KISTLER

measure. analyze. innovate.

Monitor processes reliably – and cut costs

Process inspection

Quality monitoring for fastening technology

Absolute Attention for tomorrow's world

Kistler develops solutions for challenges in measurement technology with a portfolio that comprises sensors, electronics, systems and services. We push the frontiers of physics in fields such as emission reduction, quality control, mobility and vehicle safety: our products deliver top performance to meet the standards of tomorrow's world, providing the ideal basis for Industry 4.0. This is how we pave the way for innovation and growth – for our customers, and with our customers.

Kistler: the byword for advances in engine monitoring, vehicle safety and vehicle dynamics. Our products deliver data that plays a key part in developing efficient vehicles for tomorrow's world.

Measurement technology from Kistler ensures top performance in sport diagnostics, traffic data acquisition, cutting force analysis and many other applications where absolutely reliable measurements are required despite extreme conditions.

By supporting all the stages in networked, digitalized production, Kistler's systems maximize process efficiency and cost-effectiveness in the smart factories of the next generation.

Contents

Process inspection: the guarantee of quality

Production processes in fastening technology demand continuous optimization to achieve the twin goals of boosting productivity and ensuring high quality. Inspection systems by Kistler make this possible: our INSPECT systems for process inspection monitor the fastening process; they verify and document the process parameters, and they deliver proof of the quality of threaded joints – either during the process or after fastening is completed. These systems allow targeted monitoring of tolerance limits, and errors can be detected at an early stage.

Kistler's measurement technology experts are constantly working to advance the development of quality assurance systems that can optimize fastening processes. The focus is always on one objective: your business success. Our inspection systems help you to consistently enhance process reliability in your operation, optimize your use of monitoring and minimize your outlay on testing and corrective actions. The end result: sustainable increases in your productivity and quality.

The benefits of INSPECT systems

- Reduced quality costs
- In-process error detection
- Immediate in-process quality correction
- Optimized fasteners
- Enhanced efficiency in the fastening process
- Documentation
- Protection against product liability cases
- Reproducible inspection processes
- Traceable results
- Compliance with standards

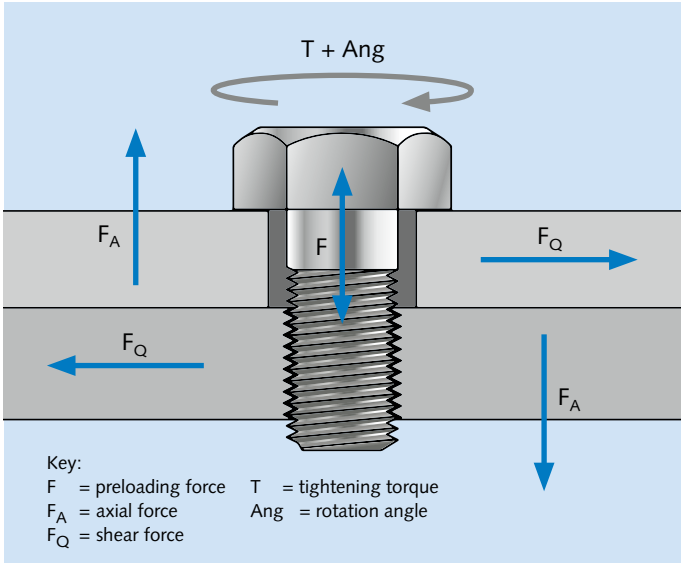
Compliance with standards: a key quality characteristic
Requirements for process inspections of fasteners are specified by various international and customer-specific standards that are constantly changing. Because Kistler's inspection systems are highly flexible, they can adapt to the new requirements – time after time – so they always take account of the latest technological developments. The software structure of our INSPECT systems is designed for regular updates, and their modular structure enables users to implement changes in hardware requirements immediately.

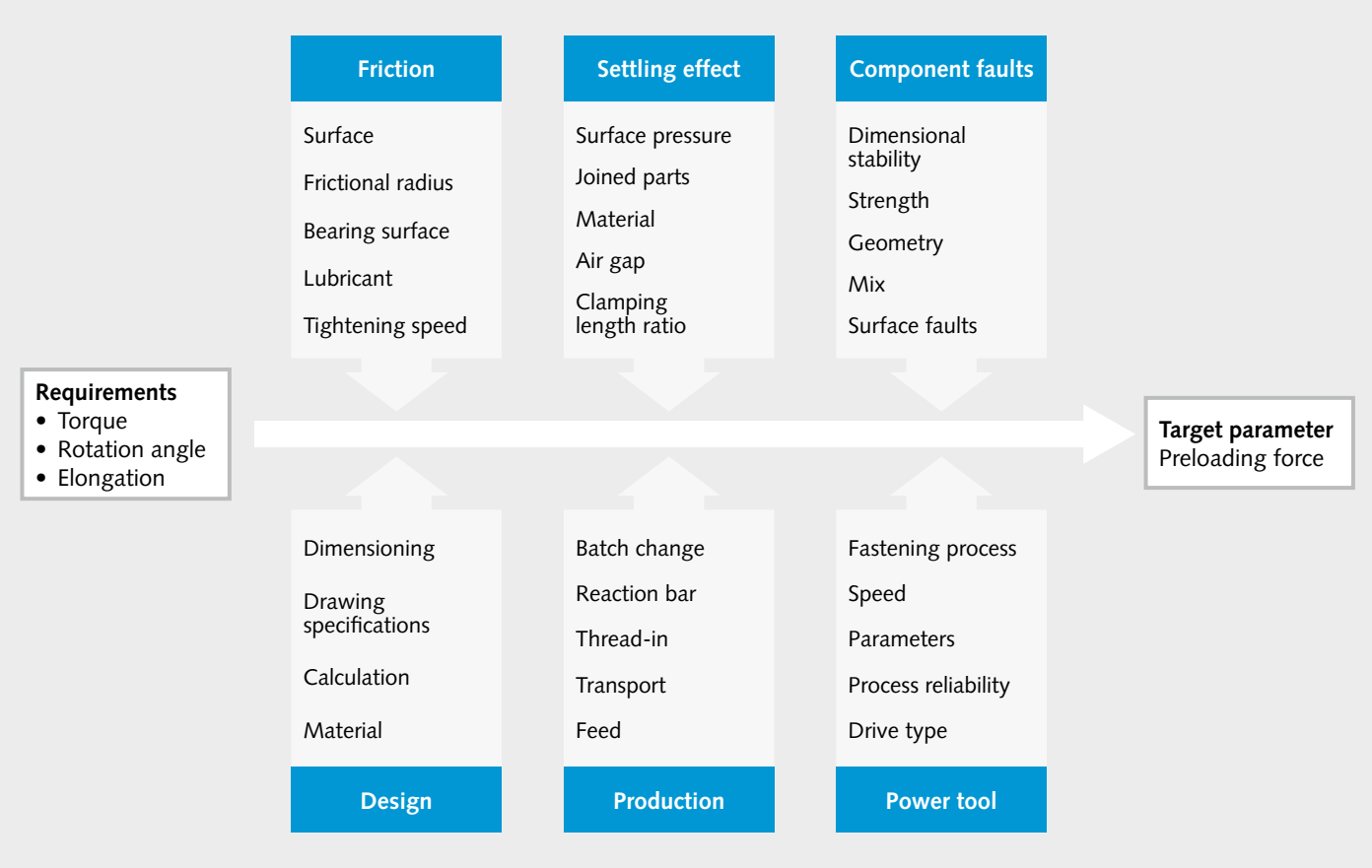
Application areas for inspection systems
- Automotive industry
- Aerospace industry
- Commercial vehicle manufacturers
- Supply sector
- Research and educational facilities
- Inspection service providers

Manufacturing processes demand reliable fastening

Threaded joints are still one of the most important methods of connecting materials in assembly technology, as they always have been. They provide a reliable way of joining several components or parts together until the joint is released as intended. This means that a threaded joint is the only connection method that can be released without destruction – and as a general rule, the joint can be used again.

Multiple components in a permanently connected state must behave like one complete component as the result of the clamping or preloading force applied between the components – even when external loads are applied. The coupled joint must not come apart due to loss of the frictional bond, otherwise the connection will be released. Furthermore, the maximum preloading force must not be exceeded, otherwise overloading will occur and the connection may fail.





Key parameters influencing the target parameter of preloading force (based on source: VDI/VDE 2645 sheet 3).

Assembling a threaded joint

The objective when assembling a threaded joint is to achieve a preloading force in the joint that is as exact and reproducible as possible. Measuring the preloading force directly during assembly is a complex and time-consuming process. In the current state of the art, therefore, torque and rotation angle are used as auxiliary variables; these measurands are recorded and statistically evaluated to validate the process. The spreads of attained torque and rotation angle inevitably produce spreads in the resultant preloading force.

Influences on the production process for a threaded joint

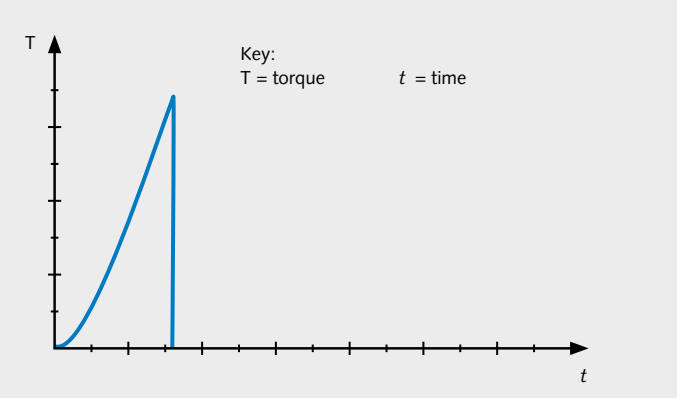
Due to numerous influencing factors, the preloading force attained has a complex relationship with the introduced torque and the rotation angle; this is clearly set out in many standards such as VDI/VDE 2645 sheet 3. So that these influencing factors can be kept as constant and low as possible at a very early stage in the process of producing a threaded joint, analysis of the influencing parameters must begin back in the planning and prototype phase. This also allows early detection of influencing factors that have not been taken into account.

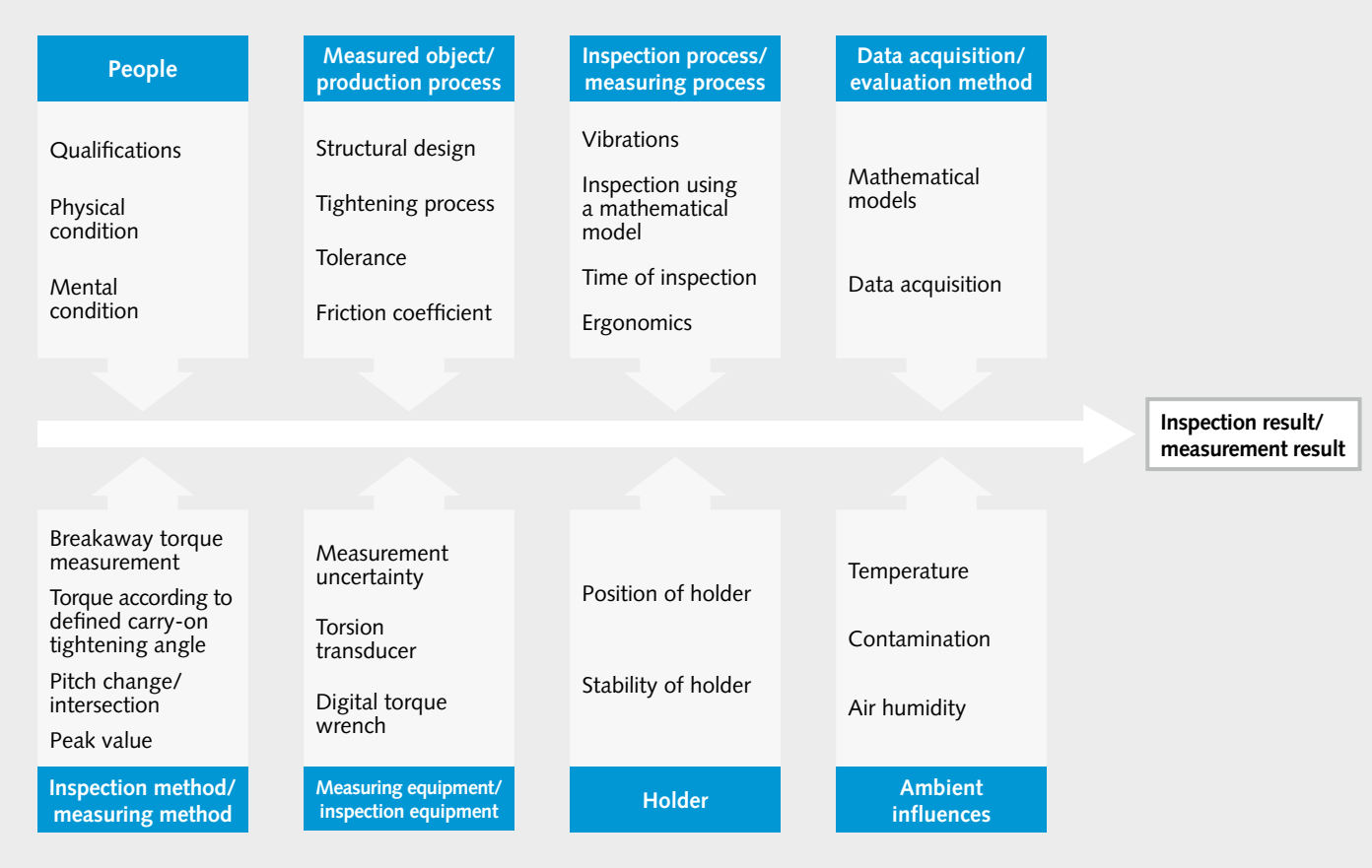
Process inspection: the systematic approach

End-to-end quality assurance – all along the line
Each INSPECT system from Kistler is a complete inspection system to determine process characteristics in fastening technology. From monitoring of the fastening process through to comprehensive documentation of the process parameters and results: these systems cover the entire range of requirements for a vast variety of process inspections. End-to-end inspection and documentation provide proof of the quality of the threaded joint. This allows targeted monitoring of tolerance limits, and process deviations can be detected at an early stage.

Definition of "Process inspection"
To ensure comparability, process inspections are always based on reference data from an identical or comparable fastening scenario and on fixed definitions of overall conditions. All the important influencing parameters for the inspection process are taken into account and recorded as appropriate. VDI/VDE 2645 sheet 3 defines the relevant methods, influencing parameters, overall conditions and evaluation algorithms. By specifying this data, process inspections are clearly defined so they ensure that a fastening process is capable of delivering quality under series conditions. Users must also have appropriate specialist knowledge about threaded joints, and staff must be suitably trained.

Process inspection in the fastening process with in-process measurement
In-process measurement is the name given to the method for verifying the fastening process directly during assembly, with a process inspection. Based on the real fastening scenario, this process inspection method takes account of all the influencing parameters directly, during the actual assembly: examples include the tightening tool spread, type of fastening process, frictional influences of the fastener components and influences caused by the worker or ambient factors. For this purpose, a torque/rotation angle sensor is adapted in the bolting assemblage between the fastener and the tightening tool; the fastening curve is recorded and evaluated statistically for the process inspection.

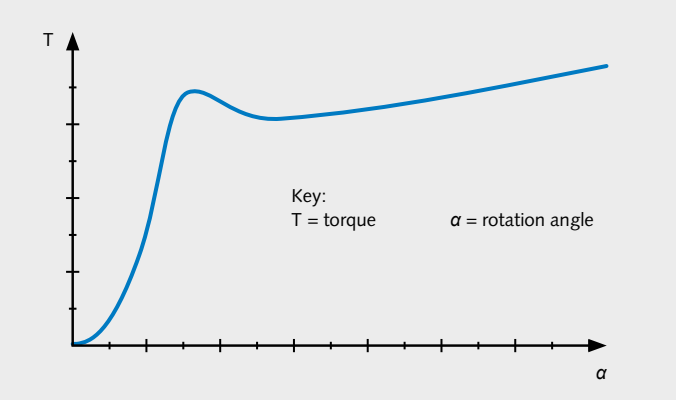




Key influencing parameters in the inspection process (based on source: VDI/VDE 2645 sheet 3).

Process inspection after completion of fastening, with carry-on tightening

Carry-on tightening is the name of the method used to verify the fastening process and perform a process inspection after the fasteners have been assembled correctly. This method is used in the real fastening scenario following assembly, usually after a defined waiting period. The purpose is to determine the torque required to carry on tightening the threaded joint by "a defined amount". This method can take account of parameters that influence the joint but which (as a general rule) only appear after assembly. Parameters that can undergo this type of process inspection include (for example) settling of the threaded joint due to surface smoothing as the result of surface pressure.



For this purpose, a torque-angle wrench is used to carry on tightening a fastener that has already been bolted, without damaging the joint itself. The fastening curve is recorded and is then evaluated statistically, using suitable evaluation algorithms to provide clear definitions for the process inspection.

Sensors, measurement and evaluation unit, parameterization and evaluation software

Torque and torque/rotation angle sensors
Sensors based on the strain gage principle with a rotating transducer shaft deliver reliable and accurate measurements. They are especially suitable for dynamic determinations of exact, reproducible torque measurement values during fastener assembly.

As an option, an incremental encoder disk is fitted on the transducer shaft to transmit the angle signal (corresponding to the direction of rotation) via an optical barrier sensor, with signal conditioning as appropriate.

The inner workings of the sensors are protected by a rugged steel or aluminum housing. This also makes them suitable for measurements under harsh production conditions. According to choice, the sensors can be equipped with a permanently connected cable or a connector; both versions are designed for Kistler measuring equipment. The integrated AUTOCODE ensures automatic sensor detection on measurement systems with a suitable AUTOCODE function: this feature minimizes errors during use.

Our inhouse development department, our own sensor manufacturing facility and our calibration laboratory accredited by DAkkS (the German accreditation body) guarantee sensors with optimum sensitivity and assured quality traceability.

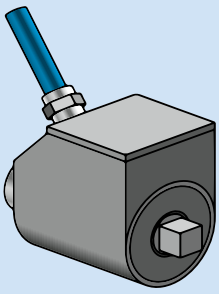
Analysis wrench or torque/rotation angle hand sensors
Sensors based on the strain gage principle with a bending beam deliver reliable and accurate measurements. They are especially suitable for quasistatic determinations of exact, reproducible torque measurement values in the carry-on tightening process.

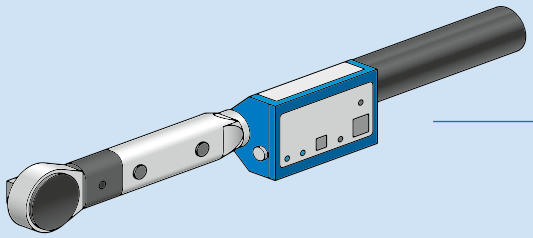
The analysis wrench is fitted with a gyroscope which transmits the relevant angle signal for the direction of rotation independently of its position, with appropriate signal conditioning. Integrated LEDs visualize status messages and attainment of the desired target value directly on the analysis wrench.

Algorithms to calculate compensation for tool deflection, dependent on the applied torque and the exchangeable output adapter, ensure highly accurate measurements of torque and rotation angle.

The integrated AUTOCODE ensures automatic sensor detection on measurement systems with a suitable AUTOCODE function: this feature minimizes errors during use.

Our inhouse development department, our own sensor manufacturing facility and our calibration laboratory accredited by DAkkS (the German accreditation body) guarantee sensors with optimum sensitivity and assured quality traceability.





Mobile measurement and evaluation unit
INSPECTpro is a highly integrated, precise and modular standalone measurement and evaluation unit suitable for a wide variety of measurands. This unit captures all measurement values and handles downstream processing as well as evaluation tasks. Measurement and evaluation tasks are carried out in real time, and the measurement profiles are outputted graphically in quasi-real time via the integrated 7.7-inch TFT touch display. Once inspection has begun, the INSPECTpro unit handles all the measurement and evaluation tasks autonomously. The INSPECTpro unit can be parameterized directly on the device itself, with no need for an additional PC connection.

The measurement and evaluation unit can be extended with optional software modules to meet individual preferences and customer-/application-specific requirements. This means, for example, that frequent or recurring inspection tasks can be stored in a fastening points administration facility so they are easily called up for inspections.

Measurement data is stored on an internal SD memory card in the measurement and evaluation unit. Another benefit: measurement data can be transmitted to a higher-level PC system via a mini USB connection.

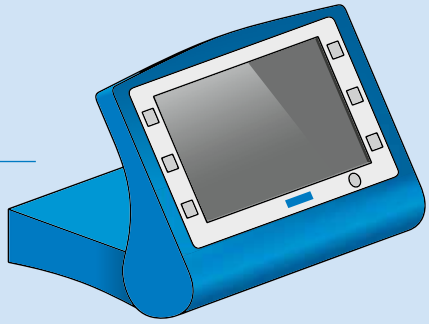
The unit can be operated independently of mains power thanks to a lithium ion replaceable battery pack; alternatively, for laboratory use, it can be run directly from mains power.

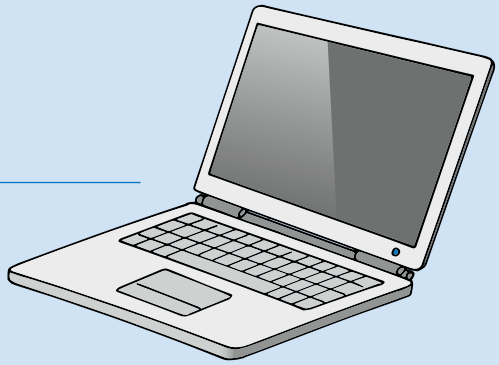
Software
CEUS – the database-supported parameterization and evaluation software used as an option – combines all the functions required for process inspection in one convenient software platform.

It maps the complete procedures for setting customer-specific or standard-compliant process parameters, with definitions of target values for process inspection.

Our software combines evaluation with corresponding results, statistical parameters and complex graphic views. It offers a convenient way to perform long-term statistical evaluations of processes, because evaluation is based on fastening points.

Data export and generation of inspection records are also integrated in the software, so the entire parameterization and evaluation process can be carried out with no need to waste time and effort on switching between software platforms.





Inspection task: in-process measurement

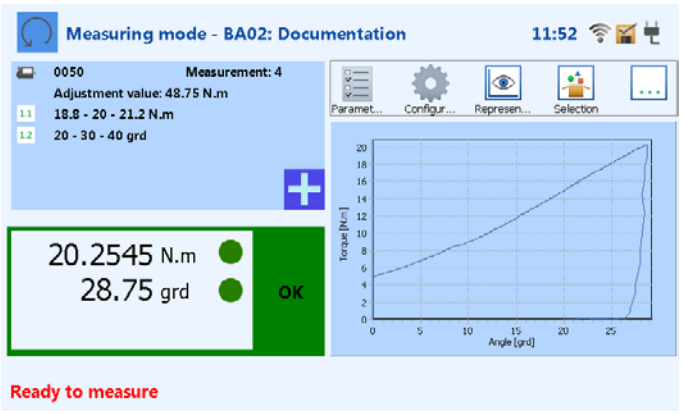
Application scope
For random sample inspections of the real joint during production, i.e. during assembly of the fasteners, all the influencing parameters are measured directly on the joint for evaluation in the measurement and evaluation unit.

System structure
A torque or torque/rotation angle sensor is adapted directly between the output of the torque tool used (square or hex version) and that of the tool used to introduce the torque into the test object. During the fastening process, the recorded torque and/or torque/rotation angle values are transmitted directly to the measurement and evaluation unit. The measurement values can be displayed in numerical and graphic form on the screen

Benefits
The combination of an autonomous, mobile INSPECTpro measuring instrument with a diverse range of torque ortorque/rotation angle sensors can accomplish a variety of in-process measurement and inspection tasks on an application- specific basis during production, with many different fastening technologies. Examples include:

- Fastening with handheld power tools
- Fastening with built-in power tools integrated in the production line
- Fastening with manual wrenches

In-process measurement in practice.



Measurement curve and evaluation of an in-process measurement.

of the measurement and evaluation unit. They can be evaluated directly on the basis of specified tolerances and statistical values. The measurement profile can also be viewed in graphic form to identify effects during tightening, joining or assembly. All measurement data can be stored directly on the measurement and evaluation unit for documentation and later evaluations.

Additional software modules allow extended graphic process evaluation via the Windows CEUS software and a fastening points administration facility, which can store the process and statistical parameters required to evaluate individual recurring fastening processes.

Key data
- Standalone measurement and evaluation unit
- Lithium ion replaceable battery pack
- Swiveling 7.7-inch TFT color touch display
- Standard torque range up to 5 000 Nm
- Measurement data export via mini USB

Options
- Mains operation
- Fastening points administration software module
- Extended graphic process evaluation with Windows CEUS software
- Adapter cables for external sensors (active and passive)

Inspection task: carry-on tightening

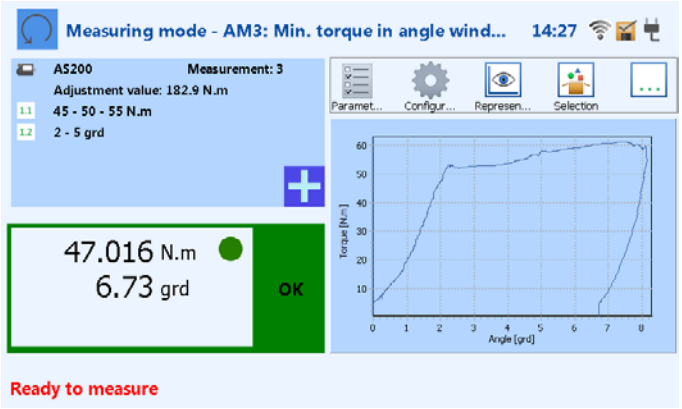
Application scope
The method known as “carry-on tightening” is commonly used to qualify the assembly torques or the threaded joint in certain cases. These include assembly processes where in-process measurement cannot be used (e.g. due to lack of space) or where the process capability has to be proven after a defined waiting period (e.g. in order to take account of settling processes in the threaded joint).

System structure
The analysis wrench is adapted to the inspection object with the torque introduction tool, and carry-on tightening of the fastener (which has already been bolted) is performed by applying a defined torque, based on process limits. During the carry-on tightening process, the torque/rotation angle values are transmitted directly to the measurement and evaluation unit. To ensure precise compliance with the specified process limits for carry-on tightening, the analysis wrench is equipped with status LEDs. These tell the operator that the threaded joint is still within the specified process limits, even after carry-on tightening.

Benefits
INSPECTpro's “Carry-on tightening” software module stores the measurement methods (based on VDI/VDE 2645 sheet 3) proposed for carry-on tightening measurements, with the corresponding evaluation algorithms; parameterization for specific fastening points is possible. Examples include:

- Peak value measurement
- Torque on rotation angle
- Minimum after breakaway
- Determination of intersection
- Pitch change

Determination of carry-on tightening in practice.



Measurement curve and evaluation of determined carry-on tightening.

The measurement values can be displayed in numerical and graphic form on the screen of the measurement and evaluation unit. Based on the predefined carry-on tightening mode and the specified tolerances and statistical parameters, these values can be evaluated directly. Another benefit: the measurement profile can be shown in graphic form to identify effects during carry-on tightening, such as any breakaway torque that may be present. All measurement data can be stored directly on the measurement and evaluation unit for documentation and later evaluations.

Additional software modules allow extended graphic process evaluation via the Windows CEUS software and a fastening points administration facility: this can store the process and statistical parameters required to evaluate individual recurring fastening processes.

Key data
- Standalone measurement and evaluation unit
- Lithium ion replaceable battery pack
- Swiveling 7.7-inch TFT color touch display
- Predefined carry-on tightening modes
- Standard torque range up to 600 Nm
- Measurement data export via mini USB

Options
- Mains operation
- Fastening points administration software module
- Extended graphic process evaluation with Windows CEUS software

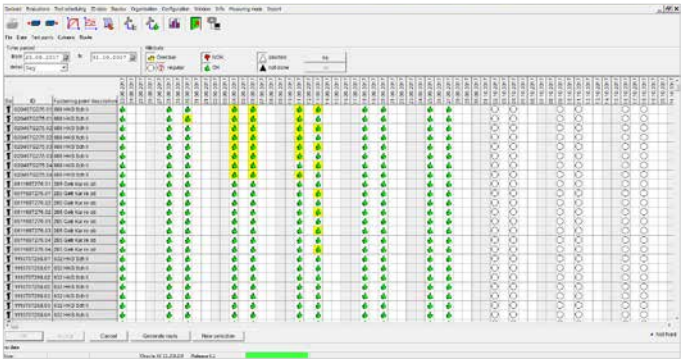
Display of results.

Parameterization and evaluation with CEUS software

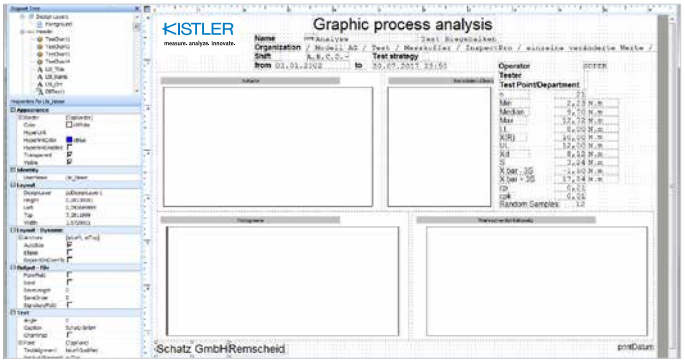
The all-in-one software solution
The Windows CEUS software developed by Kistler carries out all the tasks required before and after process inspection for standard-compliant and documented testing.

Parameterization
Thanks to parameterization with CEUS, users can freely define the process inspections they require according to their own specifications and requirements, either to meet specific customer requirements and/or to comply with standards; the inspection procedures can then be saved in the fastening points. Every single one of these fastening points can be freely configured by the user as regards threshold value, joining value, target value, evaluation algorithms for results, sensors to be used, descriptive parameters, results, specified tolerances and inspection methods. It is even possible to integrate multiple tolerance selections for target values, e.g. torque and rotation angle. This allows pre-definition of a variety of fastening scenarios for process inspection; the scenarios can be implemented and then evaluated on a comparative basis.

Benefits of CEUS
- Process inspections as per customer-specific or standard-compliant requirements
- Pre-definition of process parameters and inspection methods based on fastening points
- Data is conveniently organized and documented
- Extensive graphic analysis of measurement profiles
- Varied options for inspection reports and layouts
- Comparative evaluations



With the help of the inspection plan, the desired process inspection intervals for the fastening points to be inspected are saved in the CEUS software.



The inspection report editor allows all results, tables, graphics and user-defined parameters to be integrated in any custom report form.

Evaluation
Based on the requested process inspection, the operator can view a tabular display of multiple results from the measurement data memory for each inspection process, and the results can then be evaluated statistically.

Inspection planning
With the help of the inspection plan, the desired process inspection intervals for the fastening points to be inspected are saved in the CEUS software and transmitted to the measurement and evaluation unit via the mini USB interface. Inspection staff can use this "route" to process their workload with software support; after pending jobs have been completed (or at intervals in between), they can send the process inspection data back to the software for evaluation via the mini USB interface. This ensures adherence to the process inspection intervals, and it supplies proof of regular process inspection. At a glance, users can visualize compliance with predefined process inspection cycles as well as the results in each case. By mouse- clicking on a particular inspection point, the individual values and graphic measurement profiles can be visualized for error diagnosis.

Inspection reports and data export
The inspection report editor allows all results, tables, graphics and user-defined parameters to be integrated in any desired report form, as specified by the customer. As well as output in the form of inspection reports, all data obtained can be transferred automatically to higher-level software platforms, for example via the integrated export interface.

*Windows is a registered trademark of Microsoft Corporation.

Know-how transfer by specialists

Inspection requirements
Process inspections come in a variety of different forms; they are to be found everywhere, and they call for extensive expertise when it comes to performing the inspections and evaluating the results obtained from them. As well as specialist knowledge and continuous training on the requirements set by the standards, inspection in compliance with standards calls for process-specific inspection systems.

Service by Kistler as an independent specialist
Customers can also request us to perform inspections as an independent specialist. As well as our process-specific inspection systems, we will place our extensive service know-how at your disposal. We are ready to assist our customers as a professional partner for basic and advanced training, to ensure the reliability of fastening processes.

Our range of services for process inspection
- Seminars and training courses for customers
- Inspections using portable systems at the customer's premises
- Inspections in the torque range from 0.2 Nm to 5 000 Nm for in-process measurements
- Inspections in the torque range from 3 Nm to 1 000 Nm for carry-on tightening

- Sales Center
- Tech Center
- Production Center

At our customers' service across the globe

Thanks to Kistler's global sales and service network, we are always close to our customers. Some 2 000 employees at 61 locations are dedicated to the development of new measurement solutions, and they offer customized on-site support for individual applications.

Find out more about our applications:
www.kistler.com/applications

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