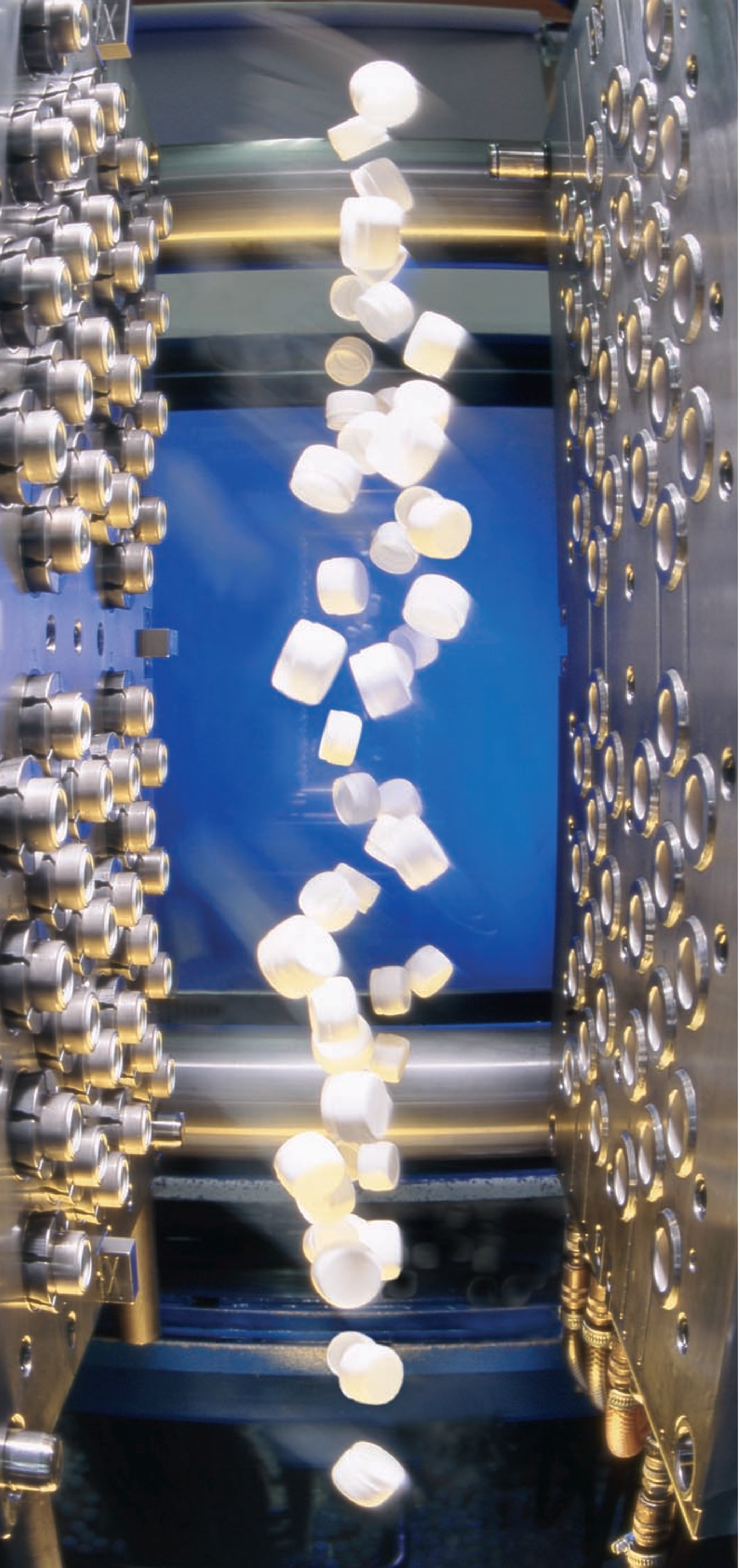

KISTLER

measure. analyze. innovate.

Plastics

100 % Quality
Injection Molding

Kistler – Your partner for efficiency and quality

Sensors and systems for optimizing, monitoring and documenting the quality data during injection molding processes is only part of the solutions for the industry provided by Kistler Instruments AG. With headquarters in Switzerland, we supply plastics processing solutions as well as specific sensors and systems for combustion engines, automotive engineering, mechanical production and biomechanical engineering.

Our core competence lies in the development, production and implementation of sensors for pressure, force and acceleration measurement. Kistler electronic systems and expertise used for processing measurement signals allow the analyses of physical processes, process control and optimization as well as the enhancement of product quality for the processing industry.

Every year, Kistler invests 10 % of its sales in research and development – for innovative and efficient technical solutions at the leading edge of technology.

The Kistler group with more than 600 employees is the leading supplier of dynamic measuring technology throughout the world. Close cooperation with the customer, individual application support and short delivery times are guaranteed by the group's 18 member companies and more than 30 agencies.

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The benefits of cavity pressure measurement systems

Modern injection molding technology is faced with ever more exacting requirements and a rising number of complex injection molding processes. Equipped with high-performance systems based on measuring the pressure in the mold cavity, injection molding machines are able to produce flawless high-quality parts. These systems can automatically monitor, optimize and control injection molding processes, boost productivity and cut costs.

During the first decades of industrial injection molding the development of control systems focused on machine parameters alone. However, these processes had a rather limited informative value or benefit for users. From the early 1990s on, it became clear that for many applications, high process constancy and optimum part quality could only be ensured over a long period of time by using measuring systems which focused on the pressure in the mold cavity.

Mold cavity pressure measurement and systems using cavity pressure for monitoring and controlling injection molding processes offer a range of technical and economical benefits such as the following:

- Reduction of the reject quota
- Optimization of the cycle time
- Shortening of installation and setup times
- Minimization of material requirements
- Reduction of personnel costs
- Less energy costs
- Active mold protection

Systems measuring the pressure in the mold cavity are almost fully automatic and easy to operate. Quartz sensors have proved to be particularly suitable for both direct and indirect cavity pressure measurement. Modern system solutions operate with a closed circuit which includes mold cavity pressure recording with the help of quartz sensors, smart electronic equipment and ergonomic software.

The processes within the mold are crucial to the quality of the injection molded parts, yet they can never be viewed directly. Attempts at describing process phases in terms of machine parameters such as hydraulic pressure, have not yielded any success. The main reason for this lies in the fact that machine parameters cannot record the effects of sprue solidification or melt compressibility.

More productivity – lower costs

Mold cavity pressure is the most informative process parameter
Only a continuous documentation of the mold cavity pressure profile yields a detailed record of the processes occurring during the injection, compression and holding pressure phases of injection molding. Only this parameter correlates with all other quality-related part properties such as weight, morphology, fidelity of reproduction, flashes, sink marks, voids, shrinkage and warpage.

The mold cavity pressure not only optimizes the change-over from compression to holding pressure, in each cycle, its profile can also be used as a criterion for determining the change-over point. It allows better maintenance of the tight part weight tolerances and numerous other quality features than any other change-over strategy, be it based on the hydraulic pressure, screw stroke or time.

Quality assurance and documentation with the help of mold cavity pressure control
The documentation of the mold cavity pressure not only proves the quality of the finished part but also allows selective monitoring and early detection of process deviations. Useful algorithms such as statistic process control or neuronal networks can deliver very precise information on the effect of the mold cavity pressure and other process or machine parameters on the mold quality.

Precise assessment of the molded parts requires systems which analyze their weight and dimensions as well as correlating features such as streaks and other surface defects while also providing automatic control of reject/accept gates. In the near future, most modern injection molding systems are likely to rely on an automatic determination of the optimum process parameters.

Mold cavity pressure control systems are reliable and durable
Despite the high number of benefits, many injection molders are still skeptical when it comes to mold cavity pressure control. On the one hand, they are averse to the investment costs and on the other hand they anticipate downtimes and follow-up costs. Experience shows, however, that improper handling of the sensors during installation, maintenance or mold changes is the main cause of machine downtimes. The systems themselves have proven their sturdiness, reliability and durability.

The large-scale production of high-quality, cost-efficient parts provides a competitive edge and as such it is the decisive criterion for the success of any injection molding business. In its wake, quality assurance will attain major importance for all injection molding processes. With a view to increasingly complex processes and more exacting quality requirements, only machines with high-performance systems which are based on cavity pressure control will be able to deliver flawless high-quality molded parts.

Prof. Dr.-Ing. Dr.-Ing. E.h. Walter Michaeli
Institute of Plastics Processing (IKV) at RWTH Aachen University

The benefits of cavity pressure measurement systems

The efficiency of a particular injection molding process is determined long before it is used for large-scale production. The consistent application of cavity pressure measurement devices generates user benefits across the entire product development chain – from mold sampling to production documentation.

Mold sampling without mold filling studies
Mold sampling or, to be more exact, the acceptance of molded parts for large-scale production, is a time-consuming process for processors as it often involves numerous mold corrections and trial runs. In this development phase, cavity pressure measurement systems can be used to analyze the process and to determine initial machine settings without mold filling studies. Moreover, the cavity pressure signal is an important tool for uncovering errors and problems at an early stage, which also minimizes the number of required repetitive mold sampling procedures. As these systems reduce the time consumed for mold sampling to a minimum, they also help to curb costs. Practical experience shows that mold cavity pressure systems can reduce the time and effort used for mold sampling by up to 75 %.

Optimum quality, minimum cooling and cycle times
One essential element of process optimization is the attempt to find an efficient production method and a safe processing window. A process with an optimum cavity pressure profile will yield high-quality parts. The achievement of minimum cycle times and sufficient part quality are at the heart of this phase. Experience shows that in 70 % of injection molds, the cycle time is 20 % longer than necessary. Adapting the mold cavity pressure will help implement shorter cycle times without affecting the quality of the molded parts and therefore allow the determination of optimum times for injection, holding pressure and cooling without trial and error. Smart self-optimizing mold cavity pressure measuring systems can automatically determine the change-over point and required residual cooling time during the active production process. At the optimum point in time during each cycle, these systems will transmit the corresponding demolding or change-over signals to the machine.

More flexibility during mold set-up
The use of a reference curve helps to significantly shorten set-up and change-over times. This reference curve of the cavity pressure is determined and saved during process optimization as soon as the optimum part quality has been achieved. During set-up, the machine operator only needs to change the machine setting parameters until the closest approximation between the current cavity pressure profile and the reference curve for optimum part quality has been achieved. In this way, even machines which show signs of wear and machines from different manufacturers will deliver molded parts with identical properties. This approach dispenses with the need for time-consuming part quality tests, which are normally required as a consequence of changes to the machine settings.

More efficient processes – better quality

Error-free production on a large scale
During large-scale production, the mold cavity pressure is used for a continuous monitoring of the quality of the molded parts. If this quality fails to meet the required standards, an accept/reject flipper gate or a handling device can be used to separate the defective parts from the batch. This integrated quality assurance system ensures the detection of flawed parts at the earliest possible stage of the production and as such is prerequisite to the implementation of "lean" production condi-tions. Moreover, this approach reduces the reject quota and helps achieve an error-free production. This in turn boosts the productivity of the machine as a consequence of an improved utilization and lower production costs.

Documented quality
The cavity pressure profile determined during the production process is a clear reflection of the quality of the parts produced and is therefore useful material for documentation. This way, random checks according to the statistic process control (SPC) based on cavity pressure measurement evolve into a 100 % quality assurance procedure. Cavity pressure measurement delivers the relevant data to certify of every individual injection molded part. It reduces the cost of part quality control and provides an automatic documentation of process data which is readily available for both producers and customers even years after active part production.

For more information on this topic, please refer to p. 20

Advantages

During mold sampling
+ Initial machine settings without mold filling studies
+ A faster procedure saves time
+ Significant cost reduction

During optimization
+ Automatic calculation of switch-over point and cooling time
+ Optimum cavity pressure profile
+ Minimum cooling and holding pressure times
+ Minimum cycle times

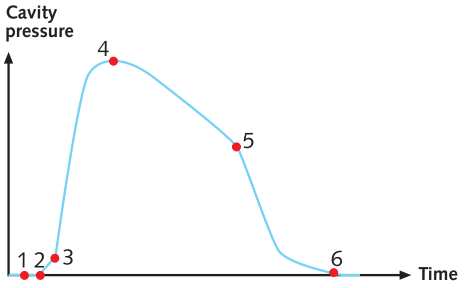
During mold set-up
+ Optimum part quality even after machine changes
+ No time-consuming part quality testing required
+ Shorter set-up times

During large-scale production
+ Automatic reject separation
+ Moving into "Lean Production"
+ Error-free production

For quality assurance
+ 100 % certified quality for each individual part
+ Cost reduction for part quality control
+ Automatic documentation of quality data

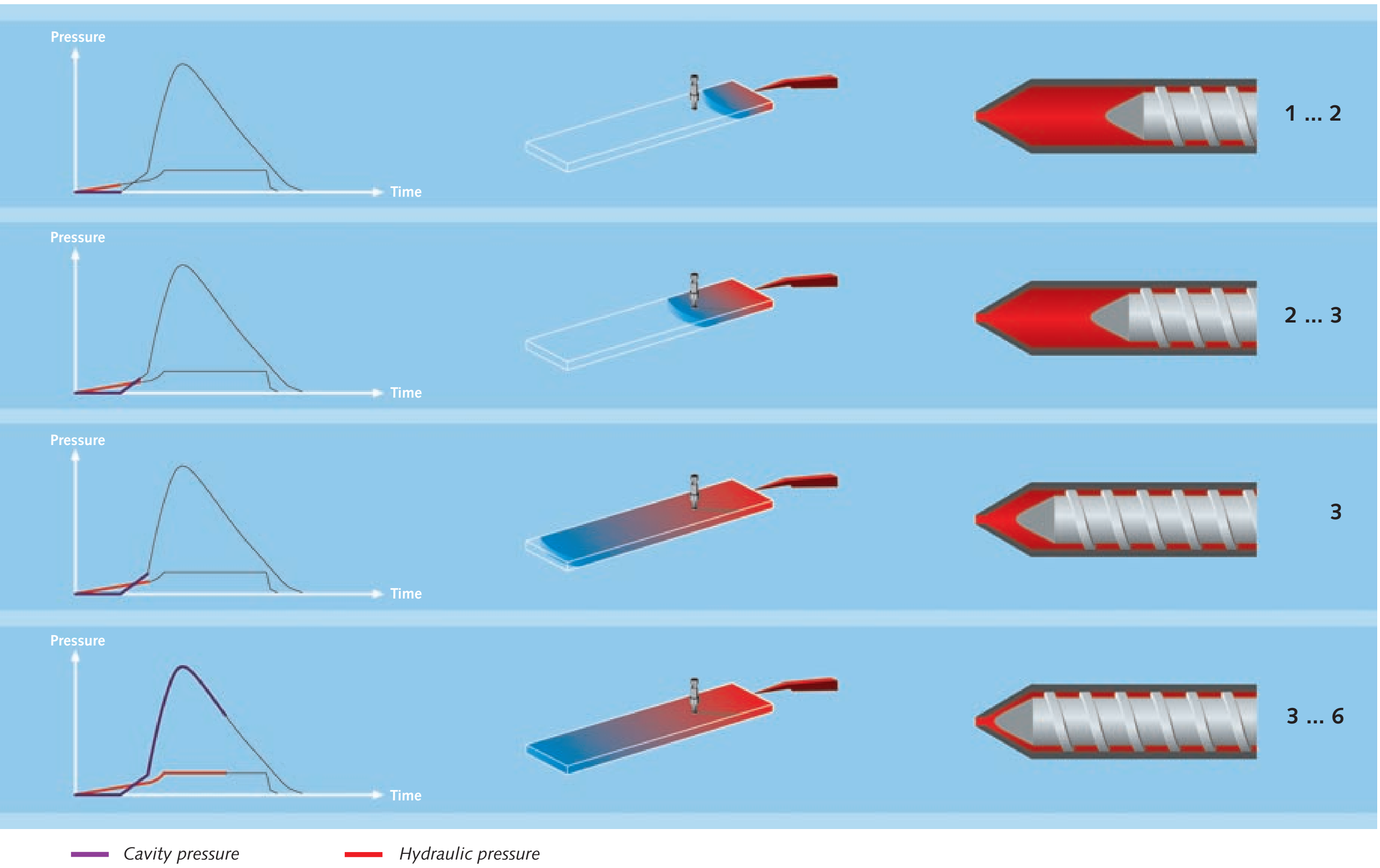
The basics of mold cavity pressure measurement

The cavity pressure within an injection mold delivers very precise information about the filling phase, the pack phase and the holding pressure phase. Gaining an insight into some physical correlations facilitates the analysis and interpretation of the cavity pressure profile during active processes.



The cavity pressure profile

At the onset of the filling phase (1) plasticized polymer material enters the cavity. As soon as the flow front reaches the sensor (2), pressure is registered. The pressure should rise in a near-linear gradient parallel to the duration of the filling time. During volumetric filling of the cavity, the filling phase has been completed (3) and the plasticized material is compacted during the compression phase to ensure the reproduction of the contours of the mold cavity. The holding pressure phase follows after the maximum cavity pressure has been reached (4). The holding pressure phase compensates for the high thermal contraction of the polymer material – i.e., the reduction of its volume following the cooling down process – by introducing more material. Up to 10 % of the part volume is being pushed into the cavity during this production phase. The fact that the molded part starts to cool down and solidify near the cavity wall inhibits the pressure transfer. The melt flow from the area in front of the screw to the cavity is slowed down as the viscosity of the material increases and the flow channel becomes more constricted in the process. The progressive solidification of the plasticized material in the gate area (5) and the progressive thermal contraction causes the pressure within the cavity to drop to ambient levels (6).

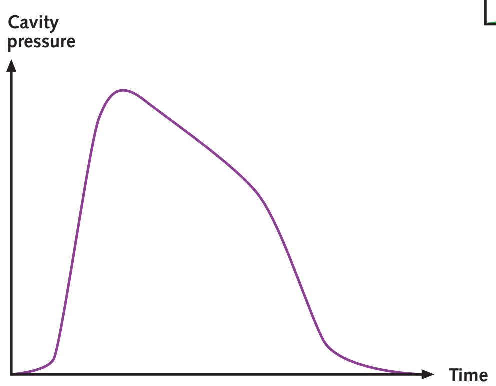


The pressure profile and its interpretation

During the mold filling phase, the different characteristics of plasticized amorphous or semi-crystalline polymers are immaterial as long as their viscosity is identical. However, both materials display a different compression behavior. A higher amount of semi-crystalline material than amorphous material needs to be introduced into the cavity at the beginning of the holding pressure phase to achieve a pressure build-up. When the melt cools down during the holding pressure phase, more semi-crystalline material must be introduced into the cavity to compensate for the volume contraction and to prevent voids in the finished part.

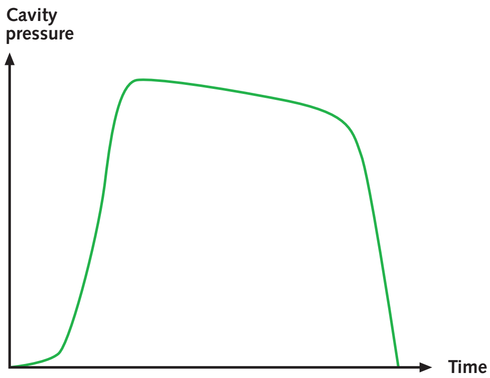
Specific characteristics of amorphous thermoplastics

During the holding pressure phase of injection molding processes involving amorphous polymers such as polystyrene (PS), acrylonitrile-butadiene-styrene (ABS), styrene-acrylo-nitrile (SAN), polymethyl methacrylate (PMMA), polycarbonate (PC) and polyvinyl chloride (PVC), the mold cavity pressure drops to ambient pressure levels parallel to the declining part temperature in the wake of an increasing viscosity and the corresponding deterioration of the pressure transfer from the area in front of the screw.



Specific characteristics of semi-crystalline thermoplastics

Due to an initially sufficient pressure transfer during injection molding processes involving semi-crystalline materials such as polyethylene (PE), polypropylene (PP), polyamide (PA) and polyoxymethylene (POM) there is almost no change in the mold cavity pressure during the period after the compression phase and the onset of the crystalline melting point. After that, however, the significant volume contraction during crystallization brings about a sudden drop in the pressure. The duration of the holding pressure phase depends on factors such as the wall thickness of the molded part, the degree of crystallization and the processing parameters. The crystalline melting point of semi-crystalline materials for example, is dependent on the prevailing cavity pressure.

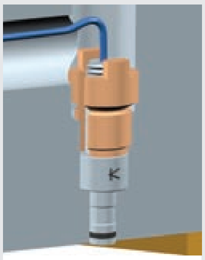


Using the mold cavity pressure in practical applications

Practical application

Installation options

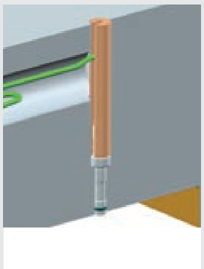
Sensor fitted directly into the drilled hole



Sensor fitted into the drilled hole with sleeve

Installation and extraction tools

Spacer sleeve



At a glance

There are two installation options to accommodate different mold concepts:

- Direct screw-mounted sensor
- Sensor with adapting spacer sleeve for direct attachment below the mold platen

Accurate pressure data that is suitable for analysis can only be acquired by means of reliable and precise measuring technology. The mold cavity pressure can be measured directly, indirectly or in combination with the contact temperature. The position of the sensors within the mold plays a crucial role in this process.

At the same time, high-resolution and reliable, sturdy, maintenance-free and durable measuring equipment is prerequisite to the reliable acquisition of the pressure and temperature data during the injection molding process. Stringent quality requirements for molded parts generate a demand for increasingly precise measurement systems. These systems are expected to register and balance minute pressure variations even at a pressure of 2 000 bar.

Kistler sensors with their dimensions meet the exacting requirements of modern injection molding technology and all its special processing methods. They have an almost unlimited service life, deliver highly linear measuring results, cover a wide frequency range up to 100 kHz and operate independently of the temperature. Piezoelectric cavity pressure sensors made by Kistler can withstand mold temperatures of up to 300 °C and any required melt temperature.

Kistler supplies a whole range of cavity pressure sensors with a standard uniform sensitivity. Equipped with Unisens technology, each sensor comes with a guaranteed uniform sensitivity within a certain tolerance range. Therefore, the electronic equipment does not require any individual adjustment.

Core competence

Unisens technology eliminates adjustments

Piezoelectric sensors discharge electricity proportionate to the cavity pressure. The proportionality is referred to as sensitivity and is measured in picocoloumbs per bar (pC/bar). Under normal circumstances, this sensitivity varies within narrow limits and must be manually adjusted on the measuring system or the injection molding machine.

Unisens technology made by Kistler dispenses with this fine-tuning effort as the sensors operate with a fixed sensitivity. Unisens facilitates machine and system adjustment and also prevents erroneous input.

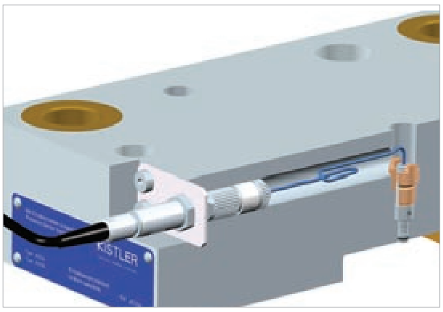
Measuring: Sensors and positioning

Direct and indirect pressure measurement

Mold cavity pressure can be measured directly, indirectly or in combination with the contact temperature.

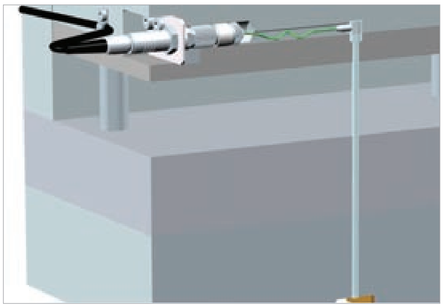
Direct cavity measurement
During direct measuring, the sensor comes into contact with the plasticized polymer material within the mold cavity and measures its pressure directly and without a transmission aid. These sensors can be installed in the drilled holes in the mold with or without an adapter. While sensors with adapters supplied by Kistler already have narrow diameter tolerances, sensors without adapters require fitting by a mold engineer.

Most sensors allow an adaptation of the sensor front to suit the cavity structure in order to prevent impressions in the molded part. Sensors for direct measurement are available in different dimensions and with front diameters of 9.5 mm, 6 mm, 4 mm, 2.5 mm or 1 mm.



For more information on this topic, please refer to p. 33

Indirect measurement behind the ejector or measuring pin
Alternatively, the force behind the ejector or measuring pin can be determined and converted to yield the actual pressure by means of the pin diameter. Indirect measuring behind the ejector is recommended for applications which do not leave enough room for a direct sensor. Adverse conditions such as friction, bending of the ejector pin, platen distortion or contaminated drilling holes have a detrimental effect on the measuring results and the corresponding control or monitoring operations. Direct measurement is clearly desirable to indirect measurement of industrial processes.

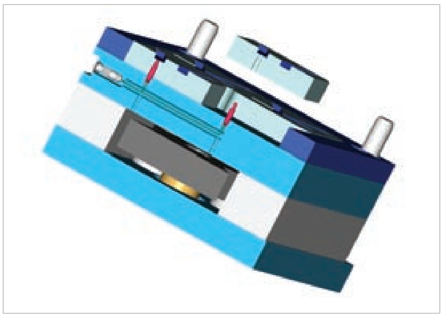


For more information on this topic, please refer to p. 43

Special sensors for molds with inserts
Modern injection molding processes demand molds which allow easy and cost-efficient maintenance. As a result, modern molds are disassembled easily and quickly and mold inserts can often be removed from the mold while it is still installed on the machine.

Kistler supports mold engineers with an adapter-based sensor Type 6155AE. It is mounted on the mold baseplate and equipped with single-wire technology. Insert changes no longer require a removal of the sensor. Thus, both the sensor and the sensor cables, which can be guided through drilled holes in the baseplate, are protected from potential damage during the removal or installation of the inserts. Drilled holes in the insert ensure an accurate positioning of the sensor.

This technology can also be used for molds without cavity inserts. In these cases, the sensor is not mounted to the baseplate but to the second mold platen, where it remains even after the mold is removed. The advantages of this method are the same as those stated above: both the cables and the sensor are protected in the mold platen. This approach is particularly safe for cavity pressure sensors in complex mold platens with a high number of cooling holes.



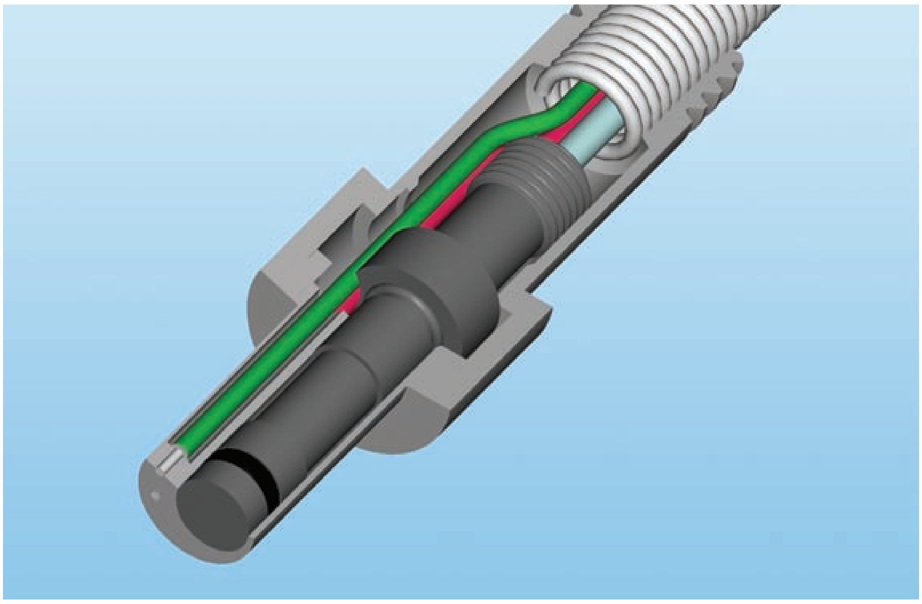
Using the mold cavity pressure in practical applications

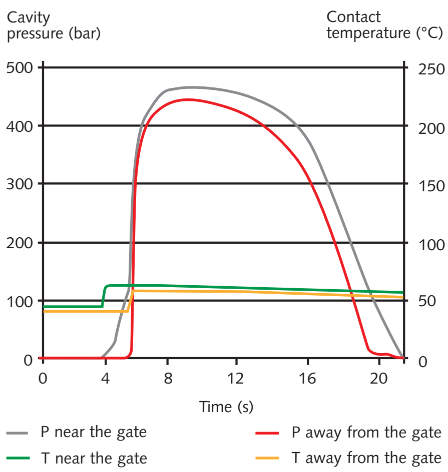
Combined sensors

Efficient process monitoring requires the measurement of both the mold cavity pressure and the temperature as both parameters are important for the production process.

The combination pressure-temperature sensor measures both the cavity pressure and the contact temperature in the same point on the molded part. While the cavity pressure sensor measures the pressure, a newly developed fast-transmission method is used to measure the temperature: both thermocouple cables run separately to the sensor front, where they are welded to a thermocouple type K (Ni-CrN). As the thermocouple is positioned at the tip of the sensor, it measures the contact temperature of the melt. Thus, even minute variations in contact temperature, which can be caused by changes such as a falling or rising melt temperature, can be monitored.

For more information on this topic, please refer to p. 40





Temperature sensors

Kistler sensors for temperature measurement are based on the same principle. Their front diameters correspond to those specified for pressure sensors (Ø 4 mm, Ø 2.5 mm and Ø 1 mm) and are compatible with standard cavity pressure sensors.

For more information on this topic, please refer to p. 41

Positioning the sensor in the mold

Accurate positioning of the cavity pressure sensor is important for a sufficient duration of the signal transmission and informative value of the measured values. Both the position of the sensor in relation to the gate and the wallthickness of the part at the installation point are of particular importance.

Measurement near the gate
The cavity pressure profile during the filling phase is measured when the melt flow front has reached the sensor. A meaningful and long-term measuring result is acquired near the gate and in the vicinity of the highest wall thickness as thick areas take longer to solidify. Sensor positioning should take into account both the fastest and the slowest melt setting points. In cavities with several gates, measurements should be taken from critical areas of the molded part.

Measurement away from the gate
The greater the distance from the gate, the later the melt flow front reaches the sensor, the later the pressure is registered and the higher the filling level must be to actually allow pressure measurement. Consequently, data about the filling phase cannot be displayed until the sensor has been reached. Measurement on the edge of a molded part, i.e. away from the gate or at the end of the flow path yields a signal only when the pressure rises suddenly during the compression phase. Measurement positions away from the gate are beneficial only for protecting components such as threaded spindles or core pullers from damage caused by pressure peaks or for monitoring specific quality problems at the end of the flow path.

Practical application

Basic rules for accurate sensor positioning

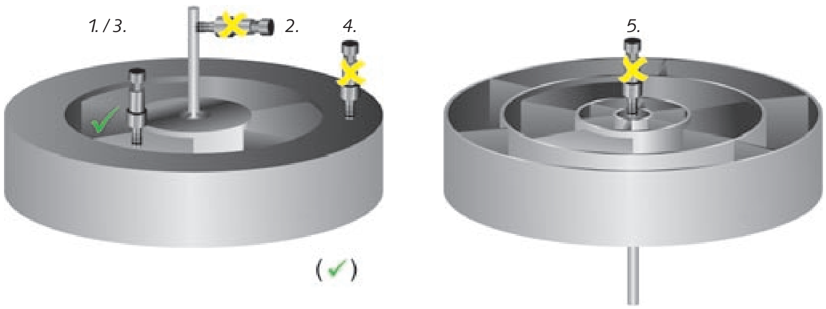
1. The cavity pressure sensor should be installed near the gate, where the pressure in the molded part is highest. The closer the sensor is positioned to the gate, the more detailed the delivered process information.

2. The sensor must be installed within the cavity and not in the gate. Sensors installed in the gate will fail to transmit signals and monitor the process during the residual cooling phase after the gate has been sealed or after the onset of shrinkage.

3. If possible, the sensor should be positioned at the thickest cross section of the molded part where the melt solidifies last and the duration of the pressure is most extensive.

4. The installation of a second sensor away from the gate for measuring large parts with a critical flow path/wall thickness ratio is recommended for the acquisition of additional part quality data.

5. Sensors must not be installed directly opposite the gate as they will measure an additional dynamic force component which will override and distort the cavity pressure signal.



Using the mold cavity pressure in practical applications

Cables ensure the accurate transmission of all signals from the sensor to the mold connector, from the mold to the charge amplifier and from the charge amplifier to the injection molding machine or to the electronic analysis equipment. In order to accommodate a wide variety of customer requirements, Kistler provides an extensive range of different connecting and extension cables.

Connecting cable: From the sensor to the plug
Kistler pressure sensors are available with classic two-wire coax cables or with the new single-wire technology. Two-wire coax cables have a connector plug at the end, which needs to be accommodated in the mold. The new technology cable has only one wire and the connector plug is no longer integrated into the cable (see info-box "Single-wire technology"). Two-wire technology *(Fig. 1)* is being increasingly replaced by single-wire technology *(Fig. 2)*.

For more information on this topic, please refer to p. 49

Extension cable: From the connector plug to the charge amplifier
The sensor's connector plug is mounted on the outside of mold. The cable must connect the connector plug with the charge amplifier, which is usually firmly installed in the injection molding machine, or with DataFlow, Kistler's analysis system. For this application, Kistler provides extension cables in a variety of designs, depending on the production environment and the distance to be covered, and a wide range of different sheathings, colors and cable length *(Fig. 3, 4)*.

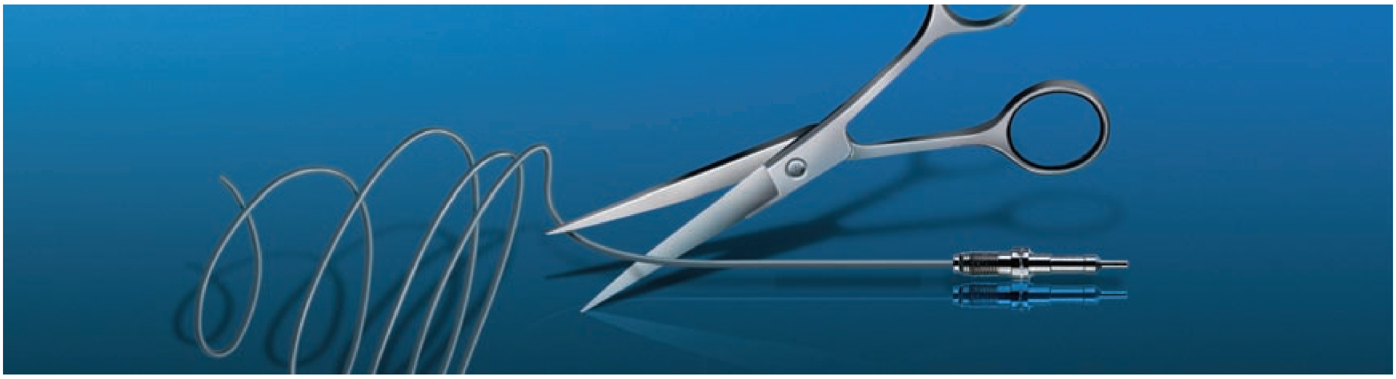
For more information on this topic, please refer to p. 50

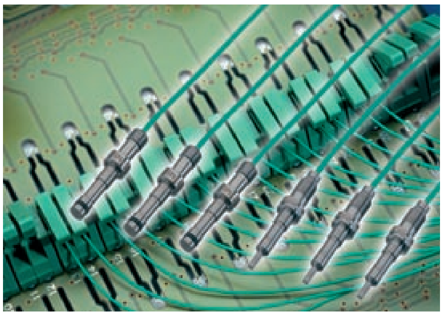
Connection cable: From the charge amplifier to the machine or analysis equipment
The charge amplifier and downstream equipment are linked using a connecting cable. This cable is equipped with a connector for the multi-pin input socket of the charge amplifier and compatible interfaces to the injection molding machine or PC cards for signal processing by a notebook or a PC *(Fig. 5, 6, 7)*.

For more information on this topic, please refer to p. 51

Fig. 1 *Fig. 2* *Fig. 3* *Fig. 4* *Fig. 5* *Fig. 6* *Fig. 7*

Connecting: Safe transmission with suitable cables





Single-wire technology
Conventional two-wire connecting cables are being increasingly replaced by single-wire technology. The new technology cable has only one wire without shielding and the connector is no longer integrated into the cable. The shielding is provided by the injection molding machine instead. Maxwell's law, established by James Clerk Maxwell in 1864, explains why this new technology yields the same measuring results as the old approach. Similar to the conditions in Faraday's cage, there are no electric fields in the drilled hole or well of the injection mold. Faraday's cage prevents interference from external sources such as electric motors or hot runners. This has been proven to be valid by scientific research as well as by the successful industrial application of single-wire technology.

The single-wire cable has a very small diameter and can be flexibly installed in drilled cable ducts and cut to length as required. A special cut-and-grip system, which is fully integrated into the connector, helps to attach the connector to the cable. As single-wire technology is used with standard connecting cables and standard charge amplifiers, it does not incur any additional investment costs. Easier handling cuts mold costs. Single-wire technology also requires less engineering and significantly facilitates sensor installation. The service-friendly design guarantees easy handling during potential mold or sensor changes. Another decisive advantage: as operators can repair single-wire cables themselves, maintenance costs for mold cavity pressure measurement are significantly lower.

Sensors used for multi-cavity molds with more than four cavities can be connected to a mold-mounted charge amplifier without a connector by using the cut-and-grip technique. This method has the advantage of reduced space requirements on the mold as well as particularly short sensor installation and set-up times. There is no more danger of mixing up cables. The multi-cavity system (Type 6829A...) is comprised of charge amplifiers and sensors.

Advantages

The most important benefits of single-wire technology:

+ Cost-efficient mold preparation
+ The cables run through drilled holes
+ Easy installation with detachable connector
+ Mold makers can shorten cables as required
+ The technology is fully compatible with other cables and existing electronic equipment
+ Broken cables can be repaired by the operator
+ Small cable diameters allow easy installation in multi-cavity molds

For more information on this topic, please refer to p. 23

Using the mold cavity pressure in practical applications

Charge amplifiers convert charges transmitted by a piezoelectric pressure sensor into a proportional voltage, which can be used as an input variable for monitoring and control processes. Smart charge amplifiers can also utilize specific algorithms to transmit signals, e.g. for a cavity-pressure related change-over of injection molding machines.

The cavity pressure related change over from the injection phase to the holding pressure phase is a standard feature of modern injection molding machines. The cavity pressure sensor is connected to the control system via a charge amplifier, which is encased in a sturdy housing. The charge amplifier's output signals are analog and immediately available via an analog/digital converter card (A/D converter). The real-time operation of charge amplifiers even allows the control of high-speed processes based on cavity pressure.

In addition to the cavity pressure, the part surface temperature is another important process parameter used for process monitoring. During machine start-up, it can detect that the process is stationary and start the production process.

For more information on this topic, please refer to p. 55

Kistler supplies a wide range of different charge amplifiers. While Type 5039... is a pure single-channel charge amplifier, the new generation starting with Type 5155… is equipped with several channels for charge and temperature. The 1, 2 and 4-channel amplifiers have identical housings and connector with an identical pin layout. Even for changing configurations, the integration effort is therefore reduced to a minimum.

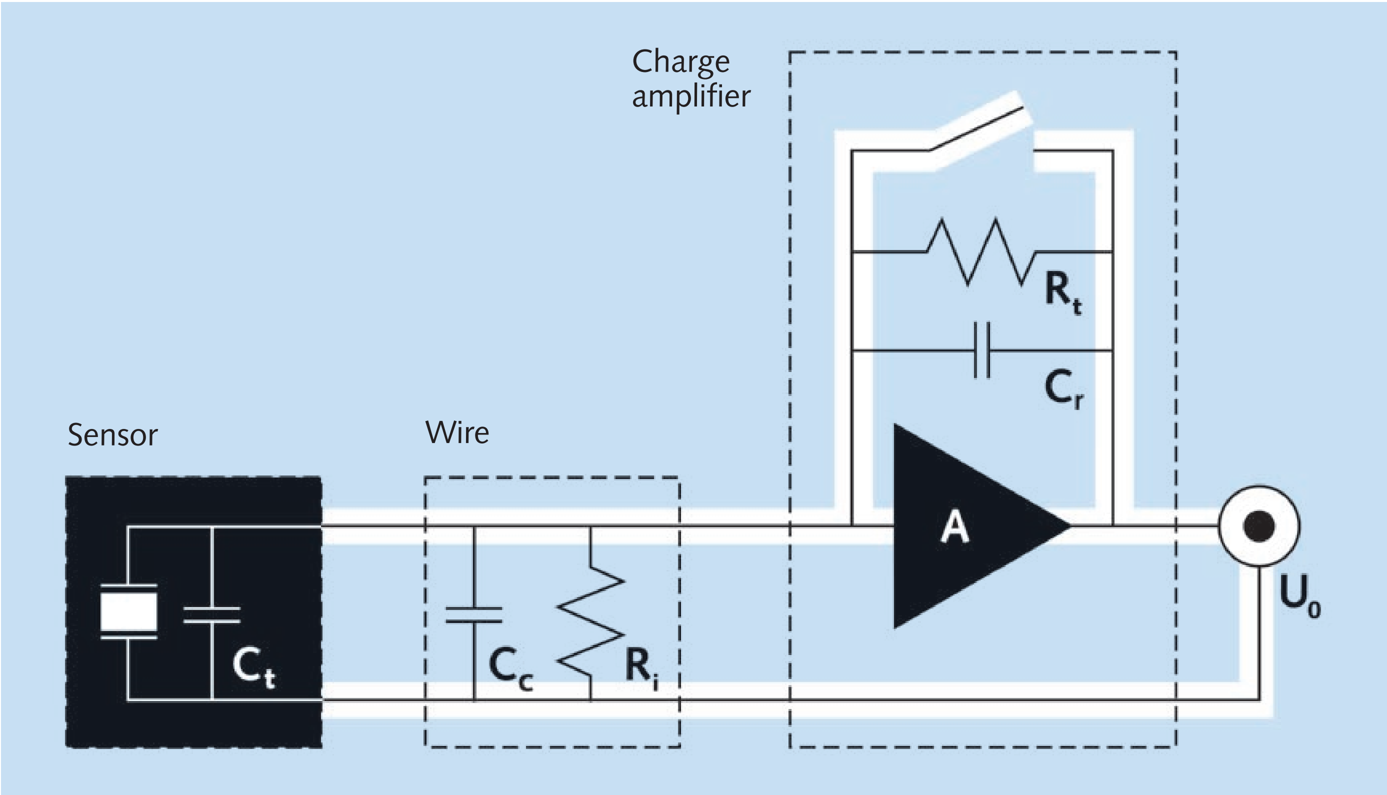
Charge amplifiers are prerequisite to cavity pressure measurement. In order to accommodate the wide variety of control hardware it is recommended that injection molding machine manufacturer supply suitable charge amplifiers with the machine.

Type 5049A...

Type 5039A...

Type 5155A...

Amplifying: From charges to signals



Smart charge amplifiers
Charge amplifiers with smart algorithms, which enhance the amplifying process, can generate control signals from the cavity pressure profile and the contact temperature. These are used as input values for injection molding machines, where they serve to increase the repeatability of the injection molding process in order to ensure the reliable production of high quality parts.

Based on the cavity pressure upon volumetric filling of the cavity, smart charge amplifiers automatically generate a signal which causes the injection molding machine to change-over from injection to holding pressure. Used in conjunction with temperature measurement equipment, these amplifiers can cut the machine's residual cooling time to the required minimum and determine the demolding point in a self-optimizing operation.

The following chapter provides detailed information on smart charge amplifiers of the SmartAmp brand supplied by Kistler.

Type 2859A... PiCo

Using the mold cavity pressure in practical applications

Smart charge amplifiers use algorithms for the self-optimizing change over from injection pressure to holding pressure or for automatically reducing the residual cooling time to the required minimum. A convenient software tool can be used to document the measured pressure and temperature values for the purpose of process optimization and quality control.

SmartAmp: Self-optimizing change over
The change-over point is an important process parameter with a significant effect on the quality and production cost of the molded part. The change over from injection to holding pressure must be executed in conjunction with a volumetric cavity filling.

Traditional methods use the injection time, the screw stroke or the hydraulic pressure to determine the change-over point. All these methods operate according to the same principle, which involves the definition of a threshold to trigger the change-over. A suitable threshold is determined manually by means of repeated fillings without holding pressure. This approach is time-consuming, costly and has two major disadvantages:

- Modification of the injection profile requires a changing or reestablishing the threshold
- As the change-over point does not account for process or material fluctua tions, the change-over is delayed or triggered prematurely

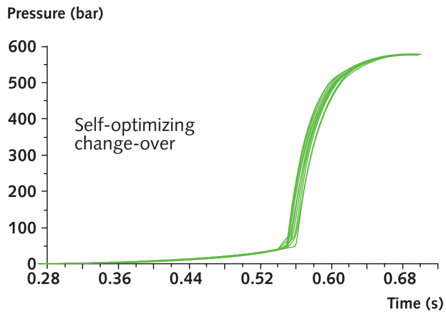
The cavity pressure profile yields accurate information on the volumetric filling process. Independent of the mold geometry, the cavity pressure rises dramatically after the holding pressure phase due to the compression of the melt. This kink in the curve has its starting point exactly at the onset of the volumetric filling process. Therefore, it is ideal for triggering the change-over process in the machine.

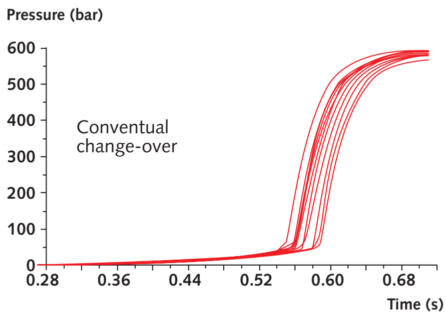
Kistler has developed an algorithm, which is integrated into the SmartAmp charge amplifier to analyze the cavity pressure profiles of a wide variety of different parts and determine the change-over point in real time. By using the cavity pressure, SmartAmp technology with "self-optimizing change-over" identifies the change-over point in a fully automatic and self-optimizing procedure. The signal transmitted by the SmartAmp triggers an automatic change-over from injection to holding pressure.

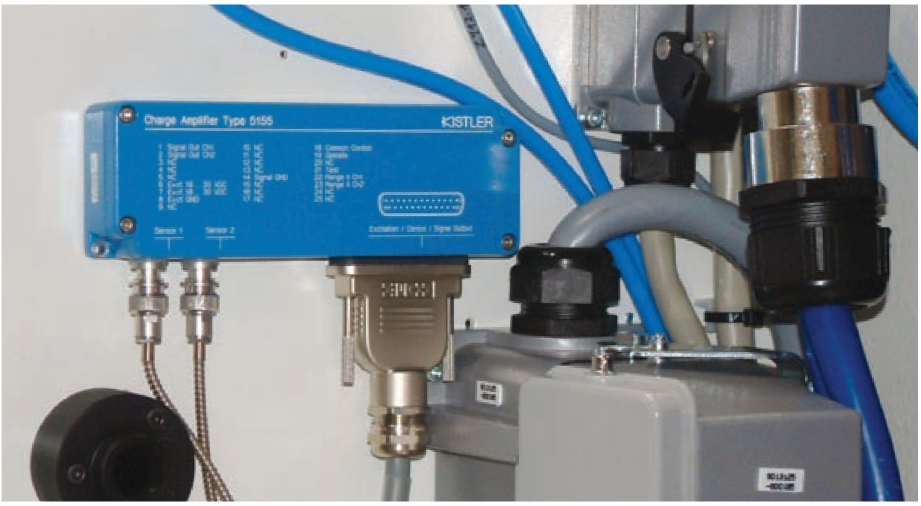
The self-optimizing change-over process is preceded by a fully automatic learning phase, which lasts 4 to 16 production cycles. This period is used to determine optimum parameters for the algorithms integrated into the charge amplifier.

The system significantly reduces the reject quota and controls the effects of batch variations on the process during the cycle. Due to the automatic recognition of the change-over point, which dispenses with the repetitive process of mold filling studies, the SmartAmp significantly facilitates mold set-up.

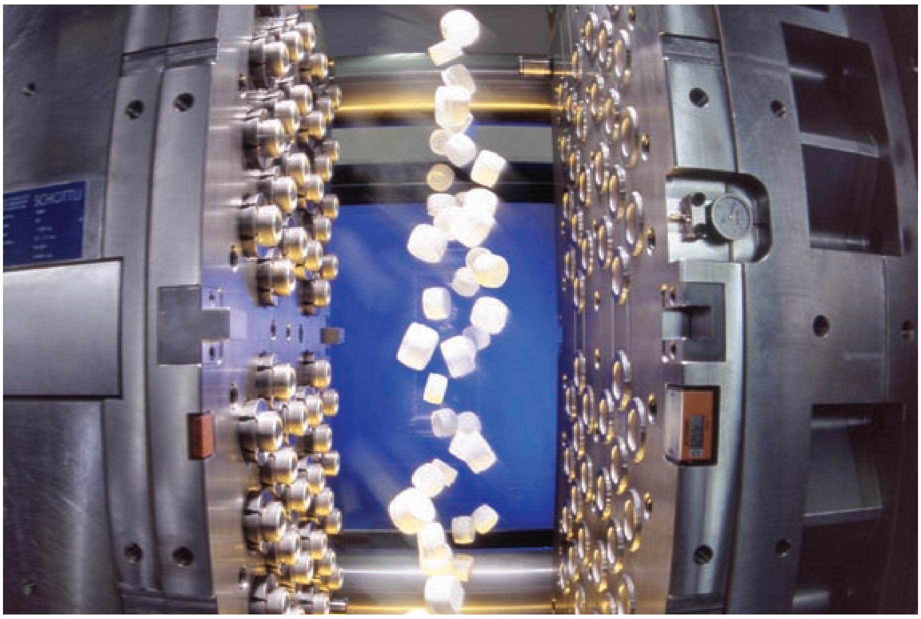
SmartAmp technology is integrated into the Type 5049A... one-channel charge amplifier and into the Type 5155A... multichannel charge amplifier.







Analyzing: Automatic optimization of injection molding processes



Advantages

Automatic recognition of the change-over point

+ Shorter set-up times
+ Automatic compensation of viscosity variations
+ Automatic compensation of process variations
+ Highly stable process

Automatic cooling time calculation

+ A significantly improved efficiency due to a reduction of cycle cooling times
+ A constant demolding temperature guarantees a reliable temperature-related part quality and a constant profile of the cavity wall temperature

Automatic cooling time calculation
Scientific studies have revealed that the majority of injection molding processes is carried out with excessive cooling times. The cooling time used during the injection molding of thermoplastic materials is determined empirically or estimated with the help of the cooling time formula and then entered into the machine's control system as a constant parameter. In order to compensate for process variations such as changes in the temperature or control-related variations to ensure a sufficiently safe production, the set cycle time often exceeds the required minimum by between 10% and 20%. This approach is detrimental to an efficient production process.

Another disadvantage of time-constant demolding is a fluctuation in the quality of the molded part, as it cannot compensate for variations in the process, the machine control and the material. These deviations, however, can have an adverse effect on warpage, dimensional stability and other properties.

Based on the part surface temperature and the mold cavity pressure, the SmartAmp technology involving automatic cooling time measurement (status-related demolding) determines the optimum cooling time for each individual cycle and transmits an analog signal to open the mold. In this way, the optimum cooling time is set for each individual cycle in order to guarantee constant temperature-related part quality while the production runs with maximum efficiency.

Self-optimizing part removal is available as an option to the Type 5155A... family of charge amplifiers. It can be integrated into the machine control system or used as additional equipment to be configured with the included Windows® software and a notebook computer. The injection molding machine must be equipped with a "mold open" input port to accommodate this application.

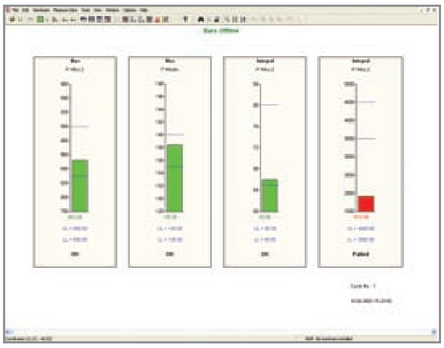
Kistler's combined pressure and temperature sensors are ideal for measuring the part surface temperature and the mold cavity pressure.

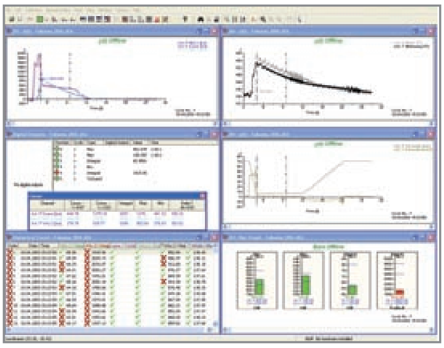
Using the mold cavity pressure in practical applications

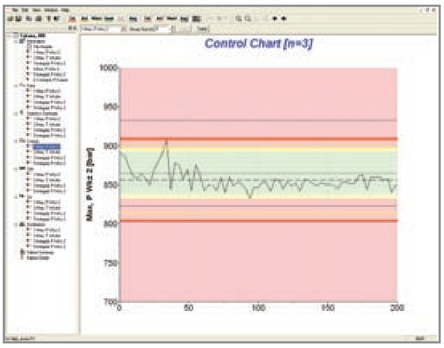
Kistler DataFlow
The optimum analysis of measured process data is prerequisite to the utilization of cavity pressure and part surface temperature measurement equipment. DataFlow provided by Kistler operates with tools which support users across the entire process chain from mold sampling, setup and process optimization to production monitoring including statistical analysis and documentation. These functions are based on the determination of the cavity pressure and the part surface temperature. Additional information such as the hydraulic pressure can also be processed.

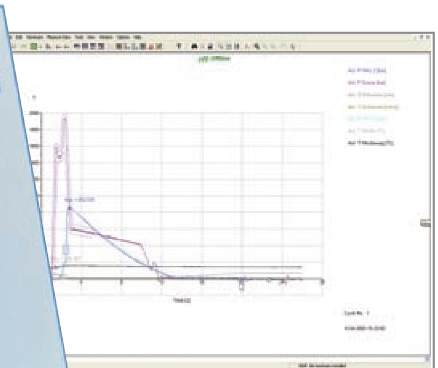
DataFlow is easy to operate as it runs on conventional personal computers or notebooks under Windows XP® and Windows 2000®. Used in conjunction with Kistler electronic equipment (Type 2859A and 2853A signal conditioners or Type 6829A multi-cavity systems), DataFlow offers a comprehensive optimization and documentation system for all injection molding processes, which also accommodates multi-component techniques and multi-cavity family molds.

DataFlow can control equipment such as reject gates and reversible belt conveyors or operate robot placing processes to ensure that all parts are separated into rejects and good parts. The networking capability of the included statistics tool provides production data where it is needed, e.g. for production planning, control or quality assurance.









Analyzing: Optimizing, monitoring and documenting injection molding processes

Dataflow provides a range of tools across the entire process chain:

During **mold sampling and optimization**, DataFlow provides process data in a variety of different graphics in order to speed up the mold sampling process and to utilize the full optimization potential.

During **process optimization**, DataFlow can be used to determine process tolerance limits and to evaluate processing properties based on the measured data. In this way, the system reduces mold sampling times and ensures a fast optimization of the process. The determined tolerance limits can be used for monitoring part properties and quality assurance during the production process and dispense with the need for manual examination.

During **mold set-up**, cavity pressure reference curves can be stored. Optimized molds can be operated fast and efficiently on different machines and the optimum operating point can be determined quickly.

During **production**, DataFlow will calculate maximum values, integrals, which can be defined as required, the filling index and the injection force from the measured process data. Moreover, the system allows the definition of tolerance ranges. Transgression of these tolerance ranges by the values recorded from the current process will either trigger an optical notification or lead to an activation of the reject gates or robots.

DataFlow provides automatic **quality control** and integrates it into the process. Trend graphics can predict errors in the active production process to eliminate them. Networking statistics allow statistical production analysis (cp, cpk values, production distribution) for the purpose of documentation. Automatic reports provide a documentation of quality for customers. Statistics data generated by DataFlow can be used to detect and eliminate weak points in the production process and help to determine the reject quota while the production monitoring function can then be used to directly identify the cause of excessive rejects.

Using the mold cavity pressure in practical applications

Sensors for cavity pressure and part surface temperature measurement

Direct Measurement

Variable	Pressure					Pressure and temperature	Temperature
Pressure range	Standard		Low pressure			Standard/ low pressure	
Process	Injection molding				Reaction IM	Injection molding	Injection molding
Material	Thermo-plastics	Thermosets Elastomers LSR	Thermoplastics	Thermosets Elastomers LSR	RIM	Thermoplastics	Thermoplastics Thermosets Elastomers LSR
Front-ø (mm) Sensor							
9,5					4079A...		
6	6152A...	6152A...	6172A...	6172A...			
4	6157B... 6155AE	6157B...	6177A...	6177A... 6167A...		6190A...	6192A...
2,5	6158A... 6159A... 6182AE		6178A...				6194A... 6195A...
1	6183AE						6193A...

The sensors type 6152A..., 6157B..., 6159A..., 6167A..., 6182AE and 6183AE with single-wire-technology can be used in the 6829A multi-cavity system.

Indirect pressure measurement

Dimensions (mm)	
ø 12,6	9204B...
ø 6	9211A... 9213A...
12,6 x 9,5	9221A...
6 x 6	9223A...

Note: The Type numbers listed in the tables describe the sensors.

Sensors for cavity pressure measurement

Sensor cables

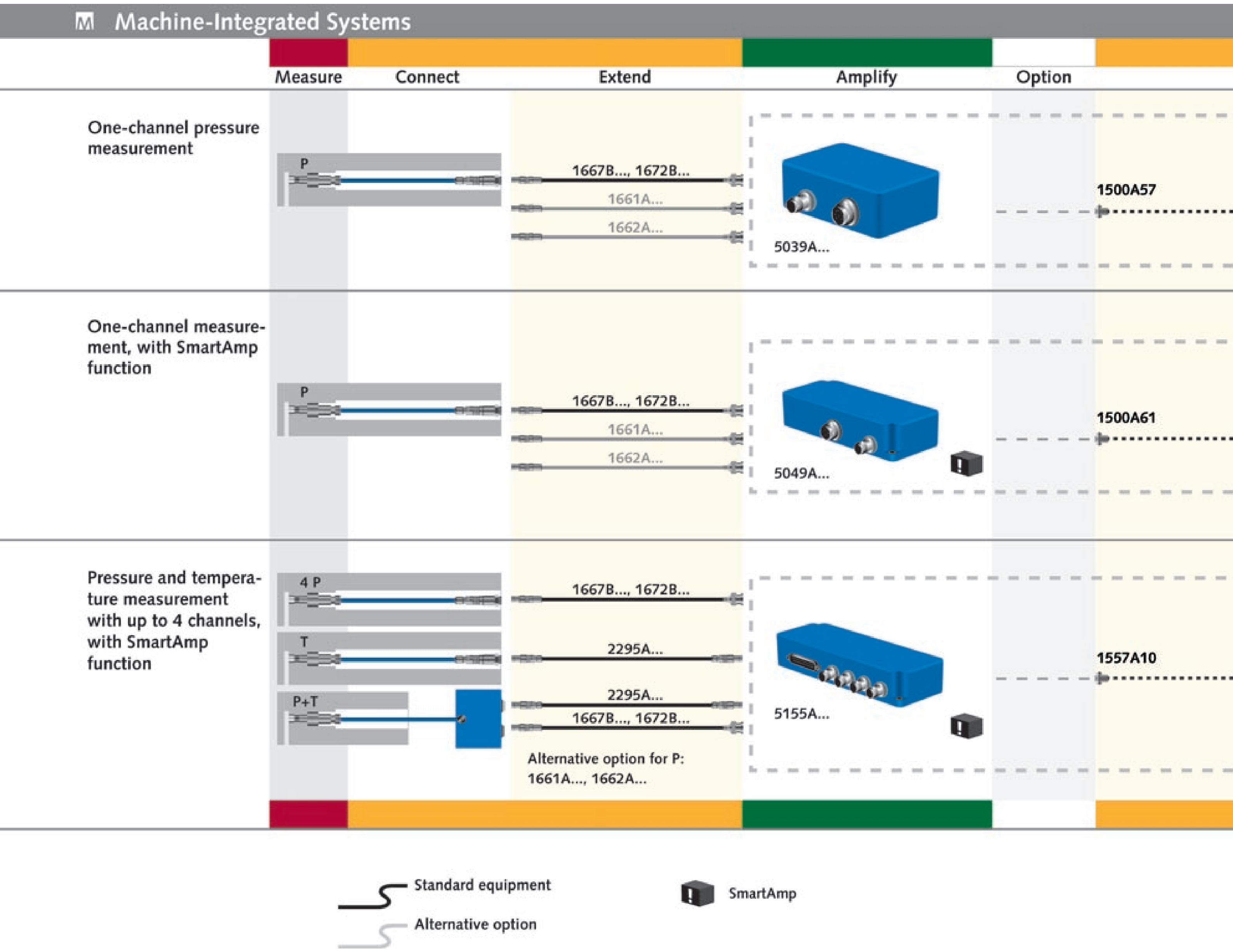
Sensors Type	Connecting Cables Type	Extension cables Type
4079A...	integral	4767A...
6152AA..., 6152AC...	1961A..., 1963A...	1667B..., 1672B..., 1661A..., 1662A...
6152AB..., 6152AD...	1955A...	1667B..., 1672B..., 1661A..., 1662A...
6152A...E	1666A1, 1666A3	1667B..., 1672B..., 1661A..., 1662A...
6155AE	integral	1667B..., 1672B..., 1661A..., 1662A...
6157BA..., 6157AC...	1961A..., 1963A...	1667B..., 1672B..., 1661A..., 1662A...
6157BB..., 6157BD...	1955A...	1667B..., 1672B..., 1661A..., 1662A...
6157B...E	1666A1, 1666A3	1667B..., 1672B..., 1661A..., 1662A...
6158A...	integral	1667B..., 1672B..., 1661A..., 1662A...
6159A...	1645C..., 1963A...	1667B..., 1672B..., 1661A..., 1662A...
6159A...U6	1645C..., 1963A...	1667B..., 1672B..., 1661A..., 1662A...
6159AE	1666A2, 1666A4	1667B..., 1672B..., 1661A..., 1662A...
6167A...	1645C..., 1963A...	1667B..., 1672B..., 1661A..., 1662A...
6172A...	1645C..., 1963A...	1667B..., 1672B..., 1661A..., 1662A...
6172A...E	1666A2, 1666A4	1667B..., 1672B..., 1661A..., 1662A...
6177A...	1645C..., 1963A...	1667B..., 1672B..., 1661A..., 1662A...
6177A...E	1666A2, 1666A4	1667B..., 1672B..., 1661A..., 1662A...
6178A...	1645C..., 1963A...	1667B..., 1672B..., 1661A..., 1662A...
6178A...E	1666A2, 1666A4	1667B..., 1672B..., 1661A..., 1662A...
6182AE	integral	1667B..., 1672B..., 1661A..., 1662A...
6183AE	integral	1667B..., 1672B..., 1661A..., 1662A...
6190A...	integral	1667B..., 1672B..., 1661A..., 1662A..., 2290A..., 2295A...
6192A...	integral	2290A..., 2295A...
6193A...	integral	2290A..., 2295A...
6194A...	integral	2290A..., 2295A...
6195A...	integral	2290A..., 2295A...
9204B...	1645C...	1667B..., 1672B..., 1661A..., 1662A...
9211A...	integral	1667B..., 1672B..., 1661A..., 1662A...
9213A...	integral	1667B..., 1672B..., 1661A..., 1662A...
9221A...	1645C...	1667B..., 1672B..., 1661A..., 1662A...
9223A...	1645C...	1667B..., 1672B..., 1661A..., 1662A...

Using the mold cavity pressure in practical applications

Sensors, cables, charge amplifiers and electronic analysis equipment must be combined in an efficient way. Only the perfect interaction of all components across the measurement chain can ensure a stable operation of the cavity pressure measurement system to the full benefit of the user.

Measuring chains are comprised of sensors, connection cables, extension cables if required, charge amplifiers and analysis equipment. The chains are used to set up control circuits for monitoring, optimizing and controlling injection molding processes and for documenting the acquired process data.

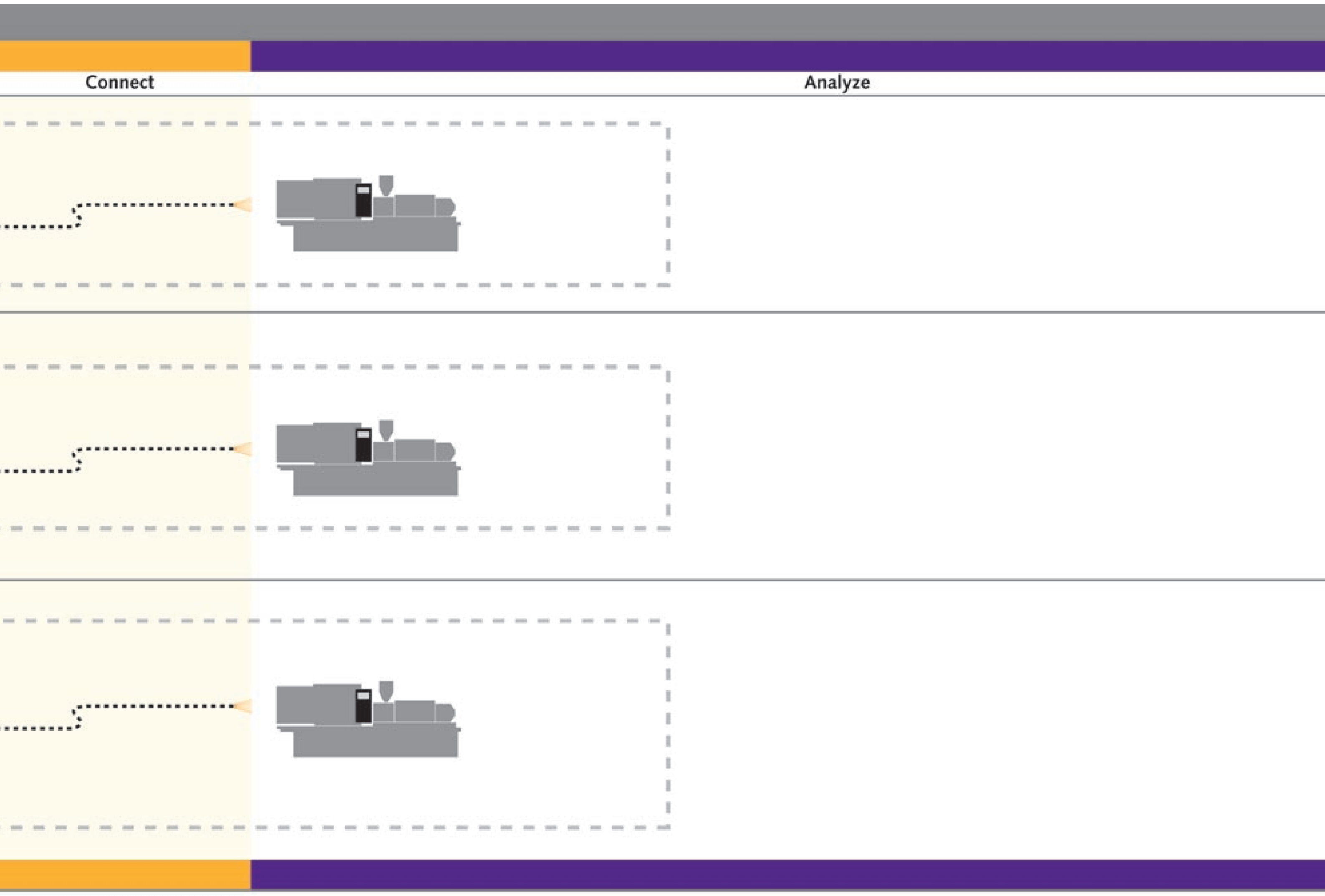
Machine-integrated systems
Machine-integrated systems acquire measuring data and/or transmit switching signals to the machine's control unit. These systems are available with one channel for pressure measurement or with multi-channel systems for combined pressure and temperature measurement. The charge amplifiers are integrated into the injection molding machine. The machine's control system is responsible for process documentation.



Measuring chains for cavity pressure measurement

Mobile systems
While mobile systems operate independently of the injection molding machine, they can still process signals transmitted by the machine for analysis and actively transmit switching signals to the machine. An external PC or notebook computer equipped with Kistler DataFlow software is responsible for controlling the process. Mobile systems are available with one channel for pressure measurement or as multi-channel systems for combined pressure and temperature measurement. As they can be used for different injection molding machines, they offer the benefit of accommodating existing molds modified with cavity pressure measurement systems.

Multi-cavity pressure measurement systems
Multi-cavity systems compile pressure measurement data from up to 32 cavities in one charge amplifier. While they operate independently of the injection molding machine, they can still process signals transmitted by the machine for analysis and actively transmit switching signals to the machine. An external PC or notebook computer equipped with Kistler DataFlow software controls the process. As mobile systems they can be used on different injection molding machines.

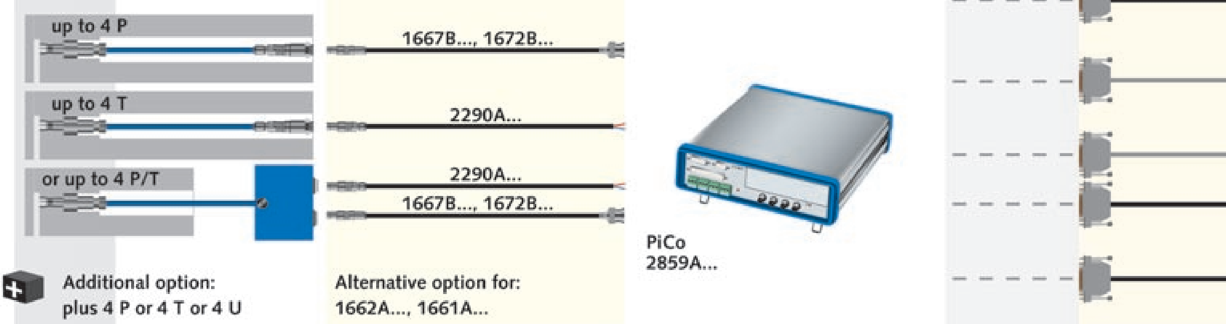


Mobile Systems

Measure | Connect | Extend | Amplify | Option

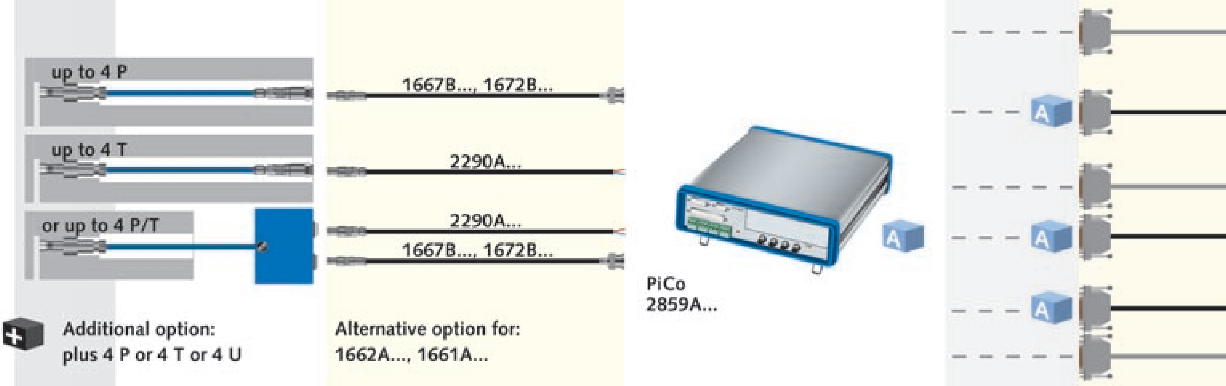
Data acquisition with up to 12 channels

For desktop PCs



Data acquisition with up to 12 channels

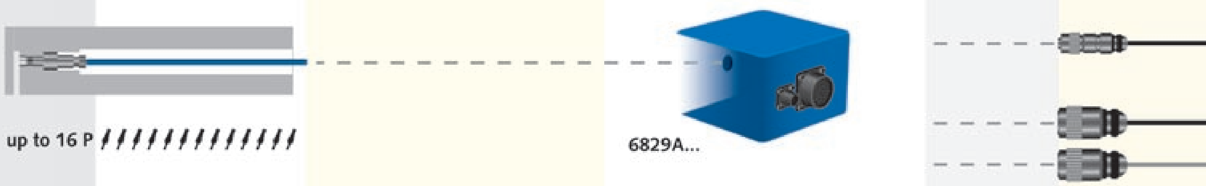
For notebooks



Multi-cavity systems for pressure measurement

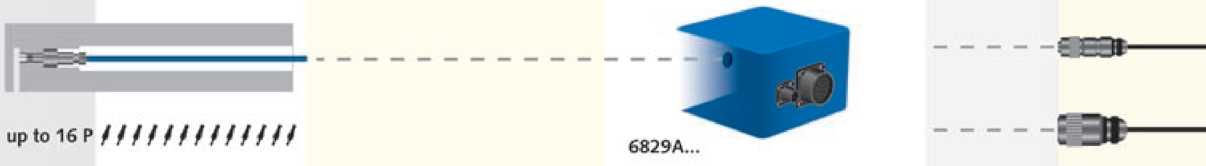
Data acquisition with up to 16 channels

For desktop PCs



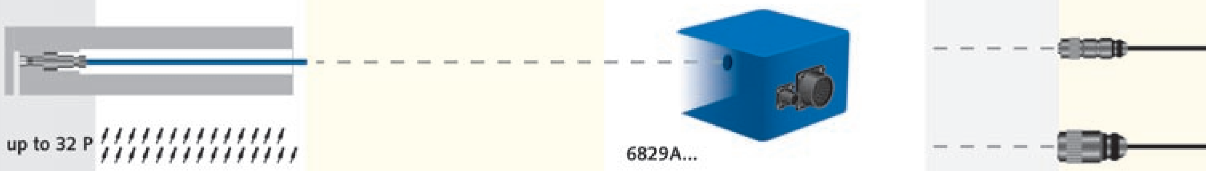
Data acquisition with up to 16 channels

For notebooks



Data acquisition with up to 32 channels

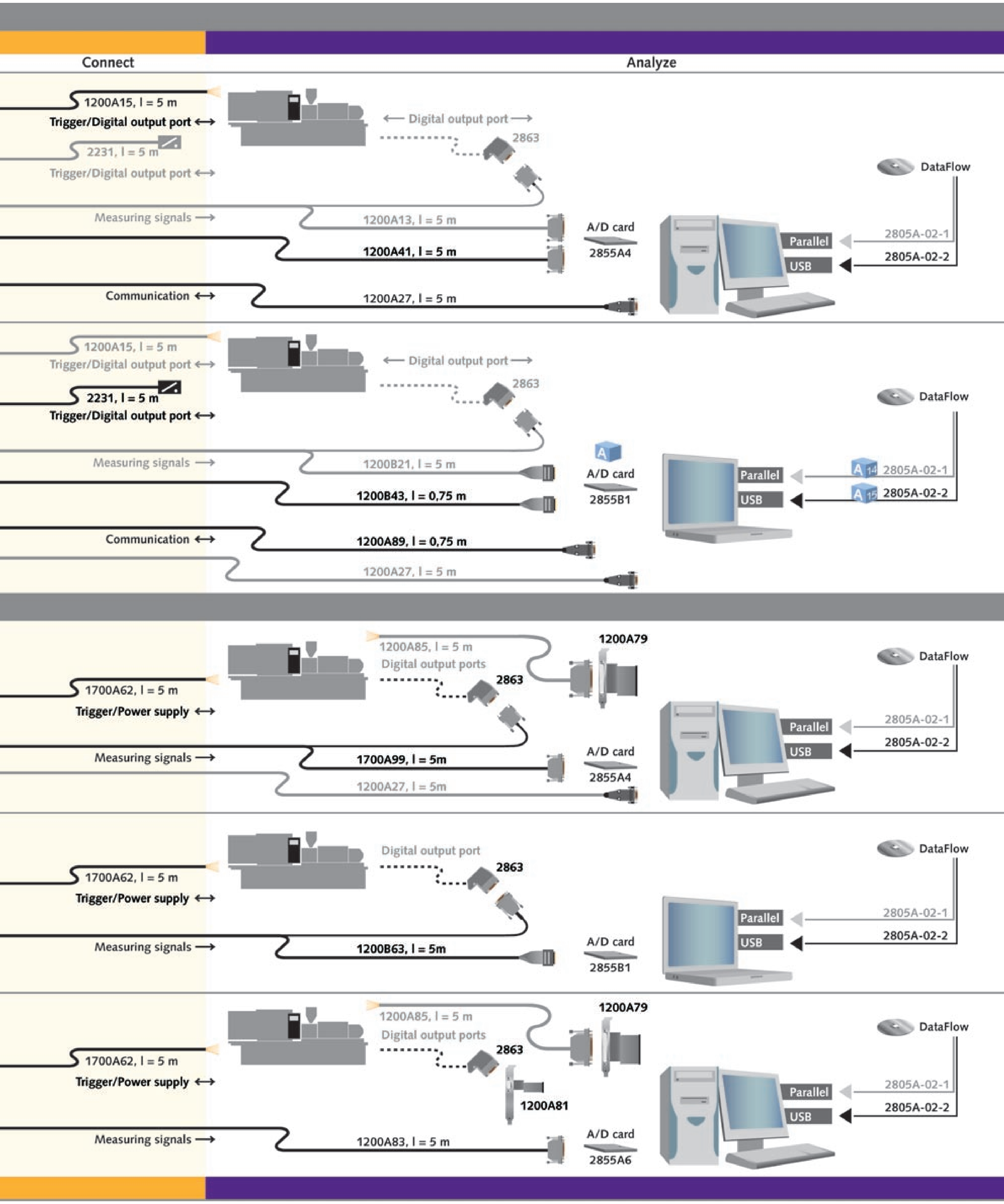
For desktop PCs



Standard equipment

Alternative option

Additional option



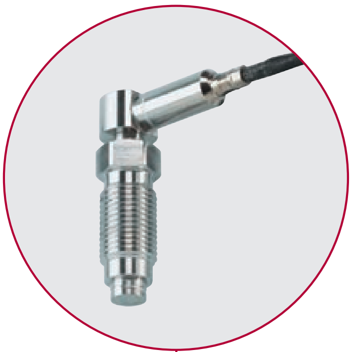
Package: 2859A10 + 2231 + 1200B43 + 1200A89 + 2855B1 + 2805A...

A14: With copy protection on parallel interface

A15: With copy protection on USB interface

Sensors and systems for injection molding machines

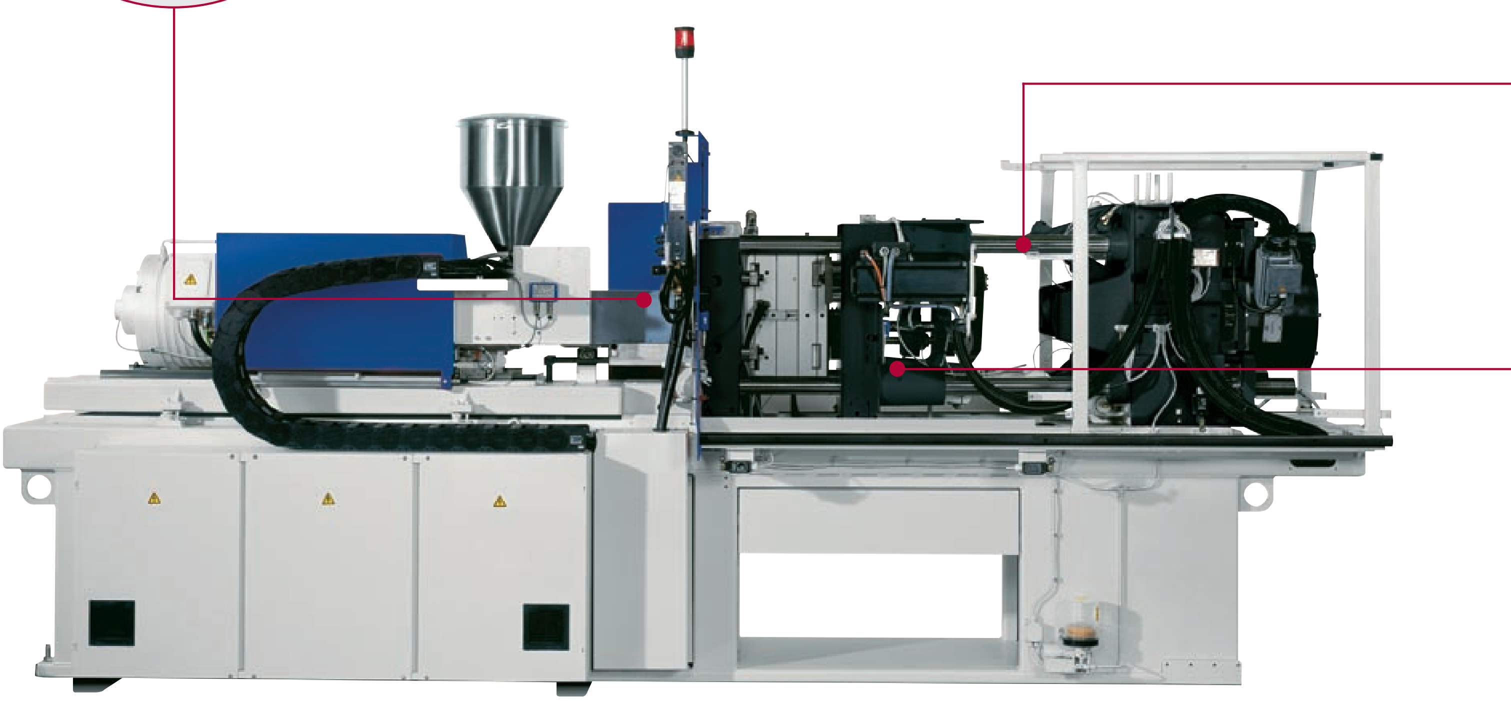
In addition to the measurement and utilization of the cavity pressure, there is a wide range of other forces such as the nozzle pressure, the tie bar extension and the clamping force to be measured during the operation of an injection molding machine. Measurement of these forces is important in view of the acceptance of electric injection and beyond.



Measuring the melt pressure

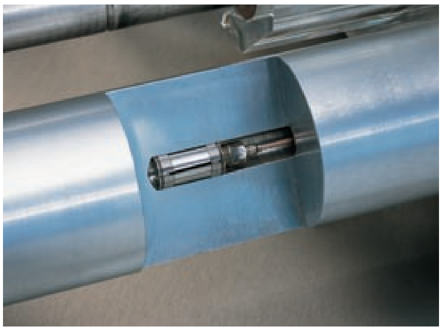
In view of recent developments in the area of electric injection molding machines, the measurement of the melt pressure has become increasingly important, as classic control parameters such as the hydraulic pressure are no longer available. As measurement sensors recording the current consumption or the torque are located at a distance from the mold, they are not as suitable for accurate control functions as the direct measurement of the melt pressure in the area in front of the screw. The Type 4013A… sensors provide fast high-precision measurement, which meets all requirements of electric injection molding machines.

The piezoresistive sensors, which can be used for pressures of up to 3 000 bar and temperatures of up to 350 °C, deliver detailed process information and are also suitable for process monitoring with hydraulic machines. Further areas of application for these sensors include pressure measurement in hot-runner systems.
In addition to pressure monitoring in the hot-runner, the acquired information can be used for control purposes. The sensor can be equipped with a temperature measurement feature for a precise determination of the melt temperature directly on the sensor's measuring component.



Measurement of the forces applied on the moving mold half of injection molding machines helps determine the machine's clamping force, and protects both the mold and the machine. Kistler force measurement systems are used to determine both the very high clamping forces and the very low mold movement forces.

Two methods of force measurement are suitable: the first method, measurement of the tie bar extension, is taken from structural machine elements, while the second method, measurement of the surface extension, is taken from areas such as the toggle clamp connecting rod.



Measuring the tie bar extension

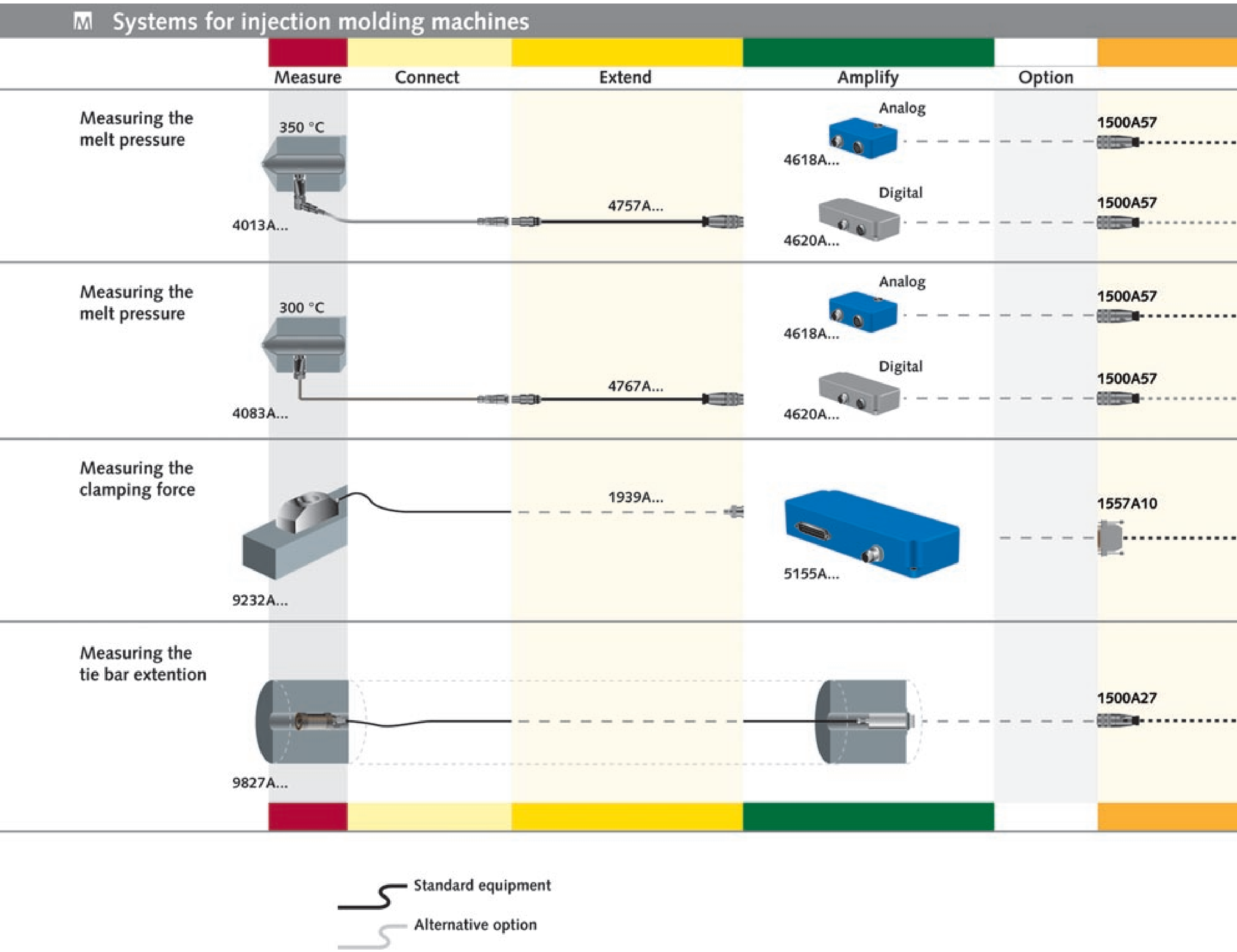
Measurement of the tie bar extension involves the installation of Type 9827A… sensors directly into the drilled holes in the tie bar. They transmit a signal which is proportional to the force. Only one sensor is sufficient for a precise determination of the clamping force and all mold movement forces. The forces measured during mold movement that can be used for protecting the mold.

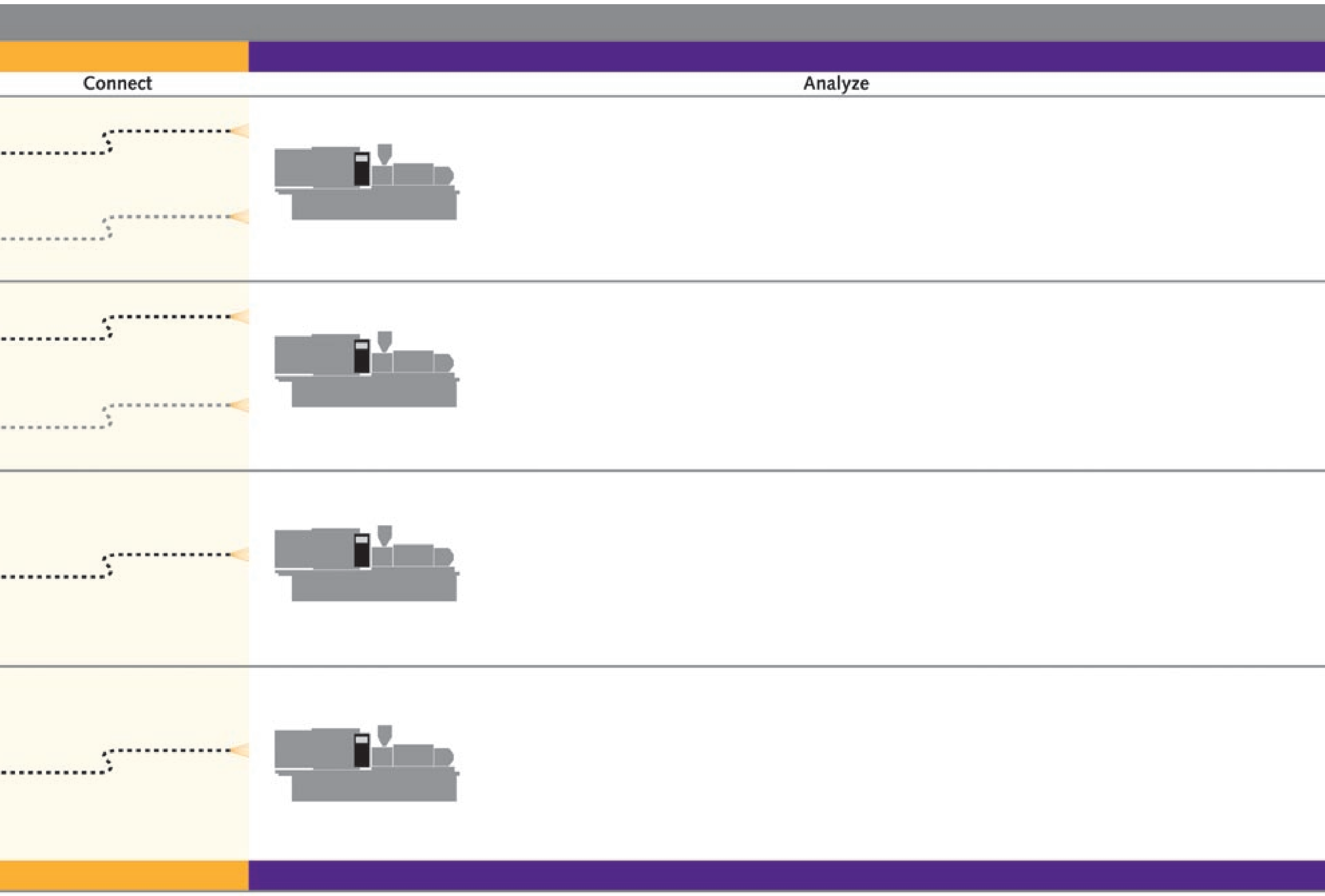
Equipping all tie bars with a sensor allows the measurement of forces on the individual tie bars to ensure parallelism of the mold platens and the mold itself, detection of overloads in individual tie bars and the active prevention of cracks in the tie bars. The charge amplifier required for this application is included in the Type 9827A... measuring chain.

Measuring the clamping force and mold protection

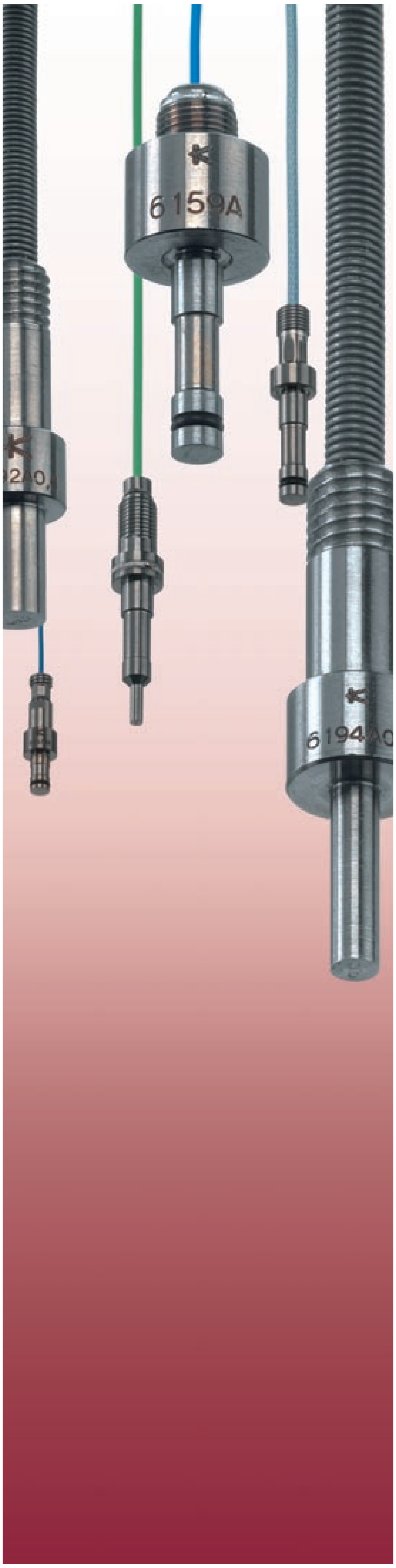
Measurement data on the surface extension mounting acquired from a sensor on structural machine components such as the toggle clamp connecting rod can be used for direct determination of the clamping force and for the purpose of mold protection, as the measured extensions are proportional to the active forces. Type 9232A sensors are mounted to the machined surface with a M6 screw. Due to the high linearity of the signal, this measurement method can be applied by using only one single sensor for measuring both the high clamping forces and the low mold movement forces. The charge amplifiers have been adapted to suit specific machinery.

Sensors and measuring chains for injection molding machines




Connect
Analyze

Measuring



The cavity pressure built up during injection molding processes can be measured directly, indirectly or in combination with the contact temperature. During direct measurement the sensor touches the plasticized material within the cavity to determine the pressure directly, without the use of transmission pins.

Alternatively, the force can be measured behind an ejector pin or measuring pin and translated into the actual pressure using the pin diameter. In addition to this, Kistler offers special sensors for molds with inserts.

Combined pressure-temperature sensors measure both the mold cavity pressure and the contact temperature at the exact same location on the molded part. Kistler sensors for temperature measurement alone are compatible with standard mold cavity pressure sensors.

In addition to the measurement and utilization of the cavity pressure, there is a wide range of other forces such as the nozzle and hot-runner pressure, the tie bar extension and the clamping force to be measured during the operation of an injection molding machine. For these measuring tasks, Kistler also provides optimized sensors to suit specific applications.

Direct cavity pressure measurement

Direct cavity pressure measurement (low-pressure processes)

Direct cavity pressure and contact temperature measurement

Direct contact temperature measurement

Indirect cavity pressure measurement

Melt pressure and temperature sensor systems

Clamping force measurement and mold protection

Tie bar extension

Direct mold cavity pressure measuring

Front diameter 6 mm Unisens

Technical Data		Type 6152AA...	Type 6152AC...
Measuring range	bar	0 ... 2 000	0 ... 2 000
Overload	bar	2 500	2 500
Sensitivity	pC/bar	-9,4 (Unisens)	-9,4 (Unisens)
Cable length	m	0,2 / 0,4 / 0,6 / 0,8 / sp* / single-wire**,***	0,2 / 0,4 / 0,6 / 0,8 / sp*/ single-wire**
Exchangeable cable		yes	yes
Connector		Fischer 1 pin neg.	Fischer 1 pin neg.
Machineable front		yes	no
Coated front		no	yes
Service temperature Melt (at the front of the sensor)	°C	<450	<450
Mold (sensor, cable)	°C	0 ... 200	0 ... 200
Connection	°C	0 ... 200	0 ... 200
Options			
Silicone-filled gap		6152AAA...	6152ACA...

Properties
The diaphragm-free piezoelectric sensor has a sleeve design. Unisens technology allows an easy configuration of the measuring systems. Sensor Type 6152AC... is a coated variation of sensor Type 6152AA... .

Areas of Application
Sensors suitable for thermoplastics, thermoset materials, elastomers and LSR. The sleeve design is practical for large molds with pressures in excess of 200 bar.

Accessories
Mounting nut Type 6453****
Spacer sleeve Type 6462
Dummy sensor Type 6552
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 6152A_000-028

Front diameter 6 mm for high-temperature applications Unisens

Technical Data		Type 6152AB...	Type 6152AD...
Measuring range	bar	0 ... 2 000	0 ... 2 000
Overload	bar	2 500	2 500
Sensitivity	pC/bar	-9,4 (Unisens)	-9,4 (Unisens)
Cable length	m	0,4 / sp*	0,4 / sp*
Exchangeable cable		yes	yes
Connector		Fischer 1 pin neg.	Fischer 1 pin neg.
Machineable front		yes	no
Coated front		no	yes
Service temperature Melt (at the front of the sensor)	°C	<450	<450
Mold (sensor, cable)	°C	0 ... 300	0 ... 300
Connection	°C	0 ... 200	0 ... 200

Properties
The diaphragm-free piezoelectric sensor has a sleeve design. Unisens technology allows an easy configuration of the measuring systems. Sensor Type 6152AC... is a coated variation of sensor Type 6152AB... .

Areas of Application
Sensors suitable for thermoplastics, thermoset materials, elastomers and LSR. The sleeve design is practical for large molds with pressures in excess of 200 bar and temperatures up to 300 °C.

Accessories
Mounting nut Type 6453****
Spacer sleeve Type 6462
Dummy sensor Type 6552
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 6152A_000-028

* customized length (l min. = 0.1 m / l max. = 5 m)
** single-wire cable length 1,5 m; Order key 6152AAE; 6152ACE
*** single-wire cable length 5 m; Order key 6152AAE1
**** included

Measuring

Direct mold cavity pressure measuring

Front diameter 4 mm Unisens

Technical Data		Type 6157BA...	Type 6157BC...
Measuring range	bar	0 ... 2 000	0 ... 2 000
Overload	bar	2 500	2 500
Sensitivity	pC/bar	-9,4 (Unisens)	-9,4 (Unisens)
Cable length	m	0,2 / 0,4 / 0,6 / 0,8 / sp*/ single-wire**,***	0,2 / 0,4 / 0,6 / 0,8 / sp*/ single-wire**
Exchangeable cable		yes	yes
Connector		Fischer 1 pin neg.	Fischer 1 pin neg.
Machineable front		yes	no
Coated front		no	yes
Service temperature Melt (at the front of the sensor)	°C	<450	<450
Mold (sensor, cable)	°C	0 ... 200	0 ... 200
Connection	°C	0 ... 200	0 ... 200

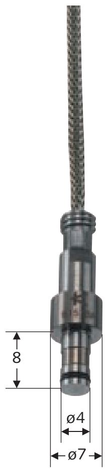
Properties
The diaphragm-free piezoelectric sensor. Unisens technology allows an easy configuration of the measuring systems. The sensor Type 6157BC... is a coated variation of the sensor Type 6157BA... .

Areas of application
Suitable for thermoplastics, thermoset materials, elastomers LSR at a pressure of more than 200 bar.

Accessories
Mounting nut Type 6457****
Spacer sleeve Type 6459
Dummy sensor Type 6545
Extension cable TNC
Type 1662A..., 1672B...
1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 6157B_000-030

Front diameter 4 mm for high-temperature applications Unisens



Technical Data		Type 6157BB...	Type 6157BD...
Measuring range	bar	0 ... 2 000	0 ... 2 000
Overload	bar	2 500	2 500
Sensitivity	pC/bar	-9,4 (Unisens)	-9,4 (Unisens)
Cable length	m	0,4/ sp*	0,4/ sp*
Exchangeable cable		yes	yes
Connector		Fischer 1 pin neg.	Fischer 1 pin neg.
Machineable front		yes	no
Coated front		no	yes
Service temperature Melt (at the front of the sensor)	°C	<450	<450
Mold (sensor, cable)	°C	0 ... 300	0 ... 300
Connection	°C	0 ... 200	0 ... 200

Properties
Diaphragm-free piezoelectric sensor. Unisens technology allows an easy configuration of the measuring systems. The sensor Type 6157BD... is a coated variation of sensor Type 6157BC... .

Areas of Application
Suitable for thermoplastics, thermoset materials, elastomers, LSR for a pressure of more than 200 bar and mold temperatures of more than 200 °C.

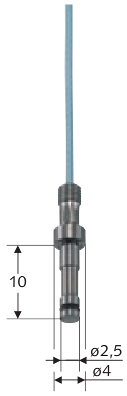
Accessories
Mounting nut Type 6457****
Spacer sleeve Type 6459
Dummy sensor Type 6545
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 6157B_000-030

* customized length (l min. = 0.1 m / l max. = 5 m)
** single-wire cable length 1.5 m; Order key 6157BAE; 6157BCE
*** single-wire cable length 5 m; Order key 6157BAE1
**** included

Direct mold cavity pressure measuring

Front diameter 2.5 mm



Technical Data		Type 6158A...	Type 6182AE
Measuring range	bar	0 ... 2 000	0 ... 2 000
Overload	bar	2 500	2 500
Sensitivity	pC/bar	-2,5	-2,5
Cable length	m	0,4 / sp*	1,5 single-wire
Exchangeable cable		no	no
Connector		Fischer 1 pin neg.	Fischer 1 pin neg.
Machineable front		yes	yes
Coated front		no	no
Service temperature Melt (at the front of the sensor)	°C	<450	<450
Mold (sensor, cable)	°C	0 ... 200	0 ... 200
Connection	°C	0 ... 200	0 ... 200

Properties
Diaphragm-free piezoelectric sensor with a small collar.

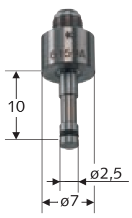
Areas of application
Suitable for thermoplastics. With its small dimensions, the sensor Type 6182AE is particularly suitable for multi-cavity molds and smaller parts.

Accessories
Spacer sleeve Type 6464**
Mounting nut Type 6458
Dummy sensor Type 6558
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 6158A_000-031
Data sheet 6182A_000-037

* customized length (l min. = 0.1 m / l max. = 5 m)
** included

Front diameter 2.5 mm



Technical Data		Type 6159A...	Type 6159A...U6
Measuring range	bar	0 ... 2 000	0 ... 2 000
Overload	bar	2 500	2 500
Sensitivity	pC/bar	-2,5	-2,5
Cable length	m	0,2 / 0,4 / 0,6 / 0,8 / sp*/ single-wire**	0,2 / 0,4 / 0,6 / 0,8 / sp*/ single-wire**
Exchangeable cable		yes	yes
Connector		Fischer 1 pin neg.	Fischer 1 pin neg.
Machineable front		yes	no
Coated front		no	yes
Service temperature Melt (at the front of the sensor)	°C	<450	<450
Mold (sensor, cable)	°C	0 ... 200	0 ... 200
Connection	°C	0 ... 200	0 ... 200

Properties
Diaphragm-free piezoelectric sensor. Sensor Type 6159A...U6 is a coated variation of sensor Type 6159A... .

Areas of application
Sensor for thermoplastics. Particularly suitable for small parts.

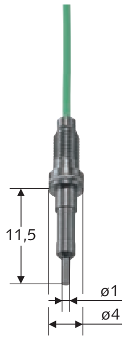
Accessories
Mounting nut Type 6457***
Spacer sleeve Type 6459
Dummy sensor Type 6549
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 6159A_000-032

* customized length (l min. = 0,1 m / l max. = 5 m)
** single-wire cable length 1.5 m; Order key 6159AE; 6159AEU6
*** included

Direct mold cavity pressure measuring

Front diameter 1 mm



Technical Data		Type 6183AE...
Measuring range	bar	0 ... 2 000
Overload	bar	2 500
Sensitivity	pC/bar	-2,5
Cable length	m	1,5 single-wire
Exchangeable cable		no
Connector		Fischer 1 pin neg.
Machineable front		yes
Coated front		no
Service temperature		
Melt (at the front of the sensor)	°C	<450
Mold (sensor, cable)	°C	0 ... 200
Connection	°C	0 ... 200

Properties
Smallest diaphragm-free piezoelectric sensor.

Areas of application
Suitable for thermoplastics, thermoset materials. With its small dimensions, the sensor is particularly suitable for multi-cavity molds.

Accessories
Spacer sleeve Type 6464*
Mounting nut Type 6458
Dummy sensor Type 6579
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 6183A_000-038

Front diameter 6 mm with mounting sleeve

Technical Data		Type 6155AE
Measuring range	bar	0 ... 2 000
Overload	bar	2 500
Sensitivity	pC/bar	-2,5
Cable length	m	1,5 single-wire
Exchangeable cable		yes
Connector		Fischer 1 pin neg.
Machineable front		yes
Coated front		no
Service temperature		
Melt (at the front of the sensor)	°C	<450
Mold (sensor, cable)	°C	0 ... 200
Connection	°C	0 ... 200

Properties
Diaphragm-free piezoelectric sensor with 4 mm front. The sensor is integrated into a 6 mm sleeve and can be mounted on the mold platen. Mold platens or inserts can be removed without disassembling the sensor. Using 20 mm or 50 mm extension sleeves, the sensor length can be adapted to suit individual mold requirements. The innovative sensor prevents damage to cables during mold disassembly.

* included

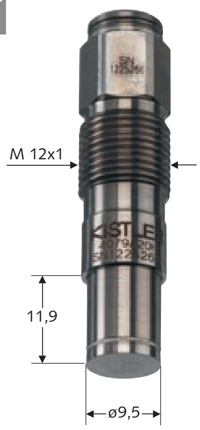
Areas of application
Suitable for thermoplastics. Ideal for molds with inserts. The innovative sleeve design can also be used in standard molds for protecting the sensor cable.

Accessories
Washer Type 6530A0,1*
Mounting plate Type 6540A
Extension sleeve 20 mm
Type 6530A20
Extension sleeve 50 mm
Type 6530A50
Dummy sensor Type 6554
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 6155A_000-510

Direct mold cavity pressure measuring

Front diameter 9.5 mm with diaphragm design (measuring chain) for low-pressure processes



Technical Data		Type 4079A...
Measuring range	bar	0 ... 5 / 10 / 20 / 50
Overload	bar	15 / 15 / 30 / 70
Sensitivity	V/bar	2 / 1 / 0,5 / 0,2
Cable length	m	2 / 5 / 10 / sp*
Exchangeable cable		yes
Connector		4 pin neg.
Machineable front		no
Coated front		no
Service temperature		
Melt (at the front of the sensor)	°C	<180
Mold (sensor, cable)	°C	0 ... 180
Connection	°C	0 ... 180

Properties
Piezoresistive measuring chain consisting of sensor, cable and amplifier Type 4620A... with diaphragm design for static long-term measurement.

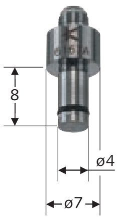
Areas of application
Sensor for processing reactive polymers (RIM) with long cycle times.

Accessories
Connection cable Type 4767A...**
Digital amplifier Type 4620A...**

Data sheet 4079A_000-414

* customized length (l min. = 0.1 m / l max. = 5 m)
** included

Front diameter 4 mm with diaphragm for low-pressure processes



Technical Data		Type 6167A...
Measuring range	bar	0 ... 200
Overload	bar	500
Sensitivity	pC/bar	-16,5
Cable length	m	0,2 / 0,4 / 0,6 / 0,8 / sp*
Exchangeable cable		yes
Connector		Fischer 1 pin neg.
Machineable front		no
Coated front		no
Service temperature		
Melt (at the front of the sensor)	°C	<450
Mold (sensor, cable)	°C	0 ... 200
Connection	°C	0 ... 200

Properties
Piezoelectric sensor with diaphragm design.

Areas of application
Sensor for low-viscosity materials as used for IC coating.

Accessories
Mounting nut Type 6457**
Spacer sleeve Type 6459
Dummy sensor Type 6545
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 6167A_000-033

* customized length (l min. = 0.1 m / l max. = 5 m)
** included

Direct mold cavity pressure measuring

Front diameter 6 mm for low-pressure processes

Technical Data		Type 6172AA...	Type 6172AC...
Measuring range	bar	0 ... 200	0 ... 200
Overload	bar	300	300
Sensitivity	pC/bar	-45	-45
Cable length	m	0,4 / sp*/ single-wire**	0,4 / sp*/ single-wire**
Exchangeable cable		yes	yes
Connector		Fischer 1 pin neg.	Fischer 1 pin neg.
Machineable front		yes	no
Coated front		no	yes
Service temperature			
Melt (at the front of the sensor)	°C	<450	<450
Mold (sensor, cable)	°C	0 ... 200	0 ... 200
Connection	°C	0 ... 200	0 ... 200
Options			
Silicone-filled gap		6172AAA...	6172ACA...

Properties
Diaphragm-free piezoelectric sensor with a very high sensitivity. The sensor Type 6172AC... is a coated variation of the sensor Type 6172AA... .

Areas of application
Sensor for processes involving a low mold cavity pressure such as foam molding or compression molding. Suitable for thermoplastics, thermosets, elastomers and LSR with a pressure below 200 bar. The sleeve design allows easy installation, particularly in large molds.

Accessories
Mounting nut Type 6453***
Spacer sleeve Type 6462
Dummy sensor Type 6552
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 6172A_000-512

Front diameter 4 mm for low-pressure processes

Technical Data		Type 6177AA...	Type 6177AC...
Measuring range	bar	0 ... 200	0 ... 200
Overload	bar	300	300
Sensitivity	pC/bar	-45	-45
Cable length	m	0,4 / sp*/ single-wire**	0,4 / sp*/ single-wire**
Exchangeable cable		yes	yes
Connector		Fischer 1 pin neg.	Fischer 1 pin neg.
Machineable front		yes	no
Coated front		no	yes
Service temperature			
Melt (at the front of the sensor)	°C	<450	<450
Mold (sensor, cable)	°C	0 ... 200	0 ... 200
Connection	°C	0 ... 200	0 ... 200

Properties
Diaphragm-free piezoelectric sensor with a very high sensitivity. The sensor Type 6177AC... is a coated variation of the sensor Type 6177AA... .

Areas of application
Sensor for processes operating with a low mold cavity pressure such as foam molding or compression molding. Suitable for thermoplastics elastomers and LSR with a pressure of below 200 bar.

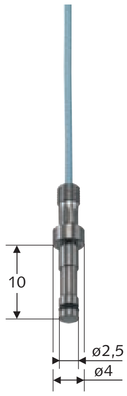
Accessories
Mounting nut Type 6457***
Spacer sleeve Type 6459
Dummy sensor Type 6545
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 6177A_000-513

* customized length (l min. = 0.1 m / l max. = 5 m)
** single-wire cable length 1.5 m; Order key 6172AAE; 6172ACE
*** single-wire cable length 1.5 m; Order key 6177AAE; 6177ACE
**** included

Direct mold cavity pressure measuring

Front diameter 2.5 mm for low-pressure processes



Technical Data		Type 6178A...
Measuring range	bar	0 ... 200
Overload	bar	300
Sensitivity	pC/bar	-10
Cable length	m	0,4 / sp*/ single-wire**
Exchangeable cable		no
Connector		Fischer 1 pin neg.
Machineable front		yes
Coated front		no
Service temperature Melt (at the front of the sensor)	°C	<450
Mold (sensor, cable)	°C	0 ... 200
Connection	°C	0 ... 200

Properties
Diaphragm-free piezoelectric sensor with a very high sensitivity.

Areas of application
Sensor for processes operating with a low mold cavity pressure such as foam molding or compression molding. Suitable for thermoplastics below 200 bar. Ideal for multi-cavity molds and small parts due to small sensor dimensions.

Accessories
Spacer sleeve Type 6464***
Mounting nut Type 6458
Dummy sensor Type 6558
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 6178A_000-514

* customized length (l min. = 0.1 m / l max. = 5 m)
** single-wire cable length 1.5 m; Order key 6179AE
*** included

Direct cavity pressure measuring for multi-cavity molds

Multi-cavity systems with sensors Type 6152, 6157, 6159, 6167, 6182 or 6183 Unisens

Technical Data		Type 6829A...
Sensors		6152, 6157, 6159, 6167, 6182 or 6183 single-wire Types only
No. of sensors / system		4 ... 32
Measuring range	bar	depending on sensor Type
Overload	bar	depending on sensor Type
Sensitivity	pC/bar	Unisens (depending on sensor Type)
Cable length	m	1,5 single-wire
Connector		MIL 41 pin
Machineable front		depending on sensor Type
Coated front		depending on sensor Type
Service temperature Melt (at the front of the sensor)	°C	<450
Mold (sensor, cable)	°C	0 ... 200
Charge amplifier	°C	0 ... 60

Properties
Multi-cavity system comprised of sensors and multi-channel charge amplifier for direct installation on mold. Cut-and-clamp technique ensures easy connection of the sensor. The charge amplifier is connected to the measuring system with only one cable, independent of the number of sensors.

Unisens technology ensures easy configuration of the measuring systems.

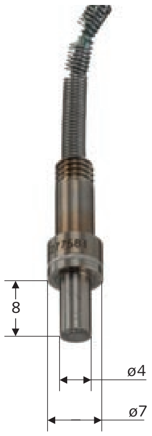
Areas of application
Suitable for molds with more than four pressure sensors. For information on the application of individual sensors, please consult the corresponding tables.

Accessories
See measuring chains on p. 26/27.

Data sheet 6829A_000-046

Direct mold cavity pressure and contact temperature measuring

Front diameter 4 mm



Technical Data		Type 6190A...
Pressure measuring range	bar	0 ... 2 000
Temperature measuring range	°C	0 ... 200
Pressure overload	bar	2 500
Pressure sensitivity	pC/bar	-2,5
Thermocouple	Type	K
Standard cable length	m	0,4 / 0,8 / 1,2 / 1,6 / 2 / sp*
Exchangeable cable		no
Pressure connector		Fischer 1 pin neg.
Temperature connector		Fischer 2 pin neg.
Machineable front		no
Coated front		no
Service temperature Melt (at the front of the sensor)	°C	<450
Mold (sensor, cable)	°C	0 ... 200
Connection	°C	0 ... 200

Properties
The combination pressure/temperature sensor measures the pressure and the part surface temperatures (contact temperatures) at one location within the cavity. The special design of the sensor requires only a very short reaction time for temperature measuring. Dimensionally compatible with Type 6157A..., 6167A... and 6177A... .

Areas of application
Injection molding of thermoplastics. Ideal for the acquisition of major process values with only one drilled hole.

Accessories
Mounting nut Type 6457**
Spacer sleeve Type 6459
Dummy sensor Type 6545
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...
Extension cable Type 2290A..., 2295A...

Data sheet 6190A_000-039

* customized length (l min. = 2 m / l max. = 3.5 m)
** included

Direct contact temperature measuring

Front diameter 4 mm

Technical Data		Type 6192A...
Measuring range	°C	0 ... 200
Thermocouple	Type	K
Cable length	m	0,4 / sp*
Exchageable cable		no
Machineable front		no
Coated front		no
Connector		Fischer 2 pin neg.
Service temperature Melt (at the front of the sensor)	°C	<450
Mold (sensor, cable)	°C	0 ... 200
Connection	°C	0 ... 200

Properties
Due to its special design, this temperature sensor has very short reaction times. Measures the part surface temperature (contact temperature). Dimensionally compatible with Types 6157A..., 6167A..., 6177A... and 6190A... .

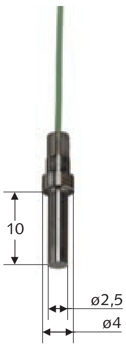
Areas of application
Suitable for thermoplastics, elastomers and LSR.

Accessories
Mounting nut Type 6457**
Spacer sleeve Type 6459
Dummy sensor Type 6552
Extension cable Type 2290A..., 2295A...

Data sheet 6192A_000-363

* customized length (l min. = 0.1 m / l max. = 5 m)
** included

Front diameter 2.5 mm



Technical Data		Type 6195A...
Measuring range	°C	0 ... 200
Thermocouple	Type	K
Cable length	m	0,4 / sp*
Exchangeable cable		no
Machineable front		no
Coated front		no
Connector		Fischer 2 pin neg.
Service temperature Melt (at the front of the sensor)	°C	<450
Mold (sensor, cable)	°C	0 ... 200
Connection	°C	0 ... 200

Properties
Due to its special design, this temperature sensor has very short reaction times. Measures the part surface temperature (contact temperature). Dimensionally compatible with Type 6158A..., 6182A..., 6178A... .

Areas of application
Suitable for thermoplastics, elastomers and LSR. Ideal for small parts and multi-cavity molds.

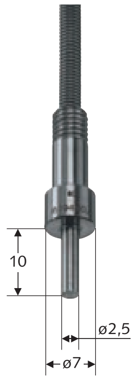
Accessories
Spacer sleeve Type 6464**
Mounting nut Type 6458
Dummy sensor Type 6558
Extension cable Type 2290A..., 2295A...

Data sheet 6195A_000-363

* customized length (l min. = 0.1 m / l max. = 5 m)
** included

Direct contact temperature measuring

Front diameter 2.5 mm



Technical Data		Type 6194A...
Measuring range	°C	0 ... 200
Thermocouple	Type	K
Cable length	m	0,4 / sp*
Exchangeable cable		no
Machineable front		no
Coated front		no
Connector		Fischer 2 pin neg.
Service temperature Melt (at the front of the sensor)	°C	<450
Mold (sensor, cable)	°C	0 ... 200
Connection	°C	0 ... 200

Properties
Due to its special design, this temperature sensor has very short reaction times. Measures the part surface temperature (contact temperature). Dimensionally compatible with Type 6159A... .

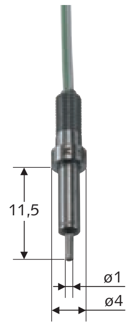
Areas of application
Suitable for thermoplastics, elastomers and LSR, ideal for small parts.

Accessories
Mounting nut Type 6457**
Spacer sleeve Type 6459
Dummy sensor Type 6549
Extension cable Type 2290A..., 2295A...

Data sheet 6194A_000-363

* customized length (l min. = 0,1 m / l max. = 5 m)
** included

Front diameter 1 mm



Technical Data		Type 6193A...
Measuring range	°C	0 ... 200
Thermocouple	Type	K
Cable length	m	0,4 / sp*
Exchangeable cable		no
Machineable front		no
Coated front		no
Connector		Fischer 2 pin neg.
Service temperature Melt (at the front of the sensor)	°C	<450
Mold (sensor, cable)	°C	0 ... 200
Connection	°C	0 ... 200

Properties
Due to its special design, this temperature sensor has very short reaction times. Measures the part surface temperature (contact temperature). Dimensionally compatible with Type 6183A... .

Areas of application
Suitable for thermoplastics, elastomers and LSR, ideal for micro parts and multi-cavity molds.

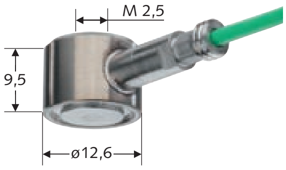
Accessories
Spacer sleeve Type 6464**
Mounting nut Type 6458
Dummy sensor Type 6579
Extension cable Type 2290A..., 2295A...

Data sheet 6193A_000-363

* customized length (l min. = 0.1 m / l max. = 5 m)
** included

Indirect mold cavity pressure measuring

Diameter 12,6 mm



Technical Data		Type 9204B...
Measuring range	kN	0 ... 10
Overload	kN	12
Sensitivity	pC/N	-1,6
Dimensions	mm	Ø 12,6
Cable length	m	0,2 / 0,4 / 0,6 / 0,8 / sp*
Exchangeable cable		yes
Connector		Fischer 1 pin neg.
Service temperature	°C	-50 ... 200

Properties
Piezoelectric force sensor with M2.5 fastening thread.

Areas of application
Indirect mold cavity pressure sensor that is fitted behind a measuring or ejector pin. Indirect measurement allows easy mold upgrading and is suitable for all injection molding processes.

Accessories
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 9204B_000-128

* to suit customers requirements

Diameter 6 mm

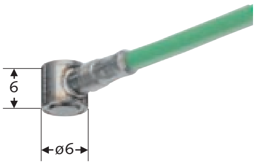


Figure shows Type 9211A...

Technical Data		Type 9211A...	Type 9213A...
Measuring range	kN	0 ... 2,5	0 ... 2,5
Overload	kN	3	3
Sensitivity	pC/N	-4,4	-4,4
Dimensions	mm	Ø 6	Ø 6
Cable length	m	0,5 / sp*	0,5 / sp*
Exchangeable cable		no	no
Connector		Fischer 1 pin neg.	Fischer 1 pin neg.
Service temperature	°C	-40 ... 150	-40 ... 150

Properties
Piezoelectric force sensor. Sensor Type 9213A is equipped with an M2.5 fastening thread.

Areas of application
Indirect mold cavity pressure sensor that is behind a measuring or ejector pin. Ideal for multi-cavity molds or small parts. Indirect measurement allows easy mold upgrading and is suitable for all injection molding processes.

Accessories
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data sheet 9211A_000-131
Data sheet 9213A_000-132

* customized length (l min. = 0,1 m / l max. = 3 m)

Indirect mold cavity pressure measuring

Measuring tongue

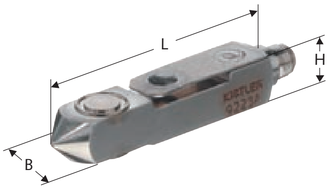


Figure shows Type 9223A...

Technical Data			Type 9221A...	Type 9223A...
Measuring range		kN	0 ... 10	0 ... 2,5
Overload		kN	12	3
Sensitivity		pC/N	-3,3	-4,5
Dimensions	l x w x h	mm	72,3 x 12,6 x 9,5	30 x 6 x 6
Cable length		m	0,2 / 0,4 / 0,6 / 0,8 / sp*	0,2 / 0,4 / 0,6 / 0,8 / sp*
Exchangeable cable			yes	yes
Connector			Fischer 1 pin neg.	Fischer 1 pin neg.
Service temperature		°C	-50 ... 200	-40 ... 150

Properties
Piezoelectic force sensor. Sensor Type 9221AA... is equipped with a standard cable, Type 9221AC... is equipped with a metal-sheathed cable.

Areas of application
Indirect mold cavity pressure gauge for measuring behind a measuring or ejector pin. Indirect measurement allows easy mold upgrading. Suitable for all injection molding techniques.

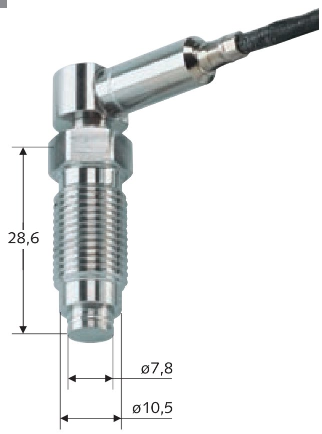
Accessories
Extension cable TNC
Type 1662A..., 1672B...
Extension cable BNC
Type 1661A..., 1667B...

Data Sheet 9221A_000-133
Data Sheet 9223A_000-134

* customized length (l min. = 0.1 m / l max. = 2 m)

Melt pressure and temperature sensors

350°C sensor



Technical Data		Type 4013A...
Measuring range	bar	0 ... 3 000
Sensitivity	mV/bar	3,33
Linearity	%FSO	<± 1
Sealing area		flat sealing
Thread		1/2 - 20UNF
Standard cable length	m	2 m (integrated)
Service temperature Sensor	°C	0 ... 350
Connection	°C	0 ... 200
Electronics	°C	0 ... 60
Options		
Temperature measurement		optional

Properties
Piezoresistive measuring chain comprised of sensor with integrated cable, extension cable and amplifier (analog: Type 4618A... or digital: Type 4620A...). This measuring chain can record both the pressure (static and dynamic) and the temperature. Consult the data sheet for selecting a suitable measuring chain.

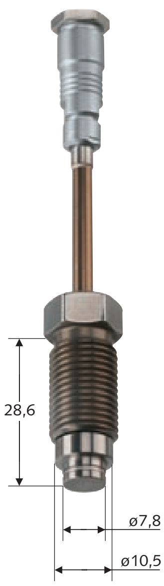
Areas of application
Control and monitoring of injection molding machines and hot-runner systems.

Accessories
Extension cable Type 4757A...*
Analog amplifier Type 4618A...**
Plug Type 1500A57**
Digital amplifier Type 4620A...**
Plug Type 1500A61**

Data sheet 4013A_000-405

* included
** optional

300°C sensor



Technical Data		Type 4083A...
Measuring range	bar	0 ... 3 000
Sensitivity	mV/bar	3,33
Linearity	%FSO	<± 1
Sealing area		flat sealing
Thread		1/2 - 20UNF
Standard cable length	m	sp*
Service temperature Sensor	°C	0 ... 300
Connection	°C	0 ... 200
Electronics	°C	0 ... 60
Options		
Temperature measurement		optional

Properties
Piezoresistive measuring chain comprised of a sensor with integrated cable, extension cable, amplifier (analog: Type 4618A... or digital: Type 4620A...). This measuring chain can record both the pressure (static and dynamic) and the temperature. Consult the data sheet for selecting a suitable measuring chain.

Areas of application
Control and monitoring of hot-runner systems by pressure and temperature measurement.

Accessories
Connection cable Type 4767A...**
Analog amplifier Type 4618A...***
Plug Type 1500A57***
Digital amplifier Type 4620A...***
Plug Type 1500A61***

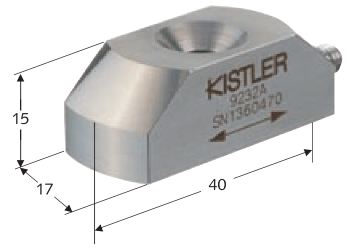
Data sheet 4083A_000-007

* customized length (l min. = 0.5 m / l max. = 10 m)
** included
*** optional

Measuring

Clamp force measurement and mold protection

Piezoelectric strain sensor



Technical Data		Type 9232A
Measuring range	με	± 600
Overload	με	± 900
Sensitivity	pC/με	-80
Service temperature	°C	0 ... 70
Exchangeable cable		yes
Connection		10 ... 32 UNF neg.

Properties
High-resolution piezoelectric surface strain sensor for force measurement. The sensor is screwed to the machined structure with an M6 fastening screw. Please specify the maximum strain for clamping force and mold protection to allow selection of the charge amplifier.

Areas of application
Measures clamping force and mold protection in injection molding machines. The charge amplifier is specially adapted to suit the application and has one output for the clamping force and one output for mold protection.

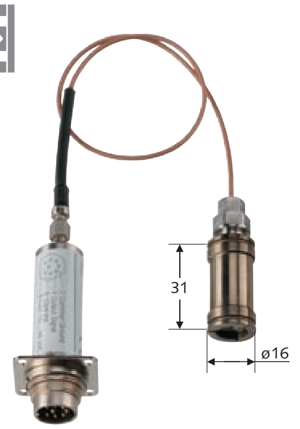
Accessories
Connection cable Type 1939A...
Charge amplifier Type 5155A...*

Data sheet 9232A_000-137

* defined to suit customer requirements

Tie bar extension

Piezoelectric strain measuring chain



Technical Data		Type 9827A2491	Type 9827A1392
Diameter	mm	12	16
Measuring range	με	± 500	± 500
Overload	με	± 1 000	± 1 000
Sensitivity	mV/με	-10,4	-7,3
Service temperature	°C	-20 ... 85	-20 ... 85
Power supply	V DC	10 ... 36	10 ... 36
Output voltage	V DC	± 5	± 5
Exchangeable cable		no	no

Properties
Measuring chain, comprised of piezoelectric longitudinal measuring pin, integrated cable and miniature charge amplifier. The sensor is clamped or screwed to the machined surface.

Areas of application
Measures clamping force and mold protection and monitors tie bar rupture in injection molding machines.

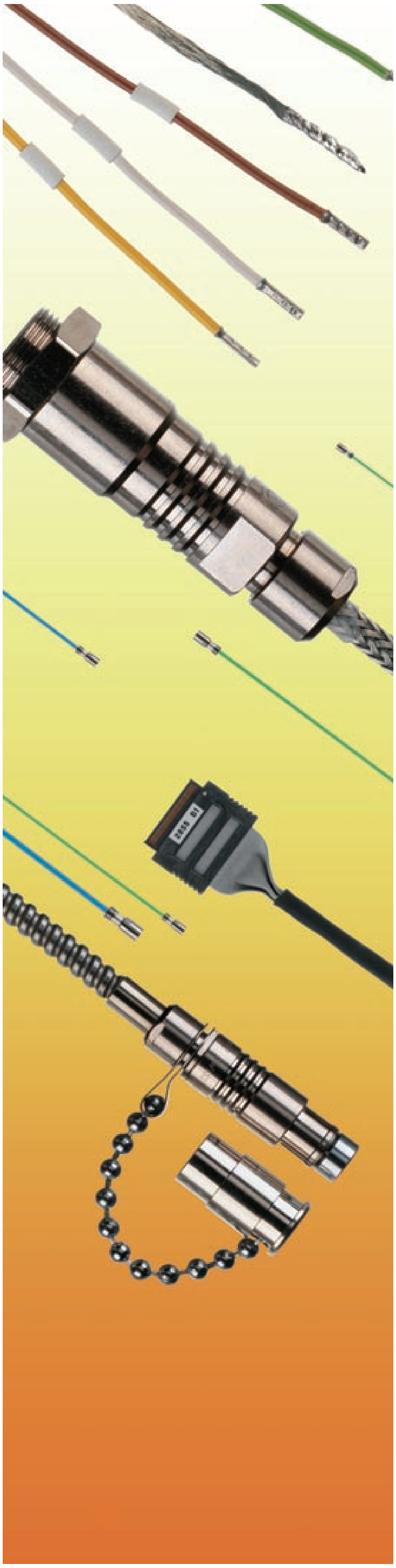
Accessories
Plug 8 pin Type 1500A27
Preload tester Type 5991

Data sheet 9827A_000-175

Figure shows Type 9827A1392

* included

Connecting and transmitting



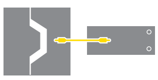
Cables ensure the accurate transmission of all signals from the sensor to the mold connector, from the mold to the charge amplifier and from the charge amplifier to the injection molding machine or the data aquisition equipment. In order to accommodate a wide variety of customer requirements, Kistler provides an extensive range of different connecting and extension cables.

Connection cables link the sensor to the connector plug. Kistler pressure sensors are available with classic two-wire coax cables or with the new single-wire technology. Two-wire coax cables have a connector plug at the end, which needs to be accommodated in the mold. The new technology cable has only one wire and the connector plug is no longer soldered to the cable. Two-wire technology is increasingly replaced by single-wire technology.

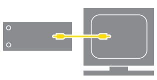
Extension cables are used to bridge the gap between the connector and the charge amplifier or the DataFlow, Kistler's analysis system. For this application, Kistler provides extension cables in a variety of designs, depending in the production environment and the length required, in a wide range of different sheathings, colors and cable lengths.

The charge amplifier and downstream equipment are linked with a connection cable. It is equipped with a connector for multi-pin input of the charge amplifier and compatible interfaces to the injection molding machine or PC cards for signal processing by a notebook or a PC.

Connection cable



Extension cable



Connection cable

Connecting cable for pressure sensors

Single-wire cables

Technical Data		Type 1666A1	Type 1666A3	Type 1666A2	Type 1666A4
For sensors Type		Unisens	Unisens	Standard	Standard
Connector			M4 x 0,35 pos. / Fischer 1-pin neg.		
Length	m	1,5	5	1,5	5
Service temperature	°C	0 ... 200	0 ... 200	0 ... 200	0 ... 200
Color		blue	blue	green	green

Single-wire plugs

Technical Data		Type 1839
For sensors Type		All single-wire sensors
Connector		Cut-and-clamp technique for single-wire Fischer 1-pin neg.
Service temperature	°C	0 ... 200

Coax cables

Technical Data		Type 1961A...	Type 1645C...
For sensors Type		Unisens	Unisens
Connector		M4 x 0,35 pos / Fischer 1-pin neg.	M4 x 0,35 pos / Fischer 1-pin neg.
Length	m	0,2 / 0,4 / 0,6 / 0,8 / sp*	0,2 / 0,4 / 0,6 / 0,8 / sp*
Service temperature	°C	0 ... 200	0 ... 200
Color		blue	green

* customized length (l min. = 0.1 m / l max. = 5 m)

Coax cables, steel braided

Technical Data		Type 1963A...	Type 1955A...
For sensors Type		all	all
Connector		M4 x 0,35 pos. / Fischer 1-pin neg.	M4 x 0,35 pos. / Fischer 1-pin neg.
Length	m	0,4 / sp*	0,4 / sp*
Service temperature	°C	0 ... 200	0 ... 300
Color		steel	steel

* customized length (l min. = 0.1 m / l max. = 5 m)

Coax cable for strain sensor Type 9232A

Technical Data		Type 1939A...
For sensors Type		9232
Connector		UNF 10-32 pos. / BNC
Length	m	sp*
Service temperature	°C	0 ... 200
Color		green

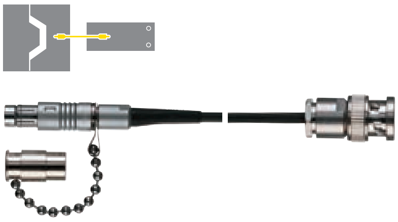
* customized length (l min. = 0.1 m / l max. = 20 m)

Data sheet 000-351

Connecting and transmitting

Extension cables for pressure sensors

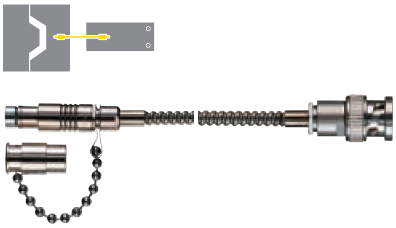
High-temperature cables, Viton-sheathed



Technical Data Type		1667B...	Type 1672B...
Connector		Fischer 1-pol. pos. BNC pos.	Fischer 1-pin pos. TNC pos.
Length	m	2 / 5 / 10 / sp*	2 / 5 / sp*
Service temperature	°C	0 ... 200	0 ... 200

* customized length (l min. = 0.1 m / l max. = 8 m)

High-temperature cables with flexible metal sheathing

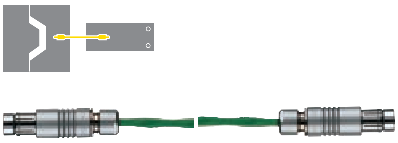


Technical Data Type		1661A...	Type 1662A...
Connector		Fischer 1-pin pos. BNC pos.	Fischer 1-pin pos. TNC pos.
Length	m	2 / 5 / 10 / sp*	2 / 5 / sp*
Service temperature	°C	0 ... 200	0 ... 200

* customized length (l min. = 0.5 m / l max. = 8 m)

Extension cables for temperature sensors

High-temperature extension cables



Technical Data		Type 2290A...	Type 2295A...
Connector		Fischer 2-pin pos. open ends	Fischer 2-pin pos. Fischer 2-pin pos.
Length	m	2 / 5 / 10 / sp*	2 / 5 / sp*
Service temperature	°C	0 ... 200	0 ... 200

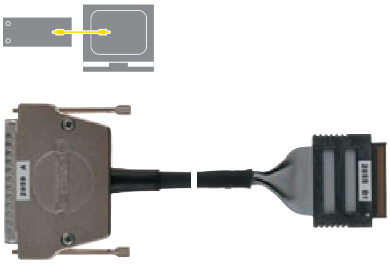
* customized length

Data sheet 000-351

Connecting and transmitting

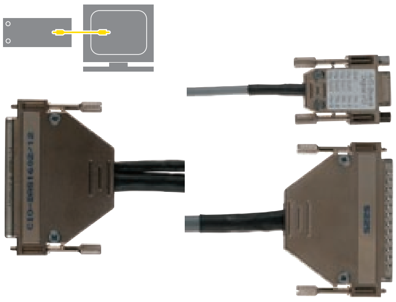
Connection cables

Signal cables for signal conditioner Type 2859A.../2853A... for notebook with A/D card Type 2855B1



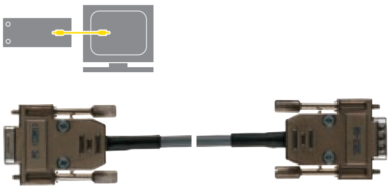
Technical Data		Type 1200B43	Type 1200B21
Connector		D-SUB 37 pos. PC Card	D-SUB 37 pos. / D-SUB 9 neg. PC Card
Length	m	0,5	5
Area of application		Connection of analog signals from Type 2853A..., 2859A... to A/D card Type 2855B1	Connection of analog signals from Type 2853A..., 2859A... 2855B1; with 4 additional digital outputs (TTL) on D-SUB 9 neg. plug

Signal cables for signal conditioner 2853A.../2859A...for desktop PC with A/D card Type 2855A3/A4/A6



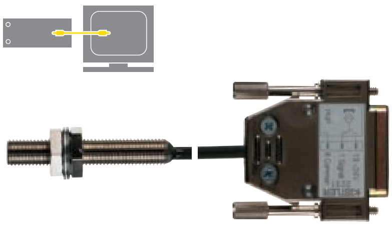
Technical Data		Type 1200A13	Type 1200A41
Connector		D-SUB 37 pos. / D-SUB 9 neg. D-SUB 37 neg.	D-SUB 37 pos. D-SUB 37 neg.
Length	m	5	5
Area of application		Connection of analog signals from Type 2853A..., 2859A... to A/D card Type 2855A3/A4/A6 (max. 16 channels); W. digital outputs (TTL) on D-SUB 9 neg. plug	Connection of analog signals from Type 2853A..., 2859A... to A/D card Type 2855A3/A4/A6 (max. 32 channels. Digital outputs with Type 1200A79 or 1200A81 only

Communication cables for signal conditioner Type 2853A.../2859A... for connection with serial interface (RS-232-C) for desktop PC and notebook



Technical Data		Type 1200A89	Type 1200A27
Connector		D-SUB 9 neg. D-SUB 9 pos.	D-SUB 9 neg D-SUB 9 pos.
Length	m	0,75	5
Area of application		Connection Type 2859A..., 2853A... to desktop PC/notebook (RS-232-C)	Connection Type 2859A..., 2853A... to desktop PC/notebook (RS-232-C)

Trigger input and digital outputs for signal conditioner Type 2853A.../2859A...

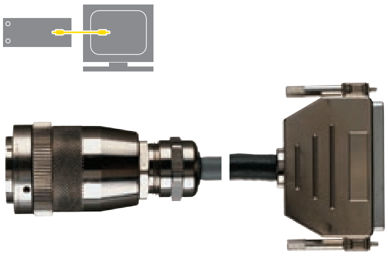


Technical Data		Type 1200A15	Type 2231
Connector		open ends D-SUB 15 pos.	Proximity switch D-SUB 15 pos.
Length	m	5	5
Area of application		Connection of trigger to Type 2853A..., 2859A... and Type 2853A..., 2859A..., digital outputs on machine, handling devices or reject gate	Proximity switch for activation of the measuring process; Connection to Type 2853A..., 2859A...

Connecting and transmitting

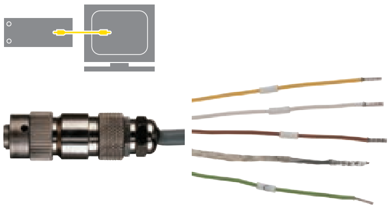
Connection cables

Signal cables for charge amplifier Type 6829A... to desktop PC with A/D card Type 2855A3/A4/A6 or notebook w. A/D card Type 2855B1



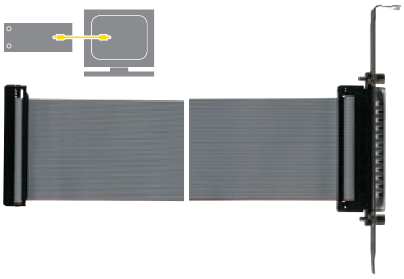
Technical Data		Type 1700B63	Type 1700A99	Type 1200A83
Connector		MIL 41 pin pos. / D-SUB 9 neg. PC card	MIL 41 pin pos. / D-SUB 37 neg.	MIL 41pin pos. / D-SUB 37 neg.
Length	m	5	5	5
Area of application		Connection of analog signals from Type 6829A... to A/D card Type 2885B1 (max. 16 channels); With 4 additional digital outputs (TTL) on D-SUB 9 neg. plug	Connection of analog signals from Type 6892A... to A/D card Type 2855A3/A4 (max. 16 channels). With 4 additional digital outputs (TTL) on D-SUB 9 neg. plug	Connection of analog signals from Type 6892A... to A/D card Type 2855A3/A4 (max. 16 channels), or 2855A6 (max. 32 channels. Digital outputs with Type 1200A79 or 1200A81 only

Reset/Operate and excitation voltage for multi-channel charge amplifier Type 6829A...



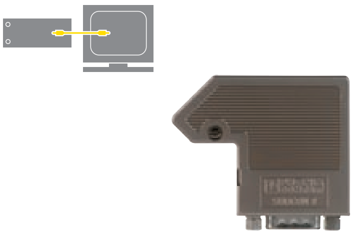
Technical Data		Type 1700A62
Connector		open ends MIL 4 pin neg.
Length	m	5
Area of application		Excitation voltage and Reset/ Operate signal for Type 6829A...

PC slot covers for digital outputs for desktop A/D cards Type 2855A3/A4/A6



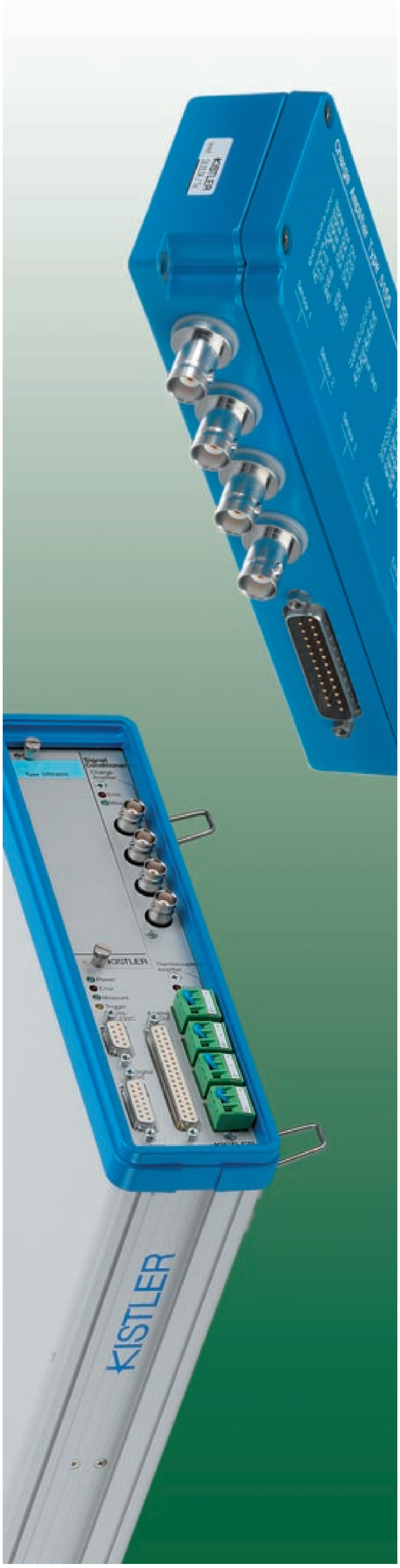
Technical Data	Type 1200A79	Type 1200A81
Connector	feature connector D-SUB 37 pos.	feature connector D-SUB 9 neg.
Area of application	Slot cover for 24 additional digital outputs (TTL) for A/D cards Type 2855A3/A4/A6	Slot cover for 4 additional digital outputs (TTL) for A/D cards Type 2855A6

Converter TTL to zero-potential switches for Types 1200B43, 1700B63, 1200A81



Technical Data	Type 2863
Connector	D-SUB 9 pos. terminal screws
Area of application	Converter for digital outputs from TTL to zero-potential switches (MOS-FET) for direct control of reject gates or handling systems with cables Type 1200B43 and 1700B63 and slot covers Type 1200A81

Amplifying



Charge amplifiers convert charges transmitted by a piezoelectric pressure sensor into a proportional voltage, which can be used as an input variable for monitoring and control processes. Kistler supplies a wide range of different charge amplifiers such as single-channel charge amplifiers or multi-channel amplifiers for charge and temperature.

Charge amplifiers with smart algorithms, which enhance the amplifying process, can generate control signals from the cavity pressure profile and the contact temperature. These are used as input values for injection molding machines, where they serve to increase the repeatability of the injection molding process to ensure high quality of the produced parts.

Charge amplifiers are encased in a sturdy housing. Their output signals are analog and immediately available via an analog/digital converter card (A/D converter). The real-time capability of the charge amplifiers allows the control of high-speed processes based on cavity pressure.

Based on forces such as the cavity pressure, smart charge amplifiers can automatically change over from injection to holding pressure or determine the optimal demolding point in a self-optimizing operation.

Charge amplifiers for integration into injection molding machines

Charge amplifiers for pressure sensors

Figure shows Type 5049A...

Technical Data		Type 5039A...	Type 5049A221
No. of channels		1	1
No. of measuring ranges		2	2
Measuring range I	pC	±5 000 ... ±50 000	±2 0000
Ratio measuring range I/ measuring range II		10 / 4 / 2	2
Measuring range I (adjusted to injection molding)	pC	±20 000	±20 000
Measuring range II (adjusted to injection molding)	pC	±5 000	±5 000
Power supply	V DC	18 ... 30	18 ... 30
Output signal	V	±0 ... 10	±0 ... 10
Sensor connector		TNC or BNC neg.	TNC neg.
Connection supply, output signal, control signals		Binder 8 pin pos.	Binder 14 pin pos.
Options			
SmartAmp self-optimized switch-over		no	yes
Output current	mA	4 ... 20	4 ... 20

Properties
Charge amplifier in industrial housing. Special types for injection molding Type 5039A221 (TNC connection) or Type 5039A222 (TNC connection).

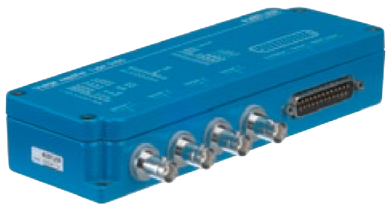
Areas of application
Integration into injection molding machines for connecting piezo-electric cavity pressure sensors for visualization and control.

Accessories
For Type 5039A...
plug Type 1500A57*
For Type 5049A...
plug Type 1500A61*
TNC-BNC-Adapter Type 1708

Data sheet 5039A_000-303
Data sheet 5049A_000-307

* included

Amplifier for pressure and temperature sensors



Technical Data		Type 5155A...
No. of channels		1, 2 or 4 load, or 1 load and 1 temperature or 2 load and 2 temperature
Measuring ranges load		2
Measuring range I		±5 000 ... ±50 000
Ratio measuring range I/ measuring range II		10 / 4 / 2
Measuring range I (adjusted to injection molding)	pC	±20 000
Measuring range II (adjusted to injection molding)	pC	±5 000
Measuring range temperature	°C	0 ... 200
Output signal	V	0 ... ±10
Power supply	V DC	18 ... 30
Sensor connector (pressure)		TNC or BNC neg.
Sensor connector (temperature)		Fischer 2 pin neg.
Connection supply, signal outputs, control signals		D-SUB 25 pos.
Options		
SmartAmp self-optimizing switch-over		on channel 1
Automatic cooling time calculation		Only option: 1 channel load and 1 channel temp.
Output current	mA	4 ... 20

Properties
Multi-channel charge amplifier and thermocouple amplifier in an industrial housing. Consult data sheet for selecting the appropriate charge amplifier.

Areas of application
Integration into injection molding machines for connecting piezo-electric cavity pressure sensors and temperature sensors for visualization and control.

Accessories
Connection cable Type 1200A73
SUB-D plug incl. cover Type 1557A10

Data sheet 5155A_000-403

Signal conditioner

Signal Conditioner

Figure shows Typ 2859A...

Technical Data		Type 2859A...	Type 2853A...
Case dimensions		Notebook-size	19" rack mount
Dimensions	WxHxD	W231 x H55 x D300 mm	3 HE/84 TE
No. of channels Integrated charge amplifier		4	-
No. of channels Integrated thermocouple amplifier		4	-
Vacant slots (4 channels)		1	8
Digital outputs for controlling reject gates or handling devices		4 (zero-potential switch)	4 (zero-potential switch)
Service temperature range	°C	0 ... 40	0 ... 60
Options			
4-channel charge amplifier	Type	5063A1	5063A1
4-channel voltage amplifier	Type	5227A1	5227A1
4-channel thermocouple amplifier	Type	2207A	2207A
4-channel amplifier interface	Type	5613A1/A2	5613A1/A2

Properties
Both signal conditioners are modular and can be extended Systems Type 2859A14 (parallel port) and 2859A15 (USB) are supplied with signal conditioner Type 2859A and DataFlow, A/D card, proximity switch as well as all cables required for operation with notebook.

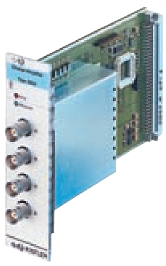
Areas of application
In combination with the Dataflow software, this product allows the visualization, optimization and monitoring of the injection molding process.

Accessories
Charge amplifier Type 5063A1
Voltage amplifier Type 5227A1
Thermocouple amplifier Type 2207A
Amplifier Interface Type 5613A1/A2
Proximity switch Type 2231

Data sheet 2859A_000-375
Data sheet 5063A_000-408

Modules for signal conditioner Type 2853A... and 2859A...

4-channel charge amplifier



Technical Data		Type 5063A1
No. of channels		4
No. of measuring ranges		2
Measuring range I	pC	±5 000 ... ±50 000
Measuring range I/ II ratio		4
Measuring range I (balanced for injection molding)	pC	±20 000
Measuring range II (balanced for injection molding)	pC	±5 000
Connector	Type	BNC neg.

Data sheet 5063A_000-408

4-channel voltage amplifier

Technical Data		Type 5227A1
No. of channels		4
Measuring range	V	±10
Adjustable amplification		1 / 2 / 5 / 10
Connector	Type	BNC neg.

Data sheet 5063A_000-408

Amplifying

Signal conditioner for signal preparation

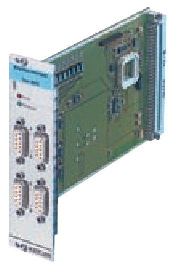
4-channel thermocouple amplifier

Technical Data		Type 2207A
No. of channels		4
Thermocouple	Type	J and K
No. of measuring ranges		2
Measuring range I	°C	0 ... 400
Measuring range II	°C	0 ... 200
Connector	Type	Phoenix terminal connector

Data sheet 5063A_000-408

Modules for signal conditioner Type 2853A... and 2859A...

4-channel amplifier interface



Technical Data		Type 5613A1	Type 5613A2
No. of channels		4	4
Measuring range	V	±10	±10
Power supply for external amplifiers	VDC	24	±15
Connector	Type	SUB-D 9 neg.	SUB-D 9 neg.

Data sheet 5063A_000-408

Analyzing

The DataFlow software is a convenient tool for documenting the measured pressure and temperature values as quality-related data for the purpose of process optimization. DataFlow operates with tools which support users across the entire process chain from mold sampling, setup and process optimization to production monitoring including statistic analysis and documentation. These functions are based on the the cavity pressure and the part surface temperature as inputs for calculation.

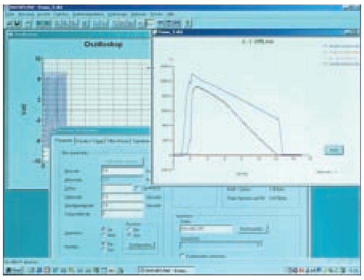
DataFlow runs on conventional personal computers or notebooks and is easy to operate. DataFlow offers a comprehensive optimization and documentation system for all injection molding processes which also accommodates multi-component techniques and multi-cavity molds. DataFlow can control equipment such as defect gates and reversible belt conveyors or can operate robot placing processes to ensure that all parts are separated into defects and accepts and good parts.

The networking capability of the included statistics tool provides production data where it is needed, e.g. for production planning, control or quality assurance.

Analyzing

Software for monitoring and statistics

DataFlow software



Technical Data		Type 2805A...
System requirements Operating system		Windows 2000®, Windows XP® Professional
Memory	MB RAM	min. 128
Interface		RS-232-C
Processor clock frequency	MHz	min. 600
Bus frequency	MHz	min. 100
Vacant slot (notebook)		PC Card
Vacant slot (desktop)		PCI

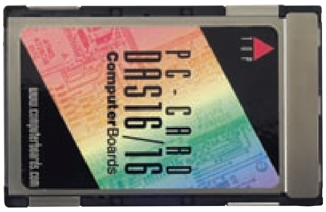
Properties
DataFlow is a universal data acquisition and analysis system for injection molding processes. Production statistics can be compiled via a network.

Areas of application
Mold trials, retrofitting, process optimization and production monitoring based on the mold cavity pressure. The statistics software allows precise documentation of all produced parts.

Accessories
Signal Conditioner Type 2859A...
Signal Conditioner Type 2853A...

Data sheet 2805A_000-369

A/D card



Technical Data		Type 2855B1	Type 2855A4	Type 2855A6
No. of channels	max.	16	16	32
PC Type		Notebook	Desktop	Desktop
Card Type		PC Card	PCI Card	PCI Card
Resolution	bit	12	16	16

Data sheet 2805A_000-369

Accessories/Tools

Kistler offers a range of accessories for mounting and calibrating sensors. Accessory sets for applications such as checking sensor bores include step drills, countersinks, twist drills, reamers, taps, reaming tools, socket wrenches and lapping tools.

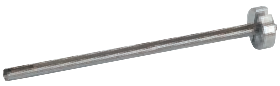
Measuring and calibration tools complete Kistler's extensive product range. Battery-operated service units can measure very high insulation resistance values of up to $4 \cdot 10^{13}\ \Omega$. They are used for checking piezoelectric sensors, charge amplifiers, electrometer amplifiers, cables and also components such as condensers.

Preload measurement units are used for in-situ measurement of charges, e.g. measuring the preload of piezoelectric strain measuring sensors required for installation. This measuring equipment is small, lightweight and they operate independently of the network with an integrated charge amplifier.

Test sets are used for checking cavity pressure sensors, which have already been installed in the injection mold. They provide a direct digital display of their pressure sensitivity in pC/bar.

Tools

Extraction tools for sensors



Technical Data		Type 1315A	Type 1358	Type 1362A...
Outer diameter	mm	Ø 5,8	Ø 3,8	Ø 6
Length	mm	50	150	150, sp*
Thread	Type	M5	M3 x 0,35	M3
Sensors	Type	6152A..., 6157B..., 6159A..., 6167A..., 6177A...	6158A..., 6178A..., 6182A..., 6183A..., 6193A..., 6195A...	6190A..., 6192A..., 6194A...

* customized length

Data sheet 1300_000-068

Tubular socket wrench for mounting nuts

Technical Data		Type 1383	Type 1356
Outer diameter	mm	Ø 10	Ø 5
Length	mm	300	150
Sensors	Type	6152A..., 6157B..., 6159A..., 6167A..., 6177A..., 6190A..., 6192A..., 6194A...	6158A,... 6178A..., 6182AE, 6183AE, 6193A..., 6195A...

Data sheet 1300_000-068

Accessory set for sensors

Technical Data		Type 1300A81	Type 1300A83
Description		Manufacturing and checking sensor bores for 4 mm front diameters	Manufacturing and checking sensor bores for 4 mm and 2,5 mm front diameters
Sensors	Type	6157B...	6152A...

Data sheet 1300A_000-072

Calibration & testing tools

Insulation tester

Technical Data		Type 5493
Measuring range	Ω	10^{11} ... 4 x 10^{13}
Description		Battery-operated service instrument for measuring insulation resistances
Area of application		Insulation testing of piezoelectric sensors, input cables and connection cables

Data sheet 5493_000-354

Preload tester

Technical Data		Type 5991
Measuring range	pC	±100 000
Output voltage	V	0 ... ±1
Description		Battery-operated preload tester for on-the-spot measurement of charges on site
Area of application		On-the-spot sensor preload measurement and testing. With one output for monitoring function

Data sheet 5991_000-340

Test set for cavity pressure sensors

Technical Data		Type 5993A1
Test force	N N	min. 70 max. 125
Description		Battery-operated handheld test instrument with test pin and connection cables. Displays the sensitivity of sensors.
Area of application		Testing the function of integrated sensors

Data sheet 5993A_000-341

Technical literature

Special publications and application brochures

Plastics	
Thermoplastic	900-319
Plastics Processing – Productivity Increases and Cost Reductions	920-231
Measuring technology for low-pressure processes – Validation of flaw mechanisms affecting in-mold foaming of automotive cockpit components	920-249
Injection Molding – Quality Assurance and Documentation with DataFlow	500-389
Single-Wire Technique – Extremely simple – simply brilliant	500-401
Injection Molding – Quality Assurance and Documentation with DataFlow	500-389

Theory	
Measuring with Crystals	900-335
PiezoStar Crystals – A New Dimension in Sensor Technology	920-240

Product overview by type numbers

Photos by
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