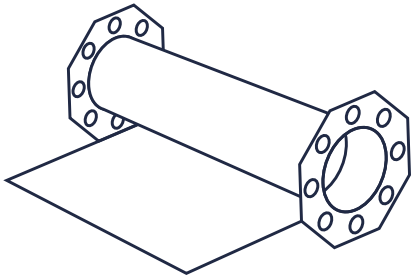
Load Cell

Reliable, but bulky and offers no data on pressure distribution



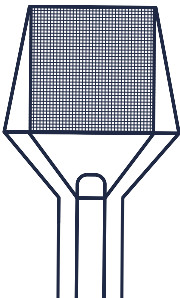
Pressure Sensitive Film

Flexible, but single use and can only measure peak pressure



Tactile Pressure Sensor

Thin, flexible, reusable sensor capturing static and dynamic pressures across a surface



Temperature Mapping

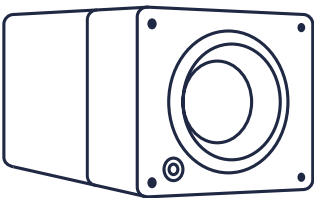
Thermocouples

Simple and widely used way to get point-specific data and requires complex wiring for multi-point or distributed sensing



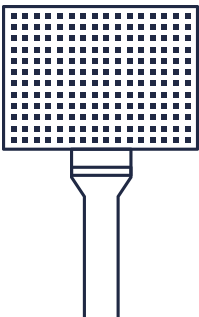
Infrared/Thermal Cameras

Non-contact, provides wide area thermal measurements quickly. Require line-of-sight, are affected by emissivity and can't measure between surfaces



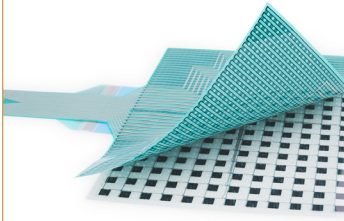
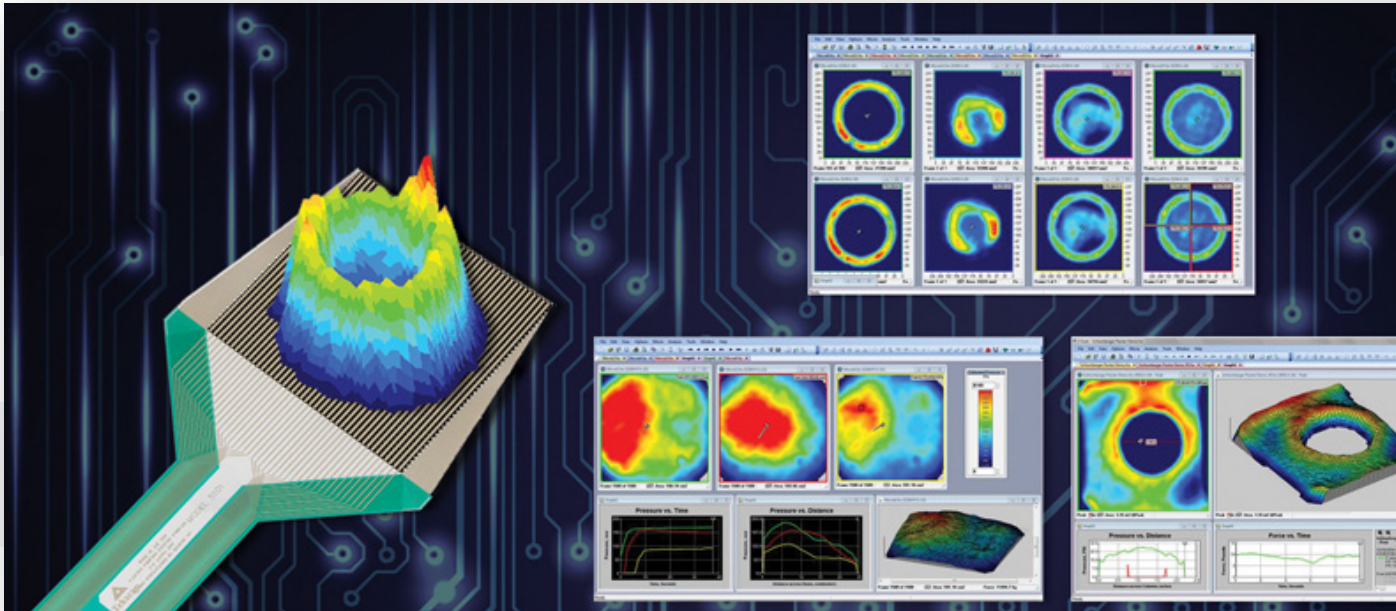
Temperature Mapping Sensor

Measures distributed surface temperature between contacting surfaces with no emissivity adjustments needed. Currently available in select configurations.



What Are the Advantages of Using a Pressure Mapping System?

Precise Pressure Distribution Visualization:	Clearly displays pressure across contact surfaces.
Real-Time Data:	Immediate feedback for on-the-fly adjustments.
Low Profile Sensors:	Thin design minimizes impact on measurements.
Multi-Application Utility:	Suitable for a wide range of surface measurements/requirements
Customizable Sensor Options:	Adapt sensors to specific dimensions, resolutions, and pressure ranges.
Software Compatibility:	Interfaces smoothly with third-party analysis tools.
Actionable Data:	Provides impactful insights to improve design, manufacturing, and quality processes.

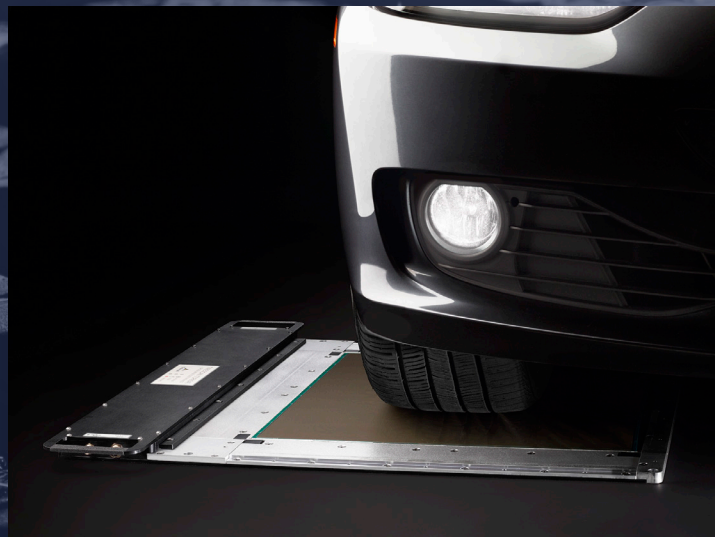


Enhancing Insight with Temperature Mapping

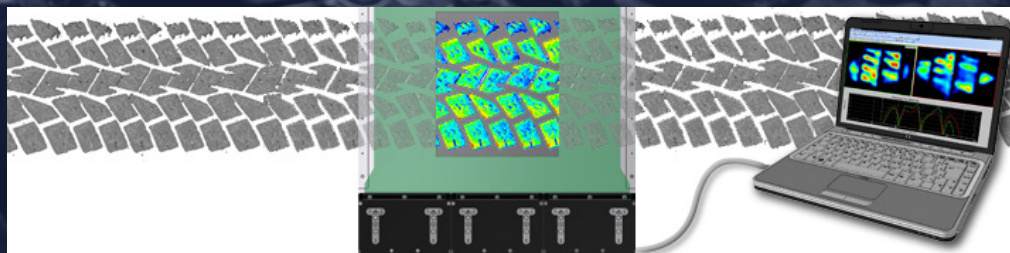
New Temperature Mapping sensor T-800 offers the ability to overlay temperature data with pressure maps, giving a complete picture of surface interactions. This is particularly important in thermally sensitive applications like fuel cell stack design and thermal management of battery enclosures

Real-World Applications: Where Pressure & Temperature Data Drive Results

The following pages highlight common automotive applications where tactile surface sensing - through pressure and temperature mapping - provides critical data. From component testing to system validation, see how engineers use this information to solve design challenges, improve performance, and accelerate development.



CrossDrive™ System



Tire Tread

Understanding tire behavior during motion is critical to designing a high-performance tire. To optimize handling and response, tire manufacturers need detailed insight into how tread patterns and compounds perform during key dynamic events - such as cornering, braking, acceleration, and deceleration. Void ratio analysis is also vital to evaluate a tread's ability to displace water and maintain grip in wet conditions.

Using a ruggedized tactile pressure sensor mounted on a steel plate - with electronics housed in metal enclosures-engineers can capture precise pressure distribution data. Measurements can be taken in both static and dynamic conditions, including camber, toe, and suspension alignment scenarios.

The point-of-contact data is analyzed using specialized software to determine perimeter area, cross-sectional pressure profile, measurement of footprint length and width, and other configurable parameters. This data supports a wide range of development and testing activities, including:

- Evaluating and comparing tread patterns and designs
- Assessing material and rubber compound performance
- Performing quality control checks
- Benchmarking competitor tires
- Studying predictive wear based on road surface
- Analyzing camber and suspension effects
- Fine-tuning race vehicle setup



Tire Footprint from Toe /
Acceleration Test

Fuel Cell Stack Assembly

Fuel cells rely on tightly stacked thin plates to manage the flow of hydrogen (or hydrocarbons) and oxygen. Uniform contact pressure between these plates is critical—not only to prevent parasitic leakage paths, but also to ensure efficient and consistent performance over time.

Both clamping pressure and clamping torque can significantly influence pressure distribution within the stack. By using tactile pressure mapping systems, engineers can visualize and quantify these effects, enabling precise optimization of clamping strategies. Real-time feedback during dynamic testing helps simplify parameter adjustments and accelerate development cycles.

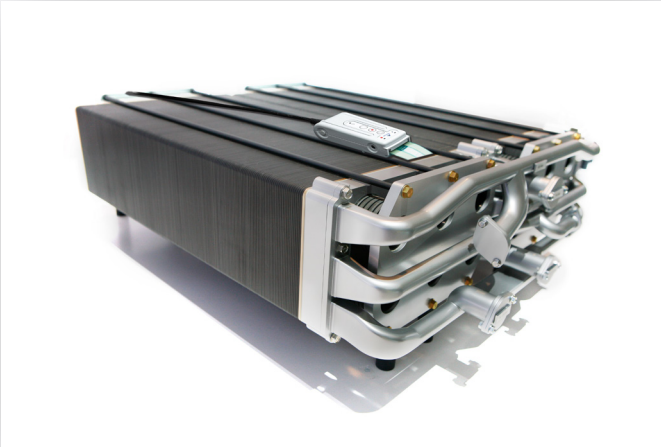
Thermal gradients are another important consideration, especially under variable operating loads. Uneven heat distribution can impact durability and overall efficiency. When combined with pressure data, temperature mapping provides a more complete understanding of contact uniformity and thermal behavior—key factors in improving performance and reducing energy losses.

In the example shown:

Figure 1 demonstrates pressure drop-off in the plate center with standard clamping.
Figure 2 illustrates a more uniform pressure profile using a reinforced clamp.

Key Benefits of Tactile Sensing in Fuel Cell Design:

- Visualize pressure and temperature distribution across the stack
- Compare assembly alternatives with measurable data
- Reduce costly design iterations and rework
- Identify and eliminate inefficiencies early in development
- Improve long-term durability and performance



Fuel Cell Stack

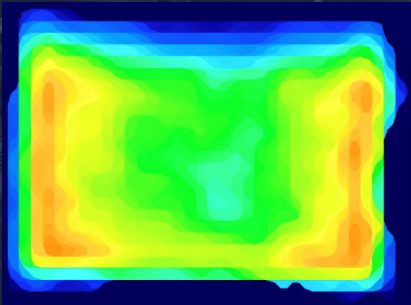


Figure 1: Standard Clamp

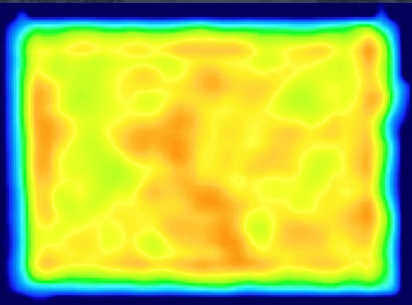
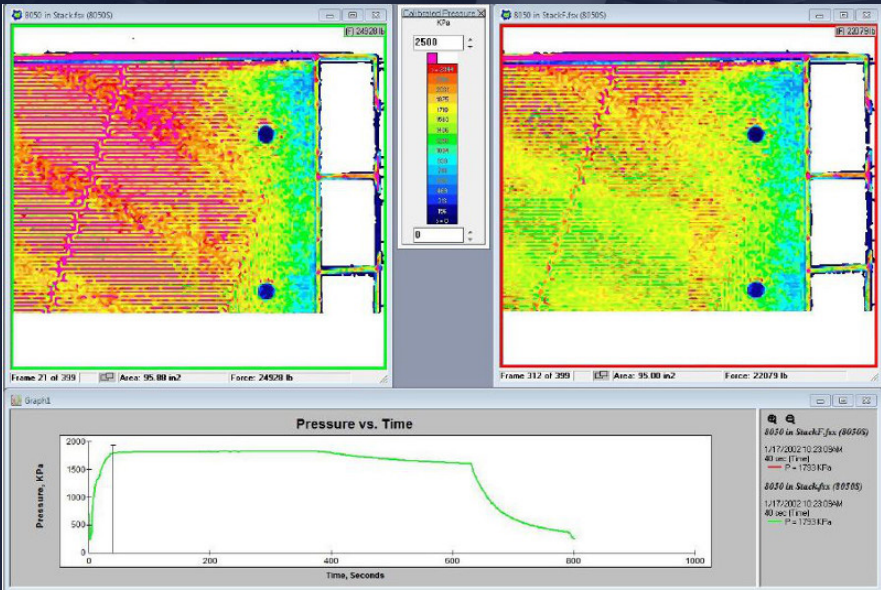


Figure 2: Reinforced Clamp



Pressure Distribution across Fuel Cell Plate.

Pressure mapping highlights how clamp design affects uniformity across the flow field. When paired with temperature data, this analysis can reveal thermal inconsistencies that impact fuel cell efficiency.

Lithium Ion Battery Design & Testing

As hybrid and electric vehicle adoption accelerates, automotive manufacturers are increasingly invested in maximizing battery life, safety, and performance. Most hybrid and electric vehicles are powered by lithium-ion batteries, which expand and contract during routine charge/discharge cycles contributing to delamination, degradation, and even thermal runaway.

Using tactile pressure sensors, engineers can capture the subtle pressure changes caused by cell expansion. Now, with the addition of temperature mapping, they can also visualize thermal propagation across the battery stack. This dual-sensing approach helps pinpoint when and where critical pressure or temperature spikes occur, enabling optimization of fixture design and stack compression strategies.

Key Benefits of Pressure & Temperature Mapping:

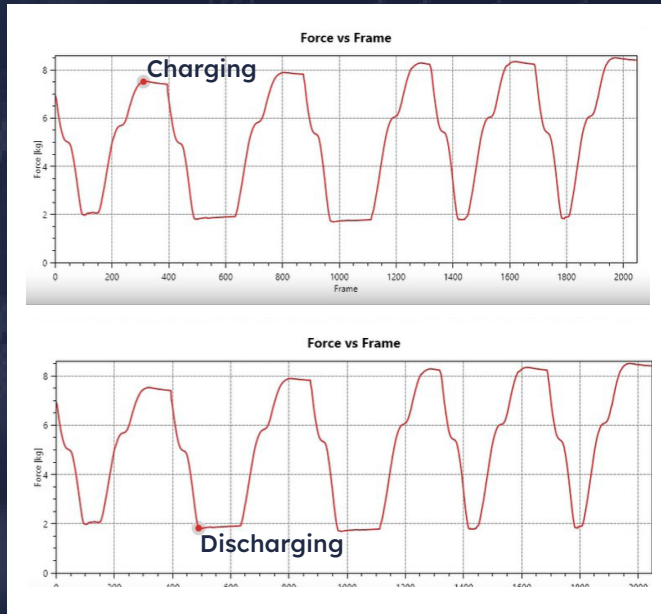
- Validate formation processes with pressure and/or temperature data
- Reduce rates of capacity fade
- Restrict thermal expansion/delamination
- Mitigate risk of thermal runaway (in extreme cases)

How does I-Scan Fit In?

The thin, conformable sensors offer the ability to capture pressure exchanges across an entire battery cell, or between cells. The technology allows engineers to:

1. Identify regions of excessive pressure, which can result in battery failure
2. Collect charge/discharge cycle data over multiple months without replacing sensor

[Click here](#) for more information about pressure mapping in battery design and manufacturing.



Pressure Distribution During Charge and Discharge Cycles

Pressure mapping reveals how cell swelling affects contact force within the stack. When combined with temperature data, this insight helps engineers visualize how heat and mechanical pressure evolve together - supporting safer, more efficient battery designs.



Did You Know?

Pressure mapping reveals how battery swelling alters internal contact forces - insight that becomes even more powerful when overlaid with temperature data to track how heat and mechanical stress interact.

Thermal Interface Optimization in EV Battery Modules

While stack compression and swelling behavior are critical in lithium-ion battery design, thermal management is also essential to maintain safe and consistent performance - especially under high loads and fast charging conditions.

EV battery modules typically rely on cooling plates, thermal interface materials (TIMs) and heat spreaders to regulate temperature. However, if surface contact is uneven, localized hotspots can form, accelerating degradation and increasing the risk of failure.

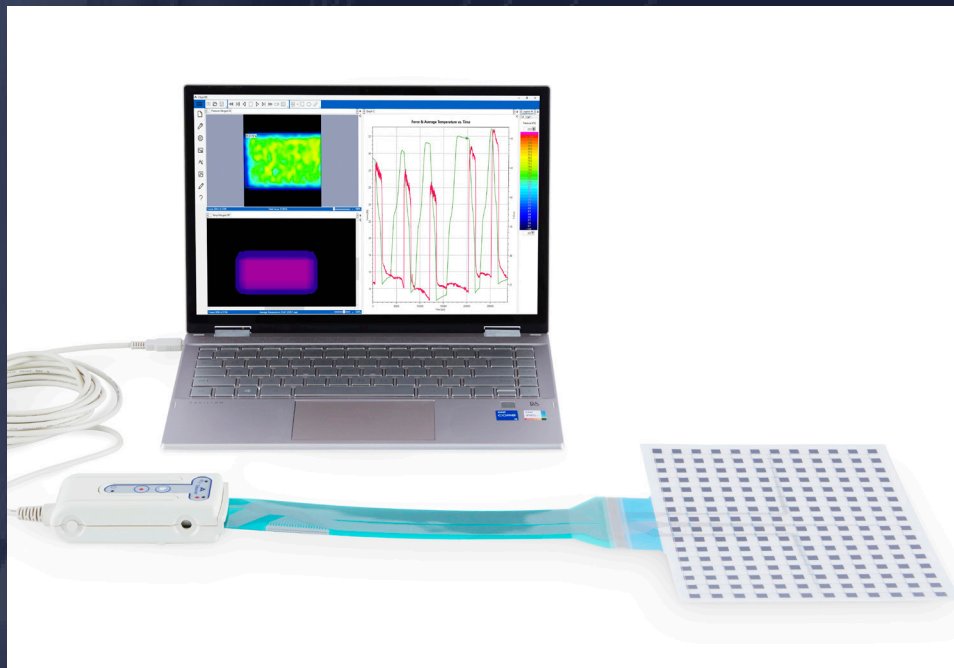
Tekscan's T800 temperature mapping sensor provides a new way to assess thermal behavior across these critical interfaces. Thin, flexible, and trimmable, the sensor fits between surfaces - such as between a cooling plate and battery cell - to measure real-time heat distribution.

Applications Include:

- Evaluating cooling plate-to-cell interface contact
- Assessing TIM coverage and compression uniformity
- Detecting localized temperature build-up

Insights Gained:

- Identify areas of uneven heat dissipation
- Improve interface material and fixture design
- Validate assembly consistency across modules



Temperature mapping during battery charge/discharge cycle.

Door Seal

Wind, noise, and water leaks in a new vehicle can be a significant source of customer dissatisfaction, create a perception of poor quality, and cause warranty expenses. Proper adjustment of hinges and door latches while the car is in the factory and the doors are being mounted can eliminate these problems.

Previously, vehicle assembly technicians have had to guess where to position the hinges and latches. To measure the pressure of the door seal, technicians would slide a piece of paper between the body and the weather strip, to feel the amount of pull in different locations. With a pressure mapping system, assembly technicians now have an electronic “feeler” gauge that measures contact pressure, while also acting as a direct feedback mechanism. Technicians can use the gauge to help them optimize seal pressure and deflection around the door frame.

In the example at right, the same total force is applied to two different door seal designs. The 3D pressure display shows a problem in Figure 1; the valley in the middle indicates a weak spot in this seal, which represents a leakage path for air or water. Figure 2 has a lower peak pressure, but a more even pressure distribution, making it the more effective seal design.

Pressure mapping enables a technician to immediately see how the door seal force changes as adjustments are made to the door latches and hinges, and while the door is mounted. The system is an effective quality control tool to ensure a tight door seal, helping to reduce or eliminate water leaks, wind noise, and air leaks in the passenger compartment.

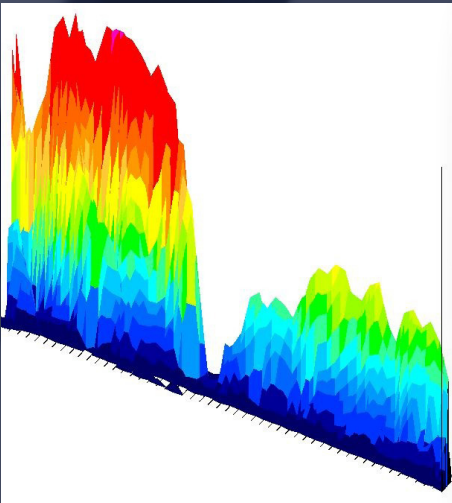


Figure 1: Door Seal Pressure Output Before Adjustments

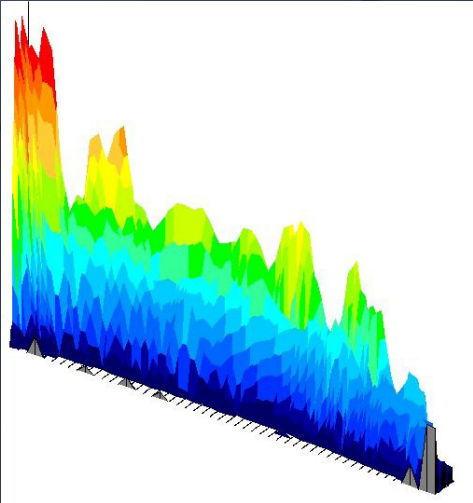


Figure 2: Door Seal Pressure Output After Adjustments



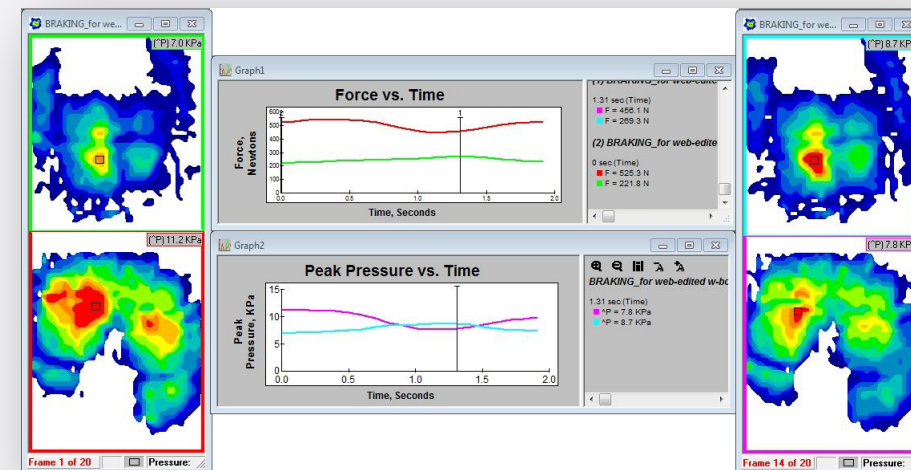
Door Seal Pressure Evaluation

Seating / Comfort

Acquiring and evaluating ergonomic measurements is a difficult challenge. Ergonomic engineers must find a way to maximize efficiency and productivity while reducing operator fatigue and discomfort. A pressure mapping system dynamically measures interface pressure between a human body and a support surface. Automobile seats can be tested to evaluate their comfort, design, material, and durability.



CONFORMat™ System Used in an Automotive Seat Test



Pressure distribution of a driver as he prepares to apply the brakes. The (red) elevated pressure on his right buttock is a result of lifting his right foot. The image on the right shows the change in pressure distribution that occurs while applying the brakes. Note the (red) high pressure region shifted from the buttocks to the lumbar region.

Pressure mapping data can facilitate:

- **Optimizing foam stiffness and cover materials**
- **Selecting the best ergonomic position of the driver**
- **Studying ease of occupant ingress and egress**
- **Measuring changes in the driver's position during high activity, and over long periods of time**

In addition to pressure, temperature mapping offers another layer of insight for seat heating evaluations. A separate temperature mapping system can be applied to assess how heat is distributed across the seat surface, helping identify cold spots, overheating zones, or delayed activation — all of which can impact occupant comfort and satisfaction. This is especially useful in climate comfort validation and quality testing of seat heating elements.

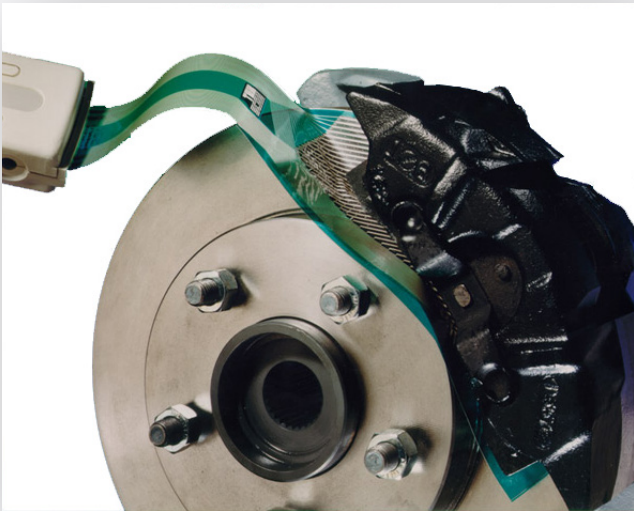
Brake Pad

A pressure mapping system is a versatile research and development tool for brake system and friction plate manufacturers interested in evaluating brake pad pressure distribution. The data provides insight into the dynamic forces and pressures acting between a brake pad and rotor or brake shoe and drum.

In Figure 1, the software clearly shows where uneven pressure exists between these mating surfaces, predicting wear and stress on the pad.

The center of force trajectory in the software output, Figure 2, reveals if the area of average pressure varies throughout a braking cycle.

Pressure mapping data can be used to address the challenges facing brake design engineers, such as predicting wear, and reducing noise, vibration, and harshness.



Brake Pressure Measurement

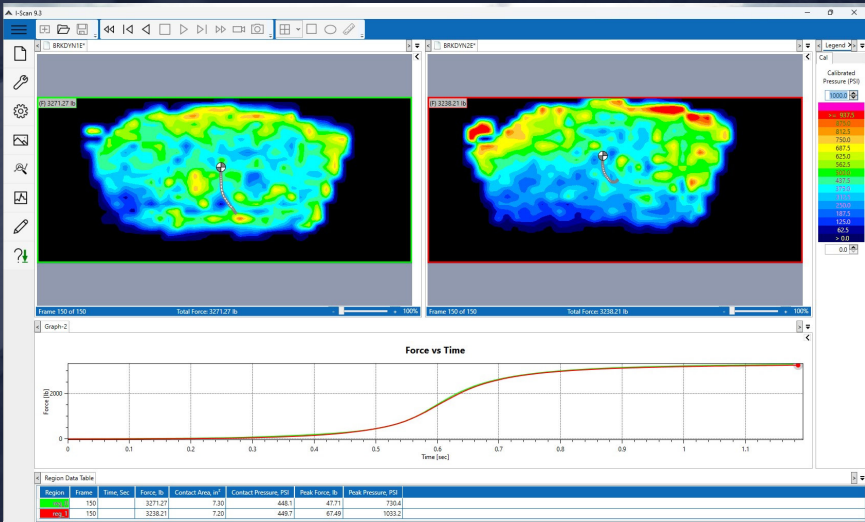


Figure 1: Difference in Pressure Pattern of Inboard (Piston Side) and Outboard (Finger Side) of Brake Pad Showing Flexing of Both Pads

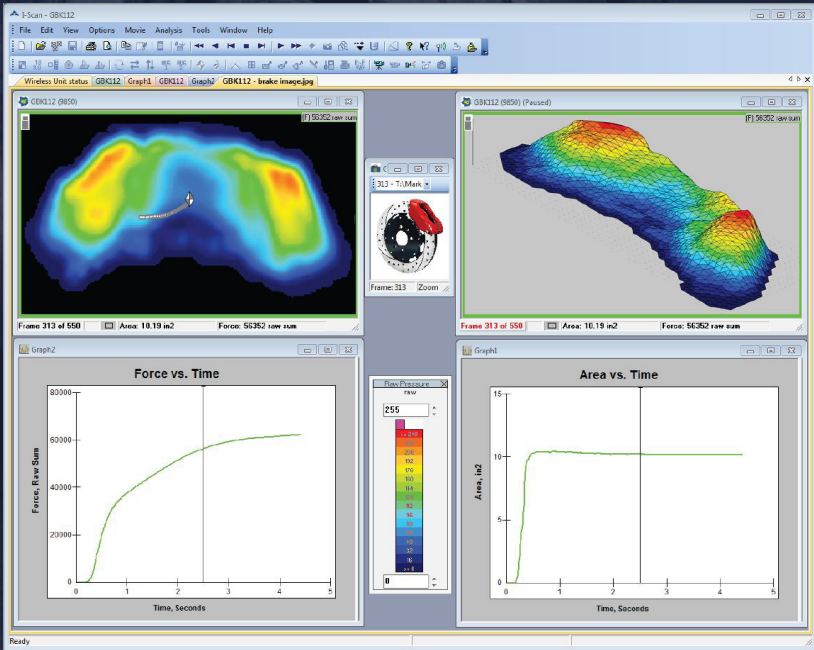
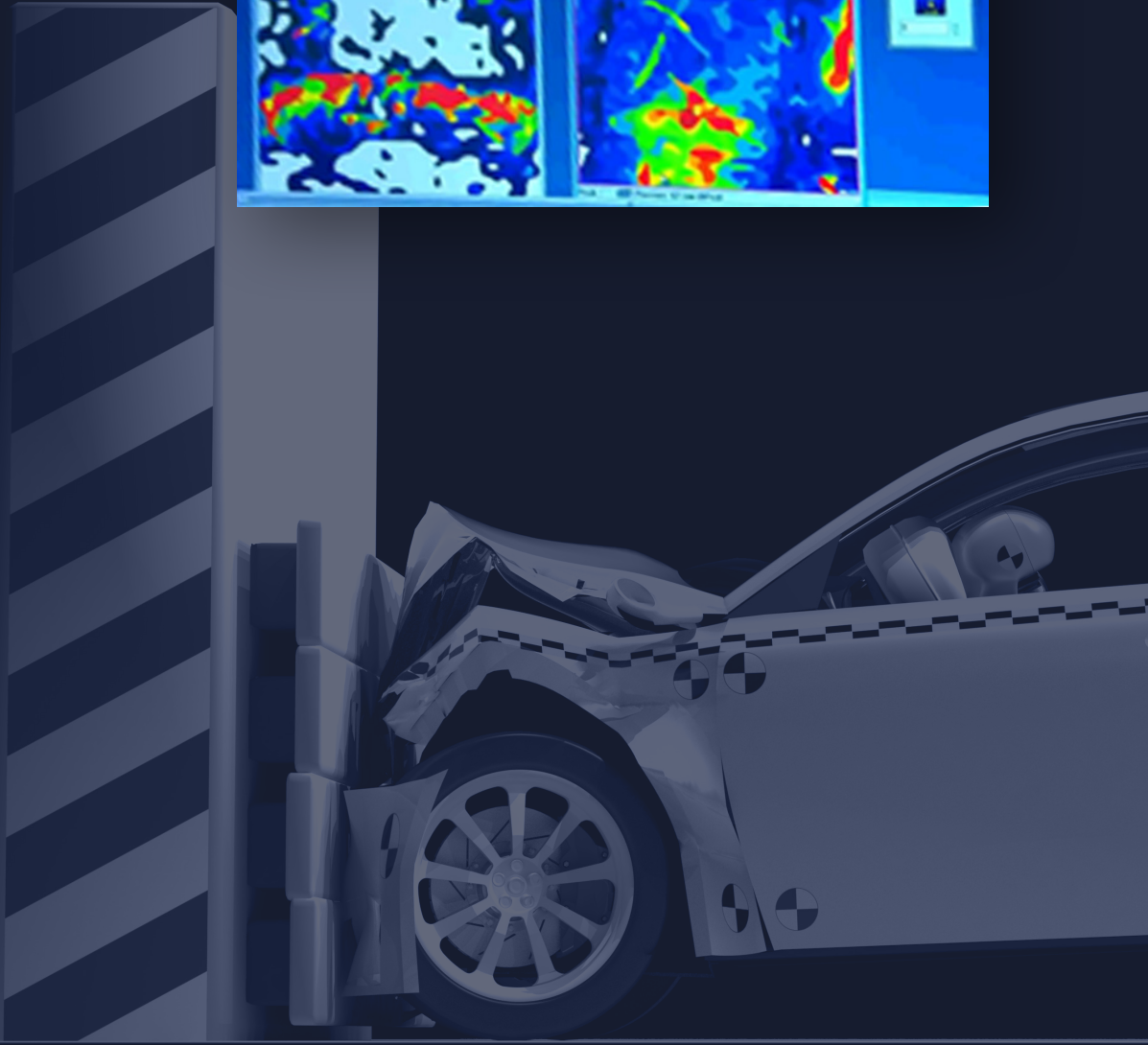
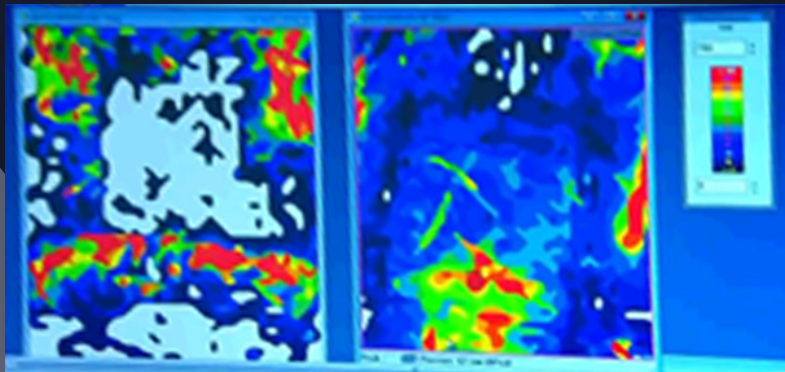


Figure 2: Analyze Peak Pressures and Center of Force Trajectory

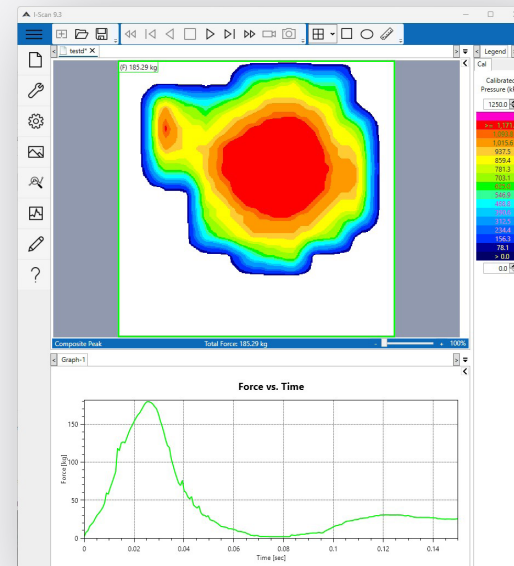


Crash / Impact Evaluation

Crash Test Dummy / High Speed Impact

Safety is certainly a major area of focus for auto manufacturers, suppliers, and research institutions alike. Among other concerns, issues with vehicle safety can also damage a manufacturer's reputation, significantly affecting business. A pressure mapping system can be used in crash test dummy studies to capture the dynamic pressure and force exerted during an impact.

The system can be used in other impact tests to identify the temporal, local, peak, and spatial pressure of two objects colliding. With scanning speeds of up to 20 kHz, even extremely rapid strikes can be recorded. The pressure distribution data can help optimize the design of various safety components, such as airbags, seatbelts, bumpers, and dashboards. Proper functionality in these areas is critical for designing safer cars and minimizing injury.



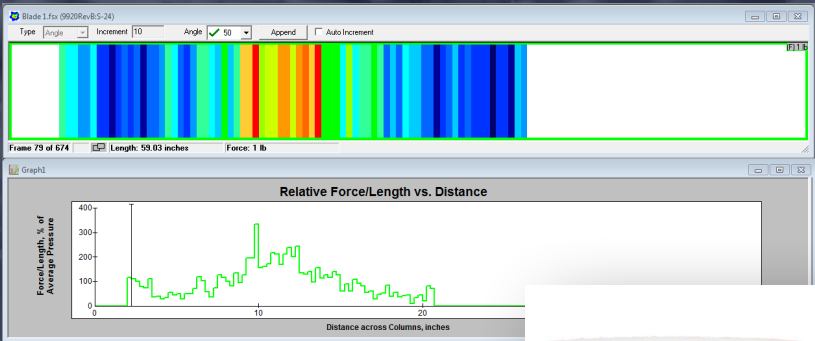
Output of Peak Pressure Exerted Upon a Crash Test Dummy's Knee During High-Speed Impact / Collision Testing

Windshield Wiper

Designing a windshield wiper system that effectively cleans a windshield is not an easy task, given the constraints. The combination of different blade lengths, durometers, low and uneven pressures, and varying windshield contours combine to make this a complicated material and dynamics problem.

A pressure mapping system can measure the force distribution along the entire length of a wiper blade at different positions on the windshield. The system collects and consolidates static measurements at the different angles to capture the full wiper cycle. Dynamic measurements can be taken in wind tunnel studies to evaluate the impact of “lift-off” on the blade pressure distribution.

Measuring blade-to-windshield interface force profiles under various testing conditions provides key insight to improve blade design and wiper system performance.



Force Output Measured:
Wiper Blade at 50° Angle on Windshield

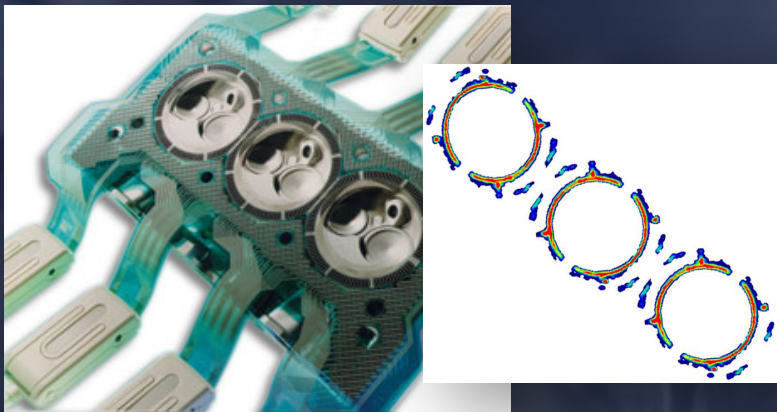
Output Displayed Graphically:
Force vs. Distance Across Sensor Rows



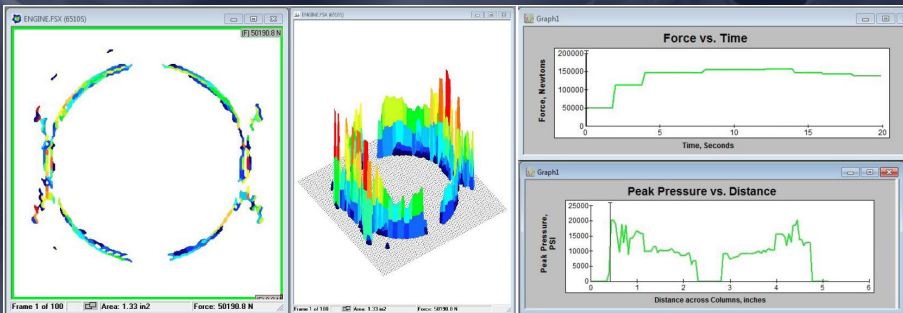
Engine Gasket

An important factor in maximizing the efficiency of an engine is making sure the combustion opening is properly sealed through the entire combustion cycle. Decisions need to be made about the block and head structure, fasteners, lubricants, torque, torque sequence, and gasket design. Pressure mapping sensors can be inserted into and around the various engine gaskets, seals, and fasteners, to measure the dynamic pressure distribution at these locations.

A pressure mapping system provides valuable data to assist designers and FEA modelers who make decisions about these components. It can be used for tests such as validating engine assembly techniques and “motoring” the engine, to characterize the seal pressure changes that occur due to vibration, cylinder pressurization, and torque. Since the system can record over time, the data reflected shows the pressure distribution of components in their relaxed state, not just the peak pressure reached during assembly tightening.

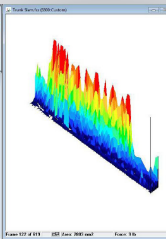


Engine Gasket Pressure Measurement



2D and 3D Pressure Output of Single Gasket Head Shown Graphically as Functions of Force vs. Time and Pressure vs. Distance. Extremely High and Low Pressures Exist, which may Yield an Uneven Seal.

Other Application Examples



Trunk & Door Slam / Seal Performance



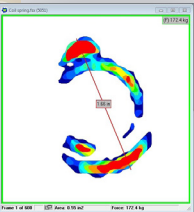
Seat Belt Design



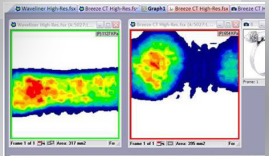
Steering Wheel Ergonomics



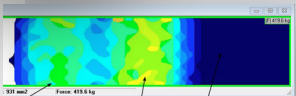
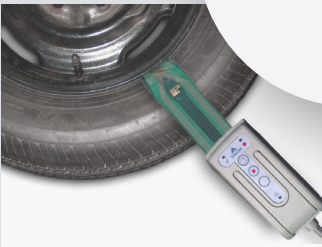
Coil / Leaf Spring Design



Hose Crimp / Clamp Testing



Tire Bead Seat / Seal Evaluation



Reveal Deeper Insights to Drive Automotive Innovation

In a competitive and rapidly evolving automotive industry, engineers need advanced tools to design smarter, safer, and more reliable vehicles.

Tekscan's surface sensing solutions—including both pressure and temperature mapping—reveal critical data at the interface of components. These insights help identify performance issues, validate designs, and optimize manufacturing processes.

Whether you're studying brake systems, seat comfort, battery components, or thermal propagation, our high-resolution sensors and powerful analysis tools provide the real-time data traditional methods can't capture.

With industry-specific sensors, high-speed and high-temperature capabilities, and flexible configurations, Tekscan systems are trusted by leading OEMs, tier 1 suppliers, and research institutions worldwide.

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