INDUSTRIAL SENSOR CATALOG INTRODUCTION

This catalog is for users and those considering the purchase of a Tekscan Pressure Measurement System. The sensors described here have a proprietary connector interface, the "T-Tab," which can only be used with a Tekscan Pressure Measurement System such as *I-Scan*®, *I-Scan* High Speed™, *I-Scan* Lite™, *I-Scan* Handheld, *BPMS*™, *CONFORMat*™, *TireScan*™, or *Wiper*™.

A Tekscan Pressure Measurement System includes scanning electronics such as a Handle or Cuff that provides sensor excitation, signal conditioning, analog-to-digital conversion and communication. The system will have one or more reusable Tekscan array sensors and Tekscan's Microsoft Windows-based pressure display and analysis software.

Each sensor pattern or model has an associated "map," that is a software "driver" which enables its operation. The map is both a license to use that model sensor as well as instructions to the software for proper sensor performance. The map is sensor-specific software that converts the stream of data from the Handle or Cuff into a screen display of pressure elements (sensels) in the proper row and column or ring and spoke arrangement to show pressure profiles. It provides information so the analysis software calculates correct values of force, pressure and area. The system must have the appropriate sensor map (license/driver) in order to use each particular sensor. Initially, a Tekscan system comes with a defined set of sensors and their associated sensor map(s). Additional sensors and maps can be purchased at any time and added to the system as measurement tasks change.

Sensors are available in various sizes, shapes, X-Y resolution, and pressure ranges, described below. Most sensors are 0.1 mm (0.004 in.) thick and consist of a large array, or grid, of independent sensing elements or sensels. Please contact Tekscan for sensor and map pricing and availability.

COMPATIBILITY

Most of the sensors described in this catalog have a "T-tab," compatible with a single "Handle." A single Handle, can address an array of up to 44 by 52 rows and columns, or 2,288 sensels. Over the years, Tekscan Handles have been produced with a variety of hardware types. Today, *Evolution*® Handles serve the majority of needs with a direct connection to the host PC through its USB port. Applications that require higher speed scanning are accomplished with *VersaTek*® Handles that connect through a *VersaTek* Hub to the host PC's USB port. In the past, there were Handles that connected through ISA or PCI interface cards or Parallel interface boxes. All single Handles are compatible with sensors that have the T-tab.

Some applications, such as tire footprint or fuel cell flow field studies, benefit from sensors with a larger number of array elements (sensels) for higher X and Y resolution. Today, this is achieved with two or more *VersaTek* Handles connected together to provide Cross-Handle Scanning (CHS). Two *VersaTek* CHS Handles can address an array with up to 88 by 104 rows and columns, or 9,152 sensels. Four *VersaTek* CHS Handles can address an array with up to 176 by 208 rows and columns, or 36,608 sensels. In the past these applications were served by Dual Handles that connected to the host PC through a PCI or ISA card. All Dual Handle sensors, such as the 5026, 6010N, 6020N, 6030N, 7100, 7501, 8000 and 8050 sensors are compatible with both Dual and *VersaTek* CHS Handles. New designs that have two CHS tabs are compatible with existing Dual Handles. Larger arrays, with three or more CHS tabs require *VersaTek* CHS Handles.

Other products

Other categories of Tekscan sensors are described elsewhere. Medical systems have sensors that connect to a "Cuff" which houses scanning electronics, analog to digital conversion, and communication. Cuffs provide left and right sensor images when attached to a subject's arm or leg. View the Medical sensor catalog.

FlexiForce® sensors respond to single point force loads. FlexiForce sensors are available in two forms. Sensors with pads connect to the ELF, Tekscan electronics and software. Sensors with pins are intended for user-designed electronics.

Sensor Families

Certain sensors have been grouped into "families," based on their combined utility for a particular application. In our experience, these groups of sensors provide useful combinations for particular application requirements, based on the shape and pressure ranges available. Examples of some of these families are noted below.

Family	Sensor Models
I-Scan or Standard	5051, 5076, & 5101
Soft Seal	6077 & 6300
Rectangle	6077 & 6300
Small Annular	6220 & 6230
Large Annular	6500, 6510
Finger / Probe	5800, 6900 & 6911
Brake Pad	9850, 9851, 9855N, & 9856N
Brake Shoe	6300 & 5511
Joint	4000, 4010N, & 4201
Pinch	5501, 5510, 5511, 5515, 5526, 5550, 5555, 5570
Ergonomic	9801 & 9830
High Speed	9500 & 9550
Catalytic Canning	5260, 5511, 5501 & 6300
CMP	5250 & 5051
Seat	5315, 5330, 5350 & 5400N
Vascular	4305, 4308
CMP (*VersaTek* Handle)	6010N, 6020N, 6030N
Wiper	9901 & 9920
Bead	8100, 8110, 8150, & 8155

Sensor Selection Criteria

A number of factors should be considered when selecting a sensor for a test. Sensor shape and pressure range are starting points for making a selection. Frequently, additional factors come into play. The following paragraphs are reminders of factors to consider when making sensor selections. A Tekscan representative is available for consultation advice on selecting sensors. In some cases, this will result in a trial experiment with materials and forces that mimic the application of interest.

Please refer to the specific sensor descriptions to help select a sensor and to determine its advantages and limitations in your application. Sensor scanning speed is a function of the software, the hardware type, the sensor layout, and the number of sensing points in the sensor.

1. Sensor Size and Shape

In most cases, it is desirable to select a sensor that covers the pressure measurement area as completely as possible. Multiple sensors can be used to cover a large area, when a single large sensor may have insufficient spatial resolution for the test. In addition, multiple smaller sensors can be placed in widely spaced, yet important, areas to reveal regional pressure distributions with high local spatial resolution while areas without interest have no measurement sensor. Sensors are often cut, punched, shimmed, or trimmed to fit an application when access is an issue.

2. Sensel Density

Sensel density is the number of active sensels per unit of area. More sensels in a given area yield better accuracy for locating individual contact locations; higher pressure distribution resolution; and better ability to visualize small structures. An alternative way to think of resolution is the pitch, or distance between the center of one sensel (sensing element) and its neighbor. Sensors with a greater number of rows and columns per unit of distance (higher density or finer pitch) have better spatial resolution. The smallest X-Y dimension that the system can indicate is the pitch.

Three examples will illustrate. Imagine a sensor with orthogonal rows and columns and the same pitch in both X and Y direction. If the sensor has a pitch of 0.5 in. (12.7 mm) or two sensels per linear inch (0.78 sensels per linear cm), it will have sensel density of 4.0 sensels per square inch (0.62 sensels per square cm). It will report loaded area in increments of 0.25 square inch (1.61 square cm). If a sensor has X and Y pitch of 0.10 in. (2.54 mm) or ten sensels per linear inch (3.93 sensels per linear cm), it will have 100 sensels per square inch (15.5 sensels per square cm). It will report loaded area in increments of 0.01 square inch (6.45 square mm). Some sensors have different row pitch than column pitch. If the sensor has rows with pitch of 0.5 in (12.7 mm) and columns of 0.1 inch (2.54 mm) it will have 20 sensels per square inch (3 sensels per square cm). It will report contact area in increments of 0.05 square inches (32.3 square mm).

Row Pitch	Column Pitch	Sensel density	Sensel area
12.7 mm	12.7 mm	0.62 per square cm	1.61 square cm
0.5 in	0.5 in	4.0 per square inch	0.25 square inch
2.54 mm	2.54 mm	15.5 per square cm	6.45 square mm
0.1 in	0.1 in	100.0 per square inch	0.01 square inch
12.7 mm	2.54 mm	3.00 per square cm	32.3 square mm
0.5 in	0.1 in	20.0 per square inch	0.05 square inch

The system reports pressure and area related to the entire sensel area. If a pointed stylus applies load to one sensel, it may actually contact only a tiny area with very high pressure. However, the reported contact area will be the entire sensel area, and the reported pressure will be derived from the entire sensel area. Thus, in the case of a point load on a large sensel, the system will report a contact area larger than the actual area of contact. The sensel area, including both the active and inactive area, is the minimum area resolution. The sensel reports as either loaded or not – regardless of what percentage of its active surface area has physical contact.

3. Sensor Pressure Range

After sensor shape is selected, consider the pressure range. The first estimate of contact pressure is the total force divided by the total area. However, interface pressures are frequently uneven, especially with hard or non-compliant contacting materials. Using the average pressure often significantly underestimates the peak pressure range of individual locations. When hard surfaces touch, it is typical to have large regions with no contact pressure and small regions with very high contact pressure.

Usually, it is desirable to have some "overhead," to be able to register peak pressure points of the interface. If the sensor becomes overloaded or saturated in some regions, it will identify locations with high pressures, but not how high those pressures are. When the sensor saturates (reaches a raw digital output value of 255), the saturation pressure is the highest pressure that will be indicated, even if the actual pressure is two, three or ten times the saturation value.

For most sensors, the pressure range label is the pressure applied in a test fixture that yields a digital output of 200. This is called P200. Tekscan systems employ an 8-bit analog to digital converter that has an output of 0-255. Since the stated range is the pressure that yields a raw output of 200 from the sensor, and it can register to a saturation value of 255, there is about 27% headroom, or over-range capability.

The sensors respond somewhat differently to the contact of different materials. That difference may be seen in an application as a higher or lower measurement range than the value labeled on the sensor. Sensors with a range up to 100 psi are tested, at the factory, in a bladder with air pressure through urethane on one side and a hard aluminum or steel surface on the other. Higher range sensors are tested with steel on both sides. Since experimental conditions may be different than that, the pressure range in the experiment at hand may differ from the labeled sensor values.

In addition to avoiding an overload, pressure resolution and the minimum pressures of interest are considerations. Tekscan sensors operate best over a range of 15 to 1. For example, a 1,000 psi range sensor will operate most accurately with an applied pressure of 66 to 1,000 psi. The best possible pressure resolution is P200 range/200. In the case of a 1,000 psi range, the best possible resolution is 5 psi. To avoid spurious output, the first three digital levels are not displayed. So the minimum pressure that a 1,000 psi range sensor will display will be 15 psi.

Most sensor models have one or more standard pressure ranges available. The standard pressure ranges are selected to serve common applications and based on sales history. Tekscan maintains an inventory of most sensors; so many sensors with standard pressure ranges are in stock, available for immediate shipment. Sensors with non-standard pressure ranges are also sometimes available from stock.

Adjustable sensitivity is available with some Tekscan scanning electronics, such as Evolution Handles. Typically, adjustable sensitivity can change the P200 value up or down by a factor of four. Consider a sensor labeled 100 with best resolution of 0.5 PSI. With low sensitivity, it might be able to behave as a sensor with P200 of 400, and best resolution of 2 psi. Alternatively, with high sensitivity, it may be able to behave as a sensor with P200 of 25 psi and best resolution of 0.125 psi.

Tekscan can also manufacture an existing sensor in a non-standard pressure range. There is a cost to set-up, manufacture, and test an existing sensor design in a non-standard pressure range. The set-up cost does not include the cost of the sensors to be ordered. A minimum order quantity of sensors must accompany such an order.

4. Temperature range:

Standard Tekscan sensors are specified to operate over a temperature range from -9° to 60°C (15° to 140°F). The Handle electronics are specified to operate over a temperature range from 0° to 50°C (32° to 122°F). Thus, for elevated or lower temperatures, the Handle should be protected from extremes of temperature.

For higher temperature applications, many sensors can be manufactured with different materials to be able to operate over a range from -9° to 200°C (15°F to 400°F). If the application requires higher operating temperatures, please contact Tekscan to discuss whether a particular sensor can be produced with high temperature materials.

5. Sensor Durability

Another consideration is durability and thickness. Many users demand the thinnest sensors possible, to minimize disruption to the contacting surfaces. However, the ultra-thin materials are typically not as durable as thicker materials.

Typically, the thicker the sensor, the more durable it will be. However, thicker sensors may affect actual contact and pressure measurement conditions. In many cases, measurement of interface pressures should be taken with the thinnest sensor available. In addition to cushioning peak pressures and filling in areas with low pressure, thicker sensors sometimes exhibit "mechanical cross talk." "Mechanical cross talk" occurs when a load in one location affects the sensor sufficiently to trigger an adjacent sensing location that is not actually being loaded.

To minimize sensor thickness, Tekscan uses the thinnest polyester that can be successfully produced. All sensor component materials are applied in the thinnest and most uniform manner possible. The resulting thickness of approximately 0.1 mm (0.004 in.) is the thinnest possible, and has the closest row and column spacing achievable by the current state-of-the-art technology. The resulting sensor has exceptional durability and meets the goals of a wide variety of applications. Since thicker polyester is readily available and easier to handle, applications requiring thicker sensors can be made on a custom basis. For applications where it is more important to be rugged than thin, some sensors are made of thicker material, so they are 0.2 mm or 0.3 mm (0.008 in. or 0.012 in.) thick.

6. Sensor Performance

Because the sensing array is a combination of "sensing areas" (the intersection between the conductive rows and columns) and "inactive areas," (non-responsive areas between the intersections) best results follow from calibration with materials whose compliance is similar to or identical to the material in the test.

In the case of a small point load on a large sensel, the system will report a contact area that is larger than the actual area of contact. The sensel area, including both the active and inactive area, is the minimum spatial resolution. The sensel is either loaded or not - regardless of what percentage of its surface area is loaded. The system will report pressure and area data, based on the sensel area.

Every grid-based sensor has "dead space" - the inactive areas between the sensing intersections. The active portion of the sensel is slightly thicker (0.1 mm) because there are two layers of substrate, two layers of conductive ink, and two layers of pressure sensitive ink. Insensitive areas, where the construction has only two layers of substrate, are thinner (0.05 mm). So in some applications, with rigid or non-compliant contacting surfaces, the entire load is born by the thicker active part of the sensel. With some soft interface materials, the load "fills in" on both the higher active region and adjacent inactive region. This is one of the reasons material compliance has an effect on sensor output. The interaction between material compliance and sensor output is why calibration should be done with material of similar compliance to the material of the test.

The accuracy of the data obtained and sensor performance are closely tied to calibration and equilibration procedures, as recommended by the user's manual and Help file. In general, you can obtain better results by selecting sensors with finer spatial resolutions and calibrating them with the material of the experiment in the pressure range of interest.

7. Sensor Life

Sensor usage affects how long a sensor will provide good data. Typically, when a sensor is loaded many times, its pressure range increases. It is said to become "colder." Poor test results can often be traced to using a sensor beyond its useful life or not recalibrating or equilibrating the sensor often enough.

The useful life of a sensor is highly application-dependent. The gentle or aggressive nature of an application will determine how long a sensor will last. If the sensor is placed between two soft surfaces that do not distort the surface shape, with low to moderate pressures, the sensor will last longer. Applications involving two hard surfaces at higher pressures tend to have shorter sensor life. Sensors that are exposed to sliding or shear forces or abrasion across their surface will also degrade more rapidly. Still, it is possible that sensors visibly wrinkled or distressed may continue to provide good results because the active aspects of the sensor are internal. However, sensors with punctures or broken traces usually become non-responsive in those areas. An effective way to evaluate sensor performance is to periodically load it with a known test condition. We suggest recalibration if results begin to vary from what had resulted under a known condition. Replace the sensor if the range of the sensor after recalibration becomes greater than is acceptable or if the sensor is physically damaged.

OTHER CONSIDERATIONS:

Custom Sensor Designs

If none of the existing standard sensor designs seem appropriate, a custom design can be considered for an application. Please contact Tekscan to discuss your needs. It is likely that some preliminary experiments will be suggested with existing sensor designs to explore "proof of concept." When the requirements are firmed up, a quotation will be provided.

Measurement of Large Areas

Some applications involve measuring areas larger than what can be covered by a single sensor could. Multiple sensors working together create a larger sensing surface or finer X-Y resolution than a single sensor can provide. For example, two Model 8000 sensors may be butted together to measure a tire patch larger than a single sensor. Virtual Sensor Array™ (VSA) combines the data from multiple sensors to appear in a single image and the output is stored in a single file. Thus multiple individual arrays are combined into a larger virtual array.

The system must have the same number of data scanning Handles as the Virtual Sensor map. Because multiple sensors are involved, multiple orientations are possible. Four sensors could be lined up in a long row or in a square. The virtual sensor map must match the desired orientation. For example, four data scanning Handles can use a VSA map to display four Model 5051 sensors in one playback window. Alternatively, with a different VSA map and the same hardware, two Model 5051 sensors can be displayed in each of two windows.

Protecting the Sensor during Measurement

Some applications benefit from shim stock placed over the sensor. Adding shim stock to an application often affects the compliance of the contacting materials, and may affect the reported pressure, requiring re-calibration.

There can be several benefits from the use of shim stock. If the contacting surfaces have sharp points or abrasive spaces, the shim can protect the sensor. Shim can reduce the effect of these aspects on sensor output in applications which have a tight radius or involve movement.

Tekscan sensors are designed to measure forces normal to the surface of the sensor. If sliding or shear forces are present, shim stock can absorb the shear so it does not affect the sensor. If materials with different compliance or softness will contact the sensor while it has the same calibration factor, shim stock can make the sensor response more consistent. If the application involves liquids, shim can keep the sensor dry. When using shim stock, the effect on reported pressure should be considered.

Information in this catalog is subject to change without notice.

307 West First St., South Boston, MA 02127
Tel: 617.464.4500/800.248.3669 fax: 617.464.4266 web: www.tekscan.com