KISTLER

measure. analyze. innovate.



Process Monitoring and Control

Efficiency in Networked Injection Molding Production

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Kistler – Your Partner for Process Efficiency and Cost Effectiveness

The Kistler Group is one of the world's leading manufacturers of sensors and systems for measuring pressure, force, torque and acceleration. Kistler systems are used to analyze measuring signals with high-precision and therefore substantially increase process efficiency and operational success.

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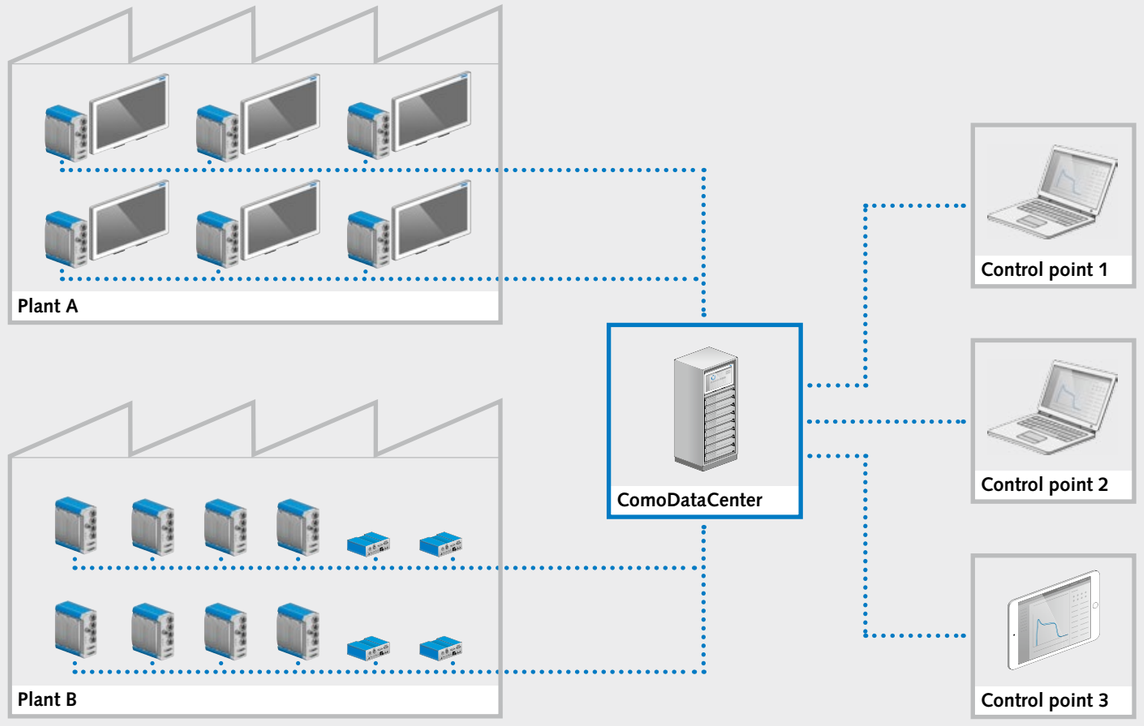
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Kistler Systems: the Ideal Basis for Enhanced Efficiency in Networked Injection Molding Production

The Industry 4.0. vision has already emerged as a distinct reality in the injection molding sector. The new approach to production focuses on consistent digitization – leading to enhanced product quality and increased cost-efficiency. Market players equipped with Kistler systems for process monitoring and control are ideally placed to meet the requirements for digital networking – with no problems.

Quality requirements for injection molding are constantly increasing, so permanent control of the entire production chain is essential. Kistler presents ComoNeo and ComoDataCenter: two system components that offer the best possible basis for achieving this goal – and they are perfectly suited to novices as well as experienced users.

First and foremost among the new features is the Restart Assistant now integrated into ComoNeo: it allows efficient reproduction of established processes when changing machines. But there are many other innovations as well: for example, the system now supports the OPC-UA interface, which is on the way to becoming the standard for injection molding production. Integration of OPC-UA in ComoNeo also makes it possible to implement Multi-Flow control as an entirely standalone solution, without an additional PC. The benefit: significantly less effort is required for the entire setup process.

Benefits of Kistler Systems:

- Zero-defect production
- Quality costs are cut
- Optimal process efficiency
- Process reliability is enhanced
- Cycle times are optimized
- Staff costs are reduced
- Plant efficiency is increased
- Rapid amortization (RoI)

Another new feature for ComoNeo: online quality prediction is integrated directly in the system, so the full bandwidth of cavity pressure monitoring methods is available – from monitoring of process fluctuations and manual or automated EO monitoring (with the EO Assistant) through to online quality prediction (with DoE). This is a high-end solution for direct calculation and evaluation of part characteristics.

In a nutshell: by adding these new features to ComoNeo and ComoDataCenter, Kistler is paving the way for yet more future improvements to product quality and cost-efficiency in injection molding production.



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www.kistler.com/injection-molding



Process Monitoring with ComoNeo: Transparent Injection Molding Processes Guarantee Quality

The ComoNeo process monitoring system uses the profile to monitor and evaluate the quality of an injection-molded part. For this purpose, the system checks whether a specified value in the profile is reached or exceeded, either with the help of defined evaluation objects (EOs) that are set manually or automatically, or on the basis of statistical test planning.

The ComoNeo monitoring system analyzes quality-relevant sections of the measurement curves captured via the measurement functions, with the help of defined Evaluation Objects – known as EOs. To do this, ComoNeo verifies whether the curves pass through the evaluation objects as predefined. (Figure 1).
If so, ComoNeo generates an "OK" result; otherwise, the result is "Not OK" (NOK). This allows sorting into good and bad parts. The EOs are set either manually or automatically. Additional practical tools are also at the user's disposal: online quality prediction based on statistical test planning, and the Restart Assistant.

Advantages of Process Monitoring with ComoNeo:

- The integrated process dashboard provides a quick overview of the status and progression of production
- Separation of good and bad parts
- Manual monitoring of cavity pressure by setting Evaluation Objects (EOs)
- Automatic monitoring of cavity pressure with the EO Assistant
- Online-quality prediction as an additional method for separating out scrap
- Restart Assistant: the simple way to transfer established processes from one machine to another

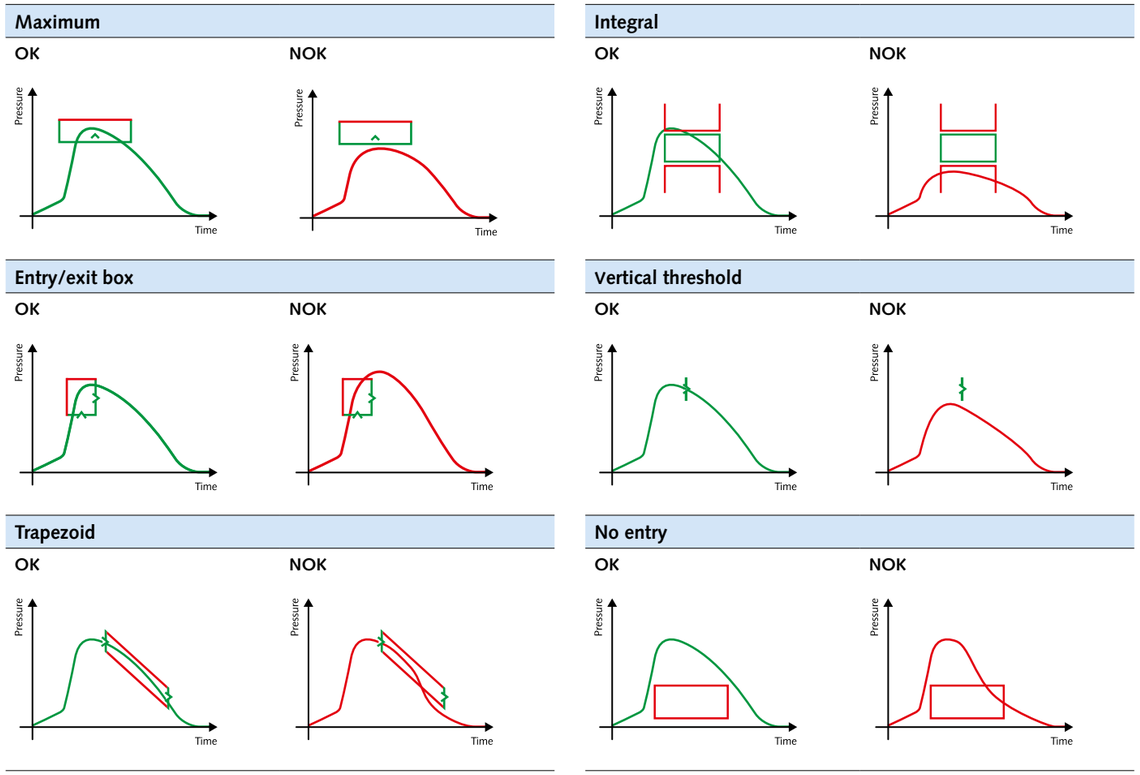


Figure 1: ComoNeo Evaluation Objects (EOs)

Manual Monitoring of Cavity Pressure

Cavity pressure monitoring with manually set EOs makes it possible to determine various quality features in the injection molding process, and they can be evaluated with reference to the specified tolerances. Six frequently used functions are presented in the following overview.

Maximum
The Maximum function checks whether the curve reaches a specified value (green line) or whether it does not exceed that value (red line). Typically, this box is used to determine whether the cavity was completely filled (short shot).

Entry/exit box
The entry/exit box ensures that values only pass through the green lines, not the red ones. These can be selected freely. The progression may be horizontal or, as in the illustrated example, via entry (below) and exit (right). This box is always rectangular. Kistler recommends this box for almost all applications because it allows checking of the pressure level as well as the time component.

Trapezoid
The curve can only enter from the left and must exit to the right. The upper and lower limits must not be at the same level. If it is necessary to ensure conformance to a specified holding pressure profile, this box is recommended.

Integral
The area below the curve must maintain a specified value for a defined period. The Integral function is used to monitor sink marks.

Vertical threshold
A vertical threshold has to be crossed from left to right. For complex curves, this EO should be used in addition to other EOs.

No entry
No curve is allowed to touch this box. This function monitors (for example) if pressure losses occur.



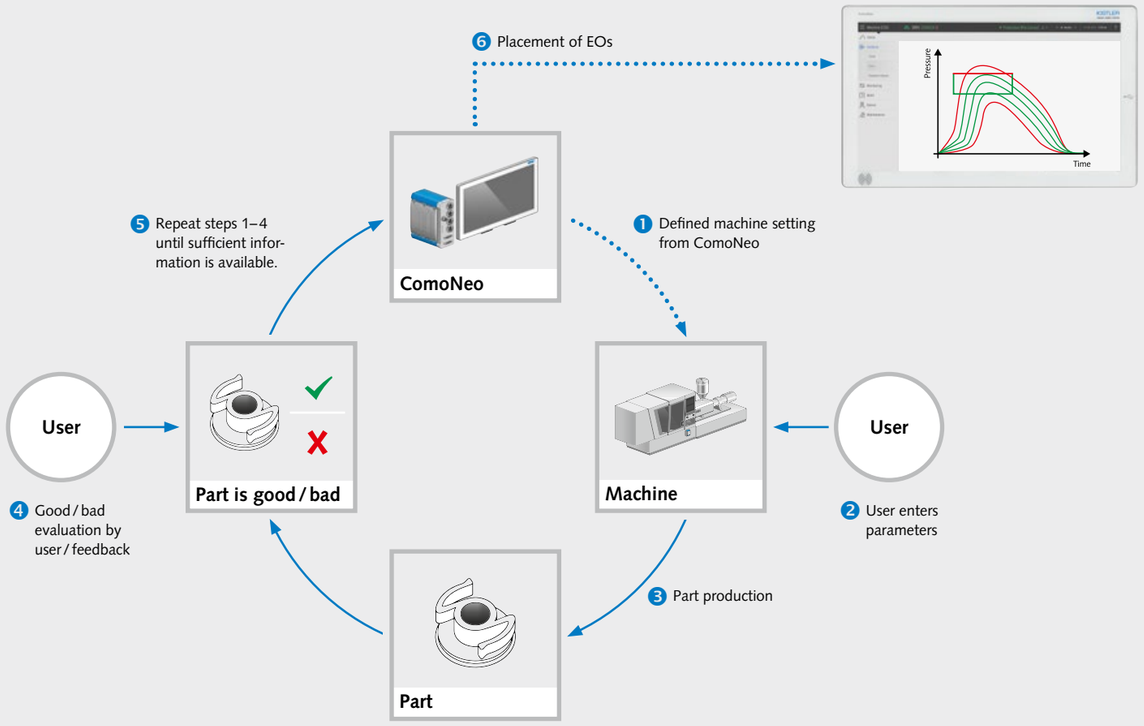


Figure 2: User-guided generation of EO limits with the EO Assistant

EO Assistant: The User-Friendly Tool for High-Precision Part Monitoring

Available since ComoNeo version 1.0, the EO Assistant is a tool that generates and positions the monitoring boxes for good / bad evaluation – guiding users quickly and seamlessly to the sorting limits. The results from the EO Assistant define the evaluation types and the relevant limits. Thanks to this approach, components can be monitored and sorted into good and bad with high precision – and pseudoscrap (i.e. "presumed" scrap) is reduced.

The EO Assistant allows user-prompted generation of the EO limits: users are guided through the procedure for defining the sorting limits. (Figure 2). This makes it unnecessary for users to have detailed previous knowledge about cavity pressure technology.

Simple User Guidance
This automated method requires an existing established process with good parts. Taking this as the basis, the EO Assistant selectively changes the machine parameters to simulate a new cavity pressure profile, with the result that the part's characteristics change.

Benefits of the EO Assistant:
- Users are guided through the individual steps
- Know-how is integrated within the system, so users do not need to be specialists
- More accurate evaluation limits (as wide as possible, as narrow as necessary)
- Scrap is separated out more accurately
- Pseudoscrap is reduced
- Systematic procedure, not dependent on individual staff members
- Random sampling with EO adjustment is possible for even greater precision
- Standardized, documented procedure
- Option of choosing the monitoring strategy (e.g. one EO across multiple cavities)

After this, the user can take measurements or perform an optical assessment to evaluate the produced parts, and then decide whether the relevant cavity pressure profile is good or bad.

Systematic changes make it possible to work through the process window within a short time and then to repeat the steps performed until sufficient information is available for automatic placement of the EOs (Evaluation Objects) to monitor the parts. Users themselves can decide when to discontinue EO evaluation. The more test cycles are completed, the more accurately the EOs can be placed. In this case, "more accurately" means that fewer good parts are declared and segregated as scrap. Of course, all bad parts are always separated out.



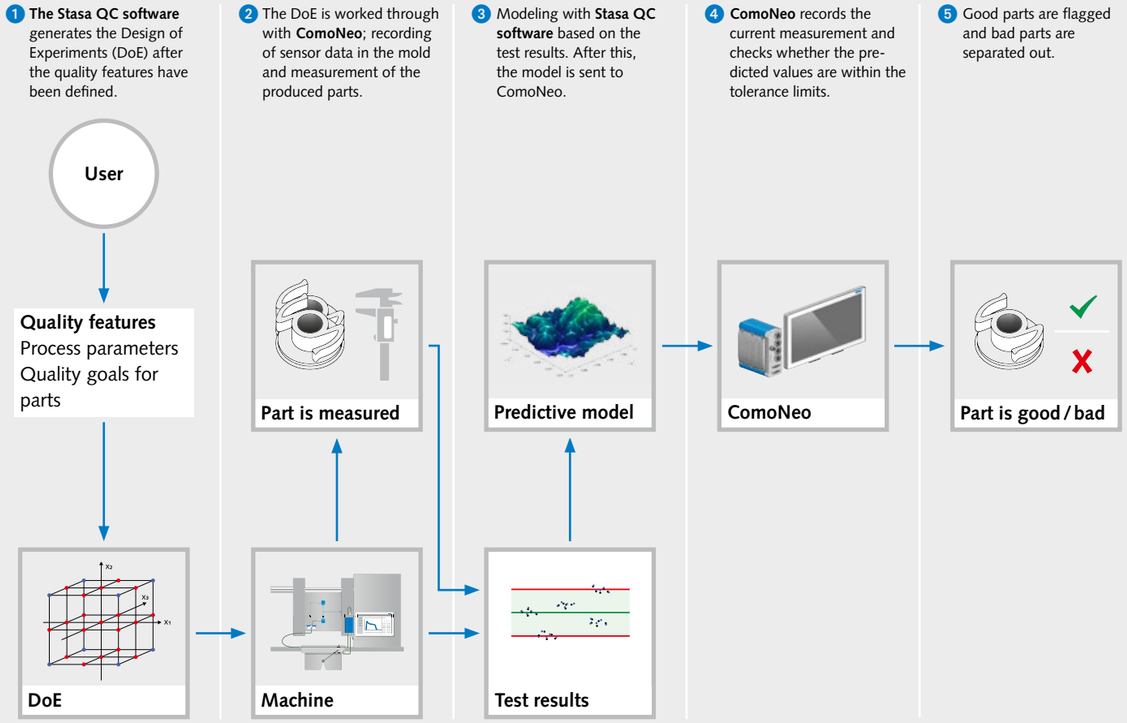


Figure 3: Workflow for online quality prediction

Online Quality Prediction: The Systematic Method to Determine Part Quality

Integrated into ComoNeo since version 2.0, online quality prediction is the basis for reliable statements about every manufactured part – ahead of time. Taking the current cavity pressure profile as the basis, the module predicts the part's eventual dimensions.

Kistler's online quality prediction is based on models that make it possible to calculate the characteristics of parts. (Figure 3). The statistical DoE (Design of Experiments) process for test planning helps to determine relationships between pressure / temperature profiles and defined quality features. To carry out online quality prediction, users need the machine and the component, plus the ComoNeo monitoring system and the Stasa QC software (PC software) to generate the DoE and the prediction model.

Performed in a Few Easy Steps

The first step is for the user to enter specified tolerance limits for the part's quality features in the Stasa QC software. Then, the software automatically generates a Design of Experiments (DoE). In the second step, the DoE is worked through with ComoNeo on the injection molding machine; all cavity pressure curves are recorded and the parts are removed and measured. Features such as surface quality or flash can also be evaluated. Then the results are fed into the Stasa QC software and linked to the mold measurements (pressure, temperature). The software uses this data to produce a model so that part quality can be predicted on the basis of the mold measurements.

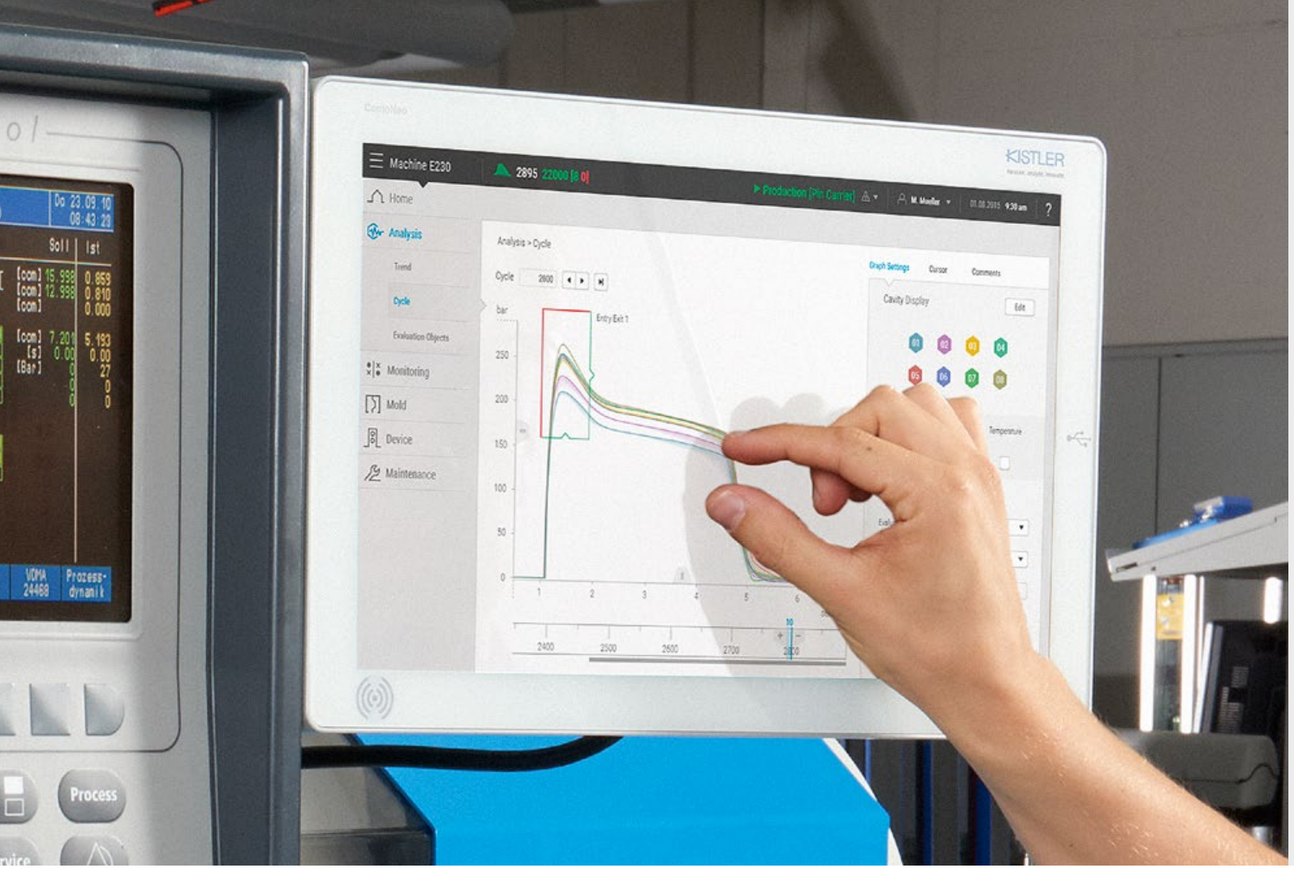
In the next step, the model is sent to ComoNeo where it is enriched with the current mold measurements as input variables. The output from the model on ComoNeo consists of predicted values for the defined quality features (length, width, weight, etc). At the same time, checks determine whether these predicted values are within the tolerance limits. Once all the features for a component are correct, the component is flagged as 'good'; as soon as a component is 'bad', it is separated out and flagged as such.

For Manufacturers of High-Grade Components

This standardized and documented procedure means that tests and model calculations can be performed regardless of which individuals are available. The transparency of the method gives users a far better understanding of the process. Manufacturers of sensitive precision parts for the medical technology sector and producers of other critical high-quality components benefit from this tool, which gives users a 100% in-process prediction of all quality features.

Benefits of Online Quality Prediction:

- An exact method for separating scrap, thanks to complete quality records
- Direct monitoring of predicted quality features makes it much easier for users to understand
- Pseudoscrap is minimized
- Simple handling of tolerances as sorting criteria (transferred from the part drawing)
- Systematic determination of part quality
- Automatic selection of relevant curve points for calculation
- Can be used even without in-depth mathematical or statistical knowledge
- Models can easily be retrained to achieve further improvement



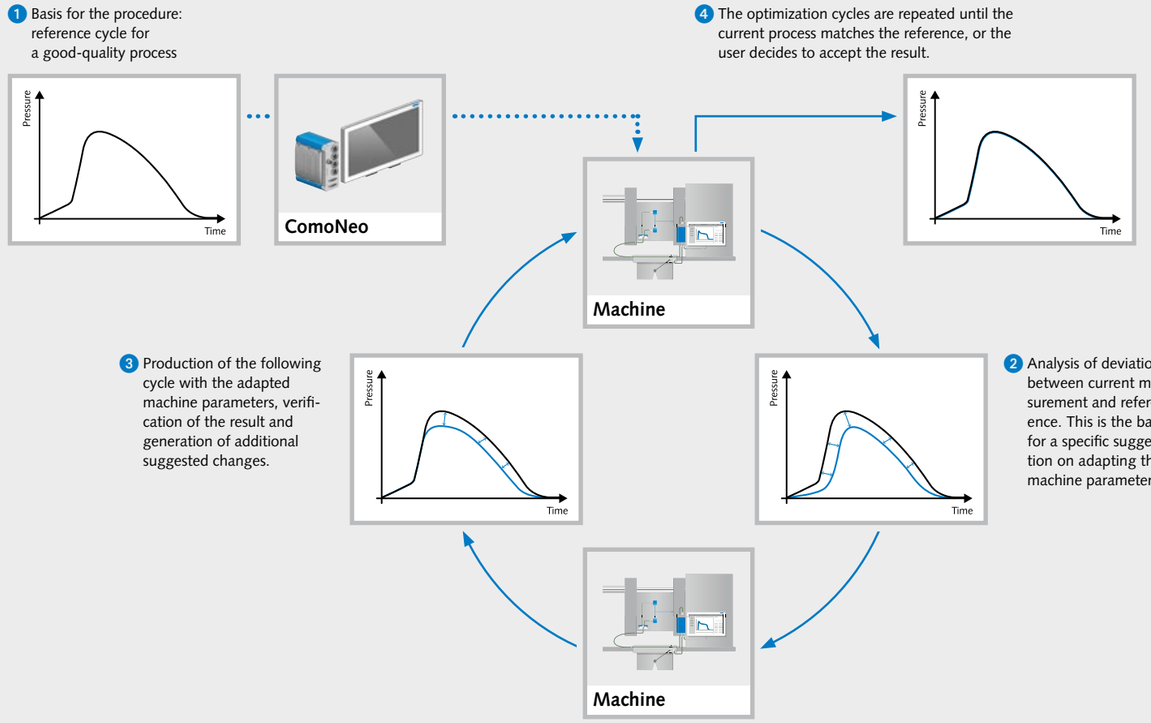


Figure 4: Step-by-step optimization in the injection molding process with the Restart Assistant

Restart Assistant: Identical Reproduction of the Injection Molding Process after Changing Machines

The Restart Assistant integrated into ComoNeo V2.0 makes it possible for users to transfer pre-established processes from one machine to another with no problems at all. This makes it easy for users who have no previous knowledge of cavity pressure to optimize processes and improve part quality.

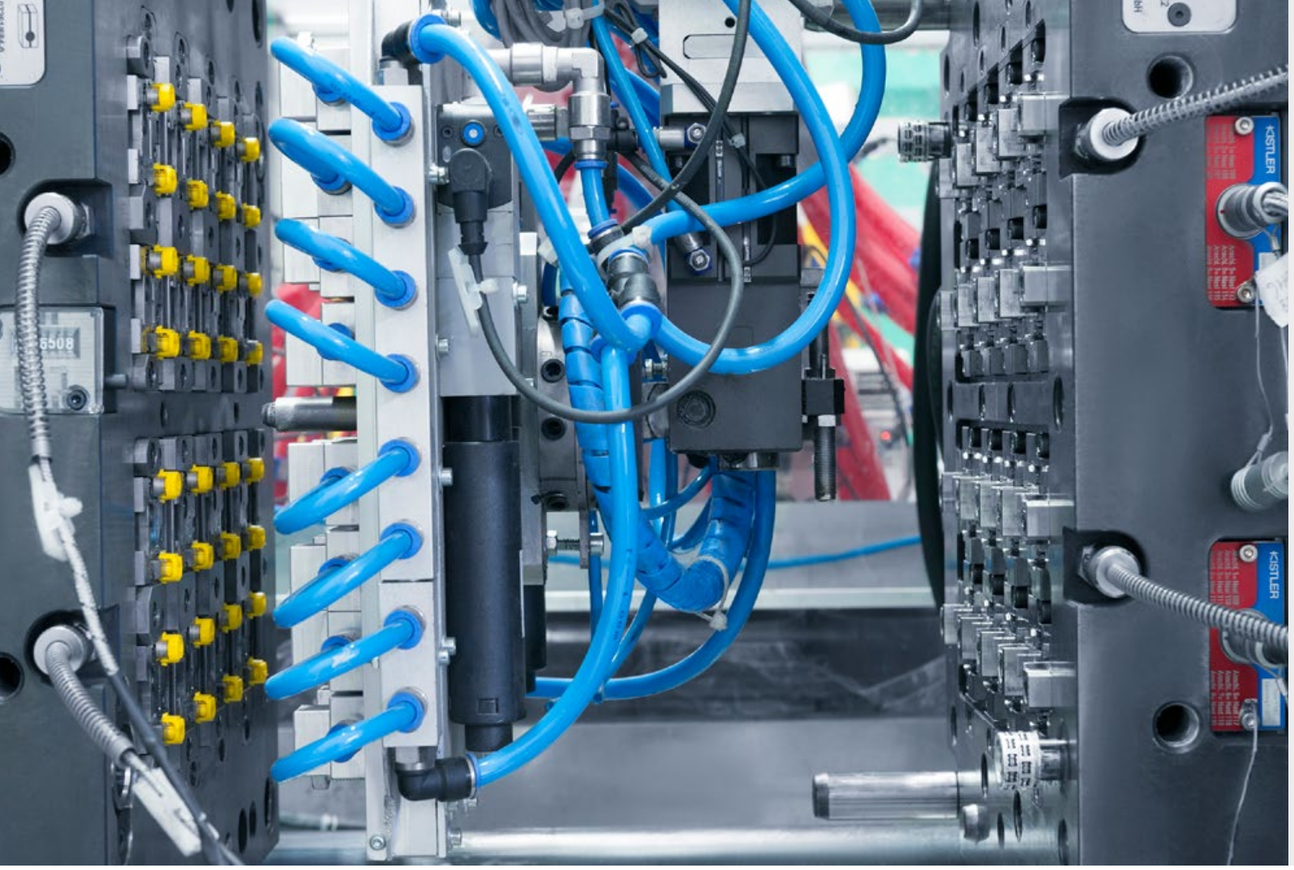
The Restart module has been integrated into the system since ComoNeo Version 2.0. The purpose of this module is to reproduce the quality of an established injection molding process identically on another machine. (Figure 4). The Restart Assistant is therefore used as a tool to optimize injection molding processes, rather than as a monitoring instrument.

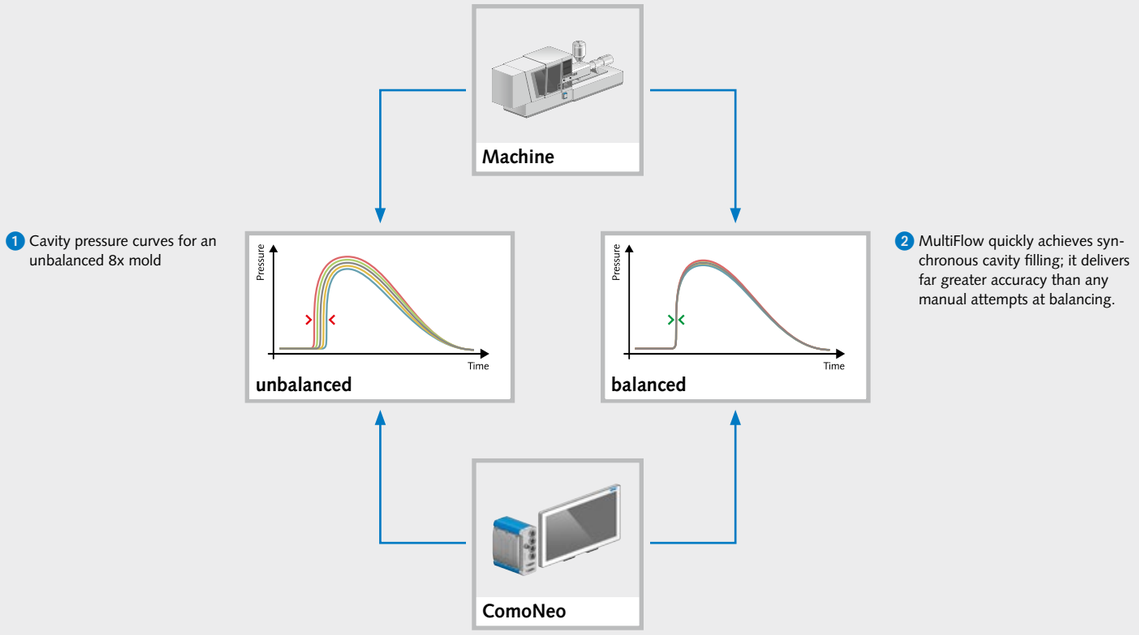
Know-How Integrated in the Assistant
With this module, processes can be quickly and systematically optimized after a machine change, and the procedure is user-guided. As the basis for the procedure, the Assistant needs a reference curve representing a process of good quality.

Benefits of the Restart Assistant:
- Users are guided through the individual steps
- Know-how is integrated within the system, so users do not need to be specialists
- Systematic approach
- Standardized, documented procedure
- Transparent, no dependencies on individual staff members
- Time is saved on process start-up
- Part quality differences are minimized when manufacturing on different machines
- Users' process understanding is actively developed

Once the reference cycle is stored and the Assistant is started, measurement and analysis of the current process can begin. Deviations from the reference cycle are analyzed in detail. Based on the degree and position of the deviation, the Assistant automatically suggests changes to the machine parameters.

After checking the results, new changes are suggested on the basis of the deviations and the Assistant's accumulated experience of previous changes. Process optimization is completed when the cavity pressure profile deviations are reduced to a tolerable level.





1 Cavity pressure curves for an unbalanced 8x mold

2 MultiFlow quickly achieves synchronous cavity filling; it delivers far greater accuracy than any manual attempts at balancing.

3 ComoNeo/Screen: MultiFlow analyzes and compares the measured pressure curves with far greater precision than any attempts at manual balancing.

Figure 5: MultiFlow synchronizes the pressure profiles on the hot runner

Process Control: New Approaches to Balanced Injection Behavior

ComoNeo is not only suitable for monitoring – it is also an excellent choice for the control of injection molding processes. As an option for ComoNeo, MultiFlow synchronizes the pressure profiles by individually controlling the nozzle temperatures on the hot runner. The system also includes automated switchover to ensure perfect timing when changing over from speed-controlled to pressure-controlled injection molding in response to cavity pressure during the hot runner balancing process.

MultiFlow is one of the control methods used for hot runner balancing. Its purpose is to use appropriate temperature control of the individual nozzles to ensure that all filling curves have identical filling, so that production quality is guaranteed.

With real-time control, the control within a cycle is either set up manually or is automated. The main advantage of manual setup for controlling is that multiple dependencies can be set; however, the Switch Level Process (SLP) scores because calculation of the switchover point is self-optimizing.

Thanks to these process control options that are newly integrated in ComoNeo, process fluctuations can now be compensated during the production phase as well. If there are multiple cavities, MultiFlow compensates for filling differences via hot runner balancing, while real-time control optimizes the switchover point for all the cavities – resulting in balanced injection behavior across the entire production sequence.

MultiFlow Control

As an option for ComoNeo and CoMo Injection, MultiFlow synchronizes the pressure profiles by individually controlling the nozzle temperatures on the hot runner. It stabilizes the process and adjusts for batch fluctuations as well as other process disruptions.

The MultiFlow option combines the advantages of automated hot runner balancing with 100% quality assurance based on cavity pressure. (Figure 5). The purpose of hot runner balancing is to ensure identical injection and pressure conditions in all the mold's cavities. The control variables used by MultiFlow are the cavity pressure profiles in the individual cavities. The actuating variables are the temperatures of the hot runner nozzles.

MultiFlow analyzes and compares the measured pressure curves. It also calculates the new setpoint temperatures for the nozzles and transmits them via an interface to the hot runner control system, which may be external or integrated in the machine.

Automated Balancing in Case of Process Fluctuations
The basis for MultiFlow is provided by reliable information about the entire mold filling process, so it enables automatic compensation for batch fluctuations and process disruptions. This is a key advantage as compared to systems based on melt front detection that control the point in time when the melt front reaches a specified position in the cavity.

Benefits of MultiFlow:

- Identical filling conditions in all cavities
- Shorter tooling and setup times
- Fast injection molding process startup
- No manual setting or readjustment of temperatures and parameters
- Fully automated compensation of material fluctuations and process disruptions
- Integrated in ComoNeo as a standalone solution (control without PC is possible)

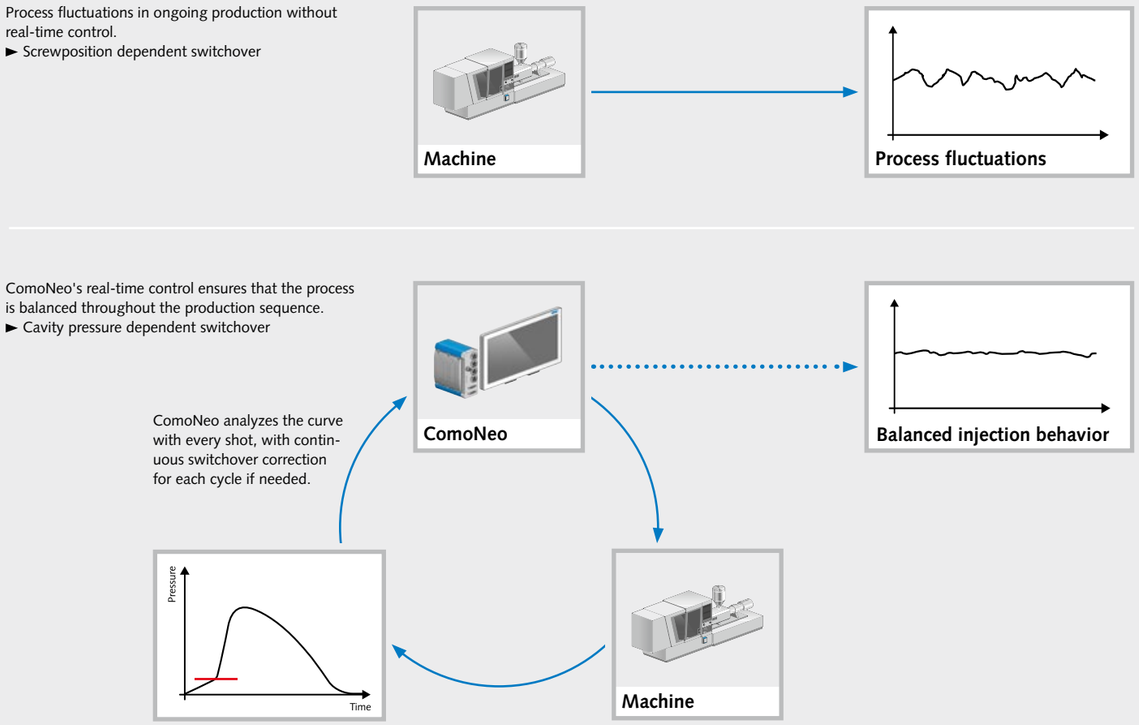


Figure 6: Compensation of process fluctuations based on cavity pressure switch-over control.

Switchover/SLP

ComoNeo provides active feedback for the machine. This allows ideal timing for the switchover from speed control to pressure control in response to cavity pressure.

The automatic switchover control can be used in two different ways. This first option involves manual setup, and control behavior is only changed after the user intervenes. The second option is SLP (Switch Level Process), with fully automated setup and optimization of control behavior from cycle to cycle. (Figure 6)

For molds with multiple cavities, automatic switchover behavior has been optimized for the specific purpose of compensating for different behavior patterns throughout the production sequence. When conditions are set manually, additional dependencies across multiple cavities are available as control criteria.

On the other hand, fully automated switchover is mainly used for molds with small numbers of cavities. The benefit here: ease of handling. All that is needed is to activate the process: everything else is controlled automatically by the internal algorithm, virtually at the touch of a button. Both switchover options actively help to prevent mold damage because safety functions respond if filling differences are excessive.

Benefits of process control with switchover/SLP:

- Perfect timing of the switchover from speed-controlled to pressure-controlled injection molding
- Switchover point can be adjusted automatically or manually, according to choice
- Minimized fill time difference
- Mold-friendly process
- Reduces stresses in the component



ComoDataCenter: Central Storage of Process Data and Integration into Higher-Level Systems

CoMoDataCenter links all the user's ComoNeo and CoMo Injection systems, combining process- and quality-related production data for both live and completed orders in one database.

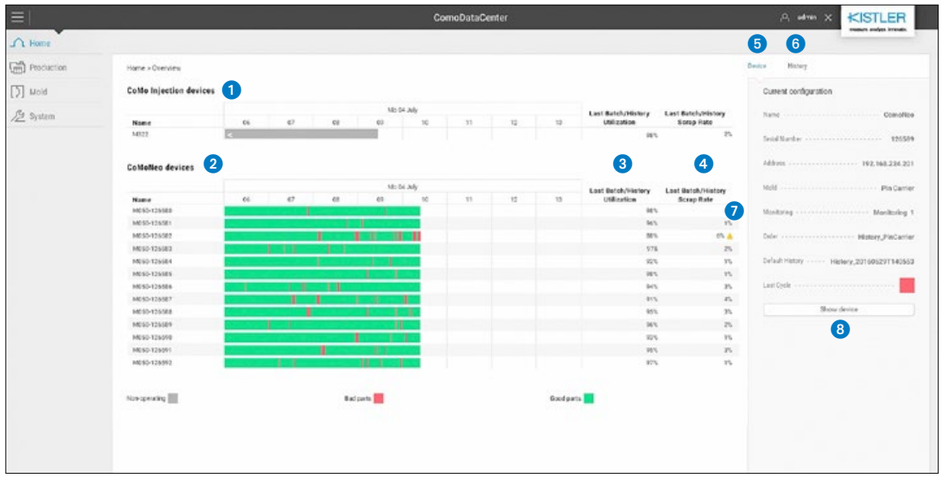
Kistler's ComoDataCenter (CDC) is also enhanced with new features that make it easier to network data and improve the traceability of part quality. For instance, the CDC is now available for ComoNeo as well. Thanks to this innovation, ComoNeo and CoMo Injection are now linked via a common database. Another new feature: mold management is now integrated into the CDC. The settings can be stored centrally, so the ComoNeo and CoMo Injection mold settings can be transferred to other plants via CDC. For existing customers, this also ensures compatibility between CoMo Injection and ComoNeo – guaranteeing that CoMo Injection users can change over gradually to ComoNeo.

Simple Data Networking
In addition, there is provision for integration into higher-level systems such as SAP or other MES systems. The CDC acts as the single interface between the process and higher-level systems.

The benefit: all data can easily be networked with other systems across the company. What's more, the CDC's user interface is now standardized with the tried-and-tested ComoNeo interface – entirely in keeping with the universal operating philosophy that Kistler advocates.

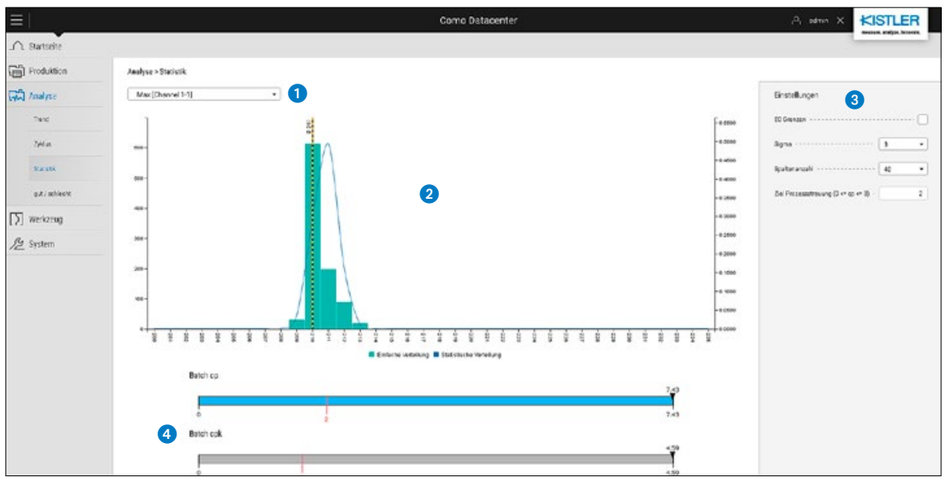
ComoDataCenter at a Glance:

- Fast overview of the production efficiency of all connected ComoNeo and CoMo Injection systems
- Central data storage for all recorded process data
- Process fluctuations are quickly detected
- Detailed analysis options and statistical evaluations of all historic and live production runs
- Storage and management of all mold settings



Overview of ComoNeo/CoMo Injection Equipment

1. Overview of all CoMo Injection equipment.
2. Overview of all ComoNeo equipment.
3. Utilization factor display: shows the performance of good part production in relation to the defined shift period.
4. Scrap rate: shows the scrap rate for the current production run.
5. The Device tab shows key information about the selected ComoNeo. This may include the mold currently loaded and the live production order.
6. The observation period can be set on the History tab.
7. Warnings indicate when the tolerance limit has been exceeded.
8. Use the Show Device key to open the selected device directly in the browser.

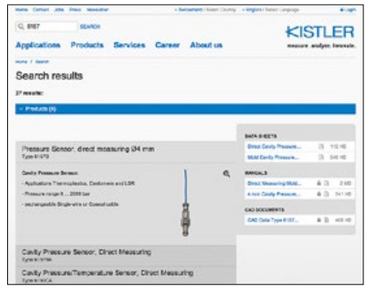


Example of a Statistical Evaluation

1. Use the dropdown menu to select the EO for which you want to view statistics.
2. The main window shows the pressure distribution for the individual cycles, the average and the relevant standard deviation.
3. Here you can adjust the visualizations. This allows you to show the EO limits and to define the sigma and cp values. You can also adjust the number of columns to be shown so that the image resolution is finer.
4. The cp and cpk values are shown in relation to the predefined limits. So at a glance, you can see how stably production is running.

Kistler – Worldwide Presence for Our Customers

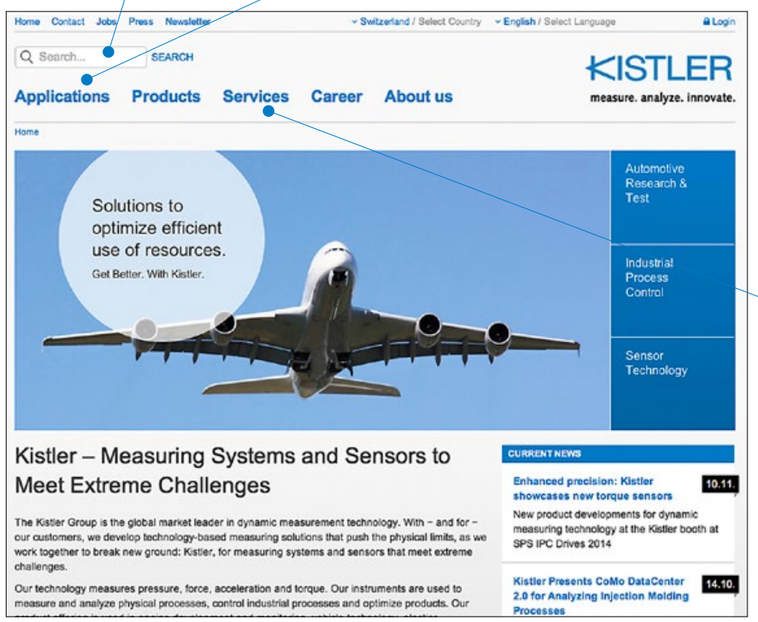
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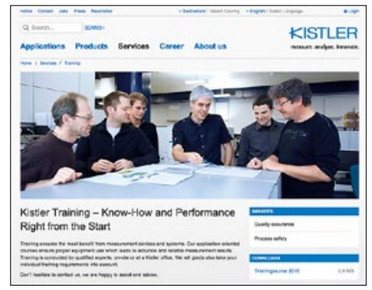


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Our Representatives Are Here to Help
Whether you would like a consultation or require support during installation – our website provides the contact information for your local representative.





Education and Training Events
Education and training courses, during which our sensors and measuring systems are explained by Kistler experts, are the most efficient way for you to obtain the required user knowledge.

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Kistler Group
Eulachstrasse 22
8408 Winterthur
Switzerland
Tel. +41 52 224 11 11

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