KISTLER

measure. analyze. innovate.

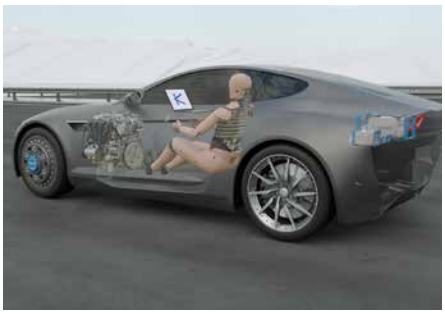
Reliable quality monitoring in production

Threaded joints

Quality monitoring for releasable fasteners

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

Focusing on your company's success

High-performance ANALYSE systems for fasteners such as threaded joints are used to monitor their functional characteristics – including friction coefficients. Analysis of tightening behavior is another important application area. In these ways, systems optimize the entire bolting process – helping to pave the way for sustainable return on investment (ROI).

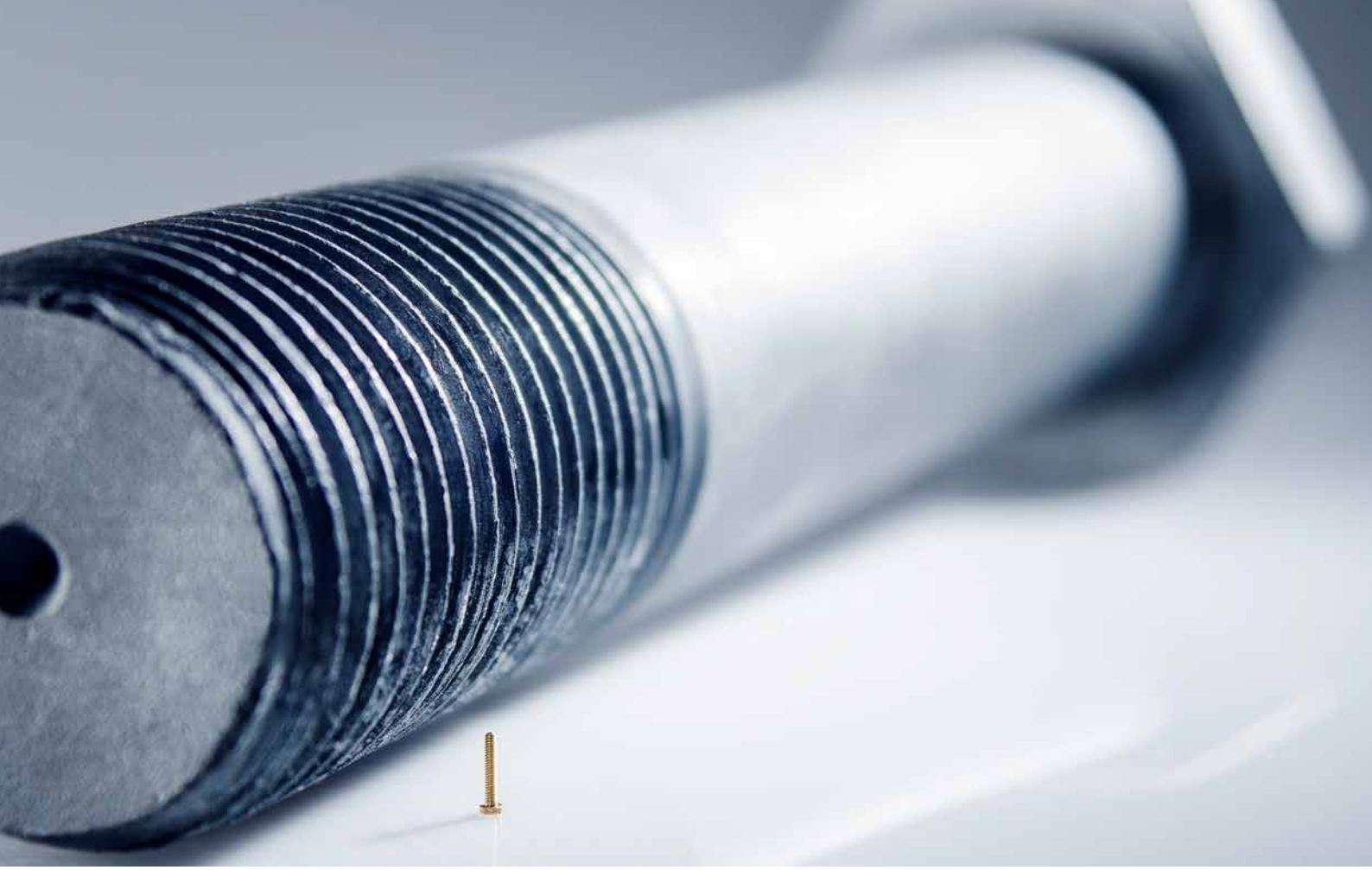
Kistler's measurement technology experts are constantly working to optimize fastening processes. The focus is always on one objective: your business success. Our inspection systems help you to consistently enhance process reliability in your operation, improve your use of monitoring and minimize your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

The benefits of ANALYSE systems

- Reduced quality costs
- Optimized fasteners
- Enhanced efficiency in the bolting process
- Documentation
- Protection against product liability cases
- Reproducible test processes
- Traceable results
- Compliance with standards

Laboratory systems from Kistler are used by renowned customers in many sectors of industry. Here are just a few examples:

- Automotive industry
- Aircraft and aerospace industry
- Commercial vehicle manufacturers
- Supply sector
- Coating system manufacturers
- Surface coating specialists
- Screw, bolt and nut manufacturers
- Research and educational facilities
- Testing service providers
- Steel construction



Systematic fastener testing

The friction coefficient is the key quality factor
To achieve the desired quality of fastening in the production process, it is necessary to test, monitor and document the surface friction coefficients of the fastening components in relation to one another.

End-to-end quality assurance – all along the line
Kistler's ANALYSE systems are complete inspection systems that enable users to determine the functional characteristics of individual fastening components or complete sub-assemblies. These systems cover the entire range of requirements for a wide variety of function tests: from measurement and control of the fastening process through to comprehensive documentation of the process parameters and results. End-to-end inspection and documentation provides proof of the quality of the threaded joint, and there are additional benefits too: targeted monitoring of tolerance limits becomes possible, and process deviations can be detected at an early stage.

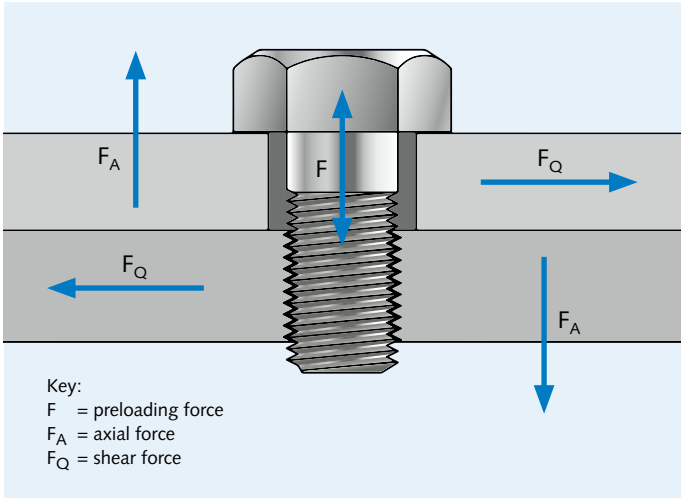
Compliance with standards: a quality characteristic
Requirements for function tests on fasteners are specified by various international and customer-specific standards that are constantly changing. Because Kistler's inspection systems are highly flexible, they can adapt to the new requirements – time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

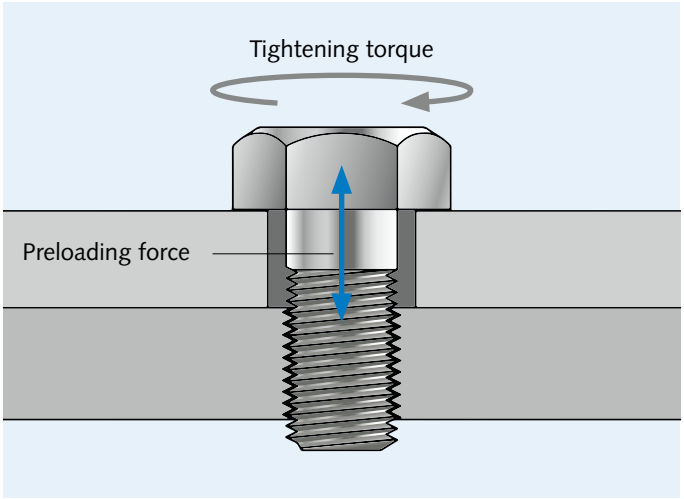
Watch this video of Kistler's ANALYSE system
This short product video explains the system's components and the possibilities it opens up. The sure way to 100% quality in your quality assurance process:
www.kistler.com/fastening-technology

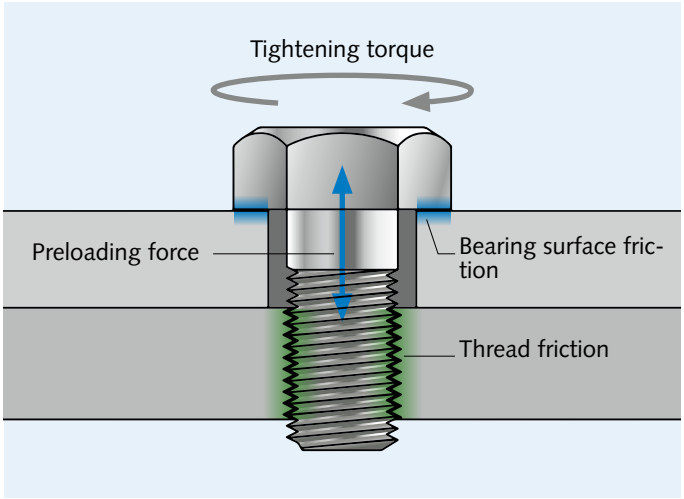
Reliable fasteners – a guarantee of quality

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 the loss of the frictional connection, otherwise the fastener will be released. Furthermore, the maximum preloading force must not be exceeded, otherwise overloading will occur and the connection may fail. Suitable methods such as carry-on tightening can also be used to provide proof of process capability.







Assembling a threaded joint

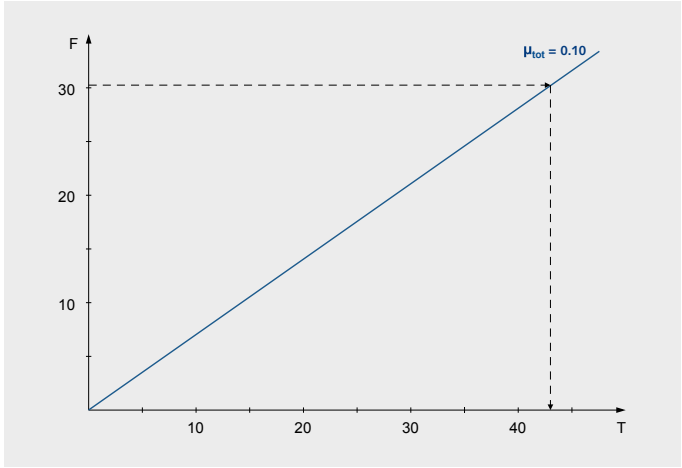
When assembling a threaded joint, the objective is to achieve a preloading force in the joint that is as exact and reproducible as possible. Measuring the preloading force directly during assembly is a complex and time-consuming process. In the current state of technology, therefore, the tightening torque is used as an auxiliary variable; this measurand is recorded and statistically evaluated to validate the process. The spreads of attained tightening torque inevitably produce spreads in the resultant preloading force.

Influence of the fastener and the components

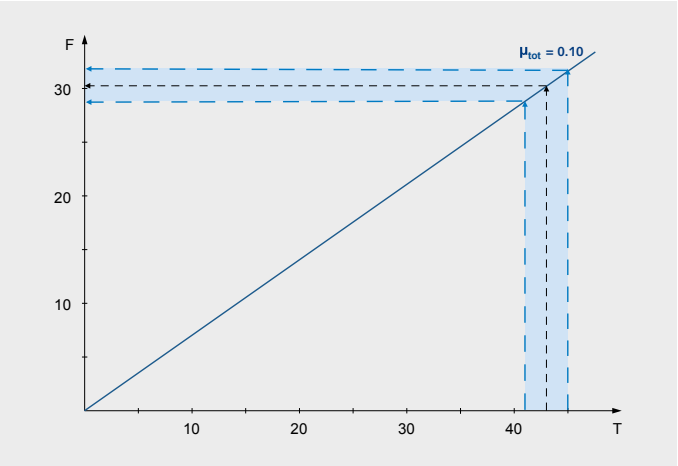
The relationship between tightening torque and preloading force basically depends on the geometry of the fastener and the frictional characteristics of the surfaces of the fastener components – known as the friction coefficients. A large portion of the energy applied during the bolting process is converted into friction in the thread and on the bearing surface between the fastener components. Depending on the surface characteristics of the fastener and the components, the frictional characteristics will change – with a direct impact on the resultant preloading force.

Theoretical calculation example: influences on a threaded joint

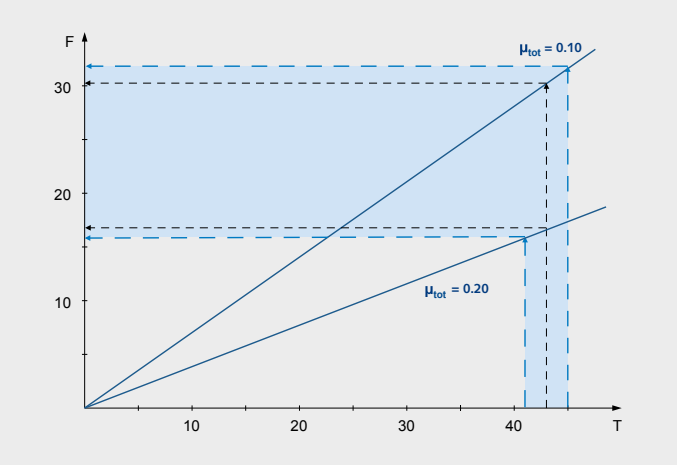
To simplify the calculation example, a threaded connection with constant total, thread and bearing surface friction coefficients is clamped to approx. 30 kN so that approx. 90% of the bolt's proof load is utilized. If we take a friction coefficient of μ = 0.10 to calculate the required tightening torque, a tightening torque of approx. 44 Nm would be needed for fastening to the desired preloading force.



If the additional influence of torque tolerances when fastening the threaded joint is approx. ± 5% (for example, in an electronically controlled fastening system), the torque tolerances would then result in a preloading force in the range from approx. 29 kN to approx. 32 kN. This corresponds to a spread of approx. 3 kN.



The spread of friction coefficients for the fasteners and components is now added in order to reproduce the real conditions. For an assumed friction coefficient window of μ = 0.10 to μ = 0.20, the tolerances would result in a preloading force in the range from approx. 16 kN to approx. 32 kN, corresponding to a spread of approx. 16 kN. With this spread, only approx. 53% of the originally desired preloading force is present, given the high friction coefficient of μ = 0.20; in some cases, the specified minimum preloading force in the threaded joint may no longer be guaranteed.



Measurement and control technology, drives and mechanical components

Adapting the test specimen
Depending on the testing requirements, different fasteners can be tested and adapted on the ANALYSE system that is used.

For standard-compliant, comparable tests, it is also necessary to use and adapt the required reference parts or application-specific parts with their defined characteristics. As well as providing protection against rotation, it is also essential to ensure that the mechanical adaptations do not impact the measurement results due to deformation.

Computer-aided design of the mechanical adaptations guarantees that they are precisely matched to the customer's specific application case.

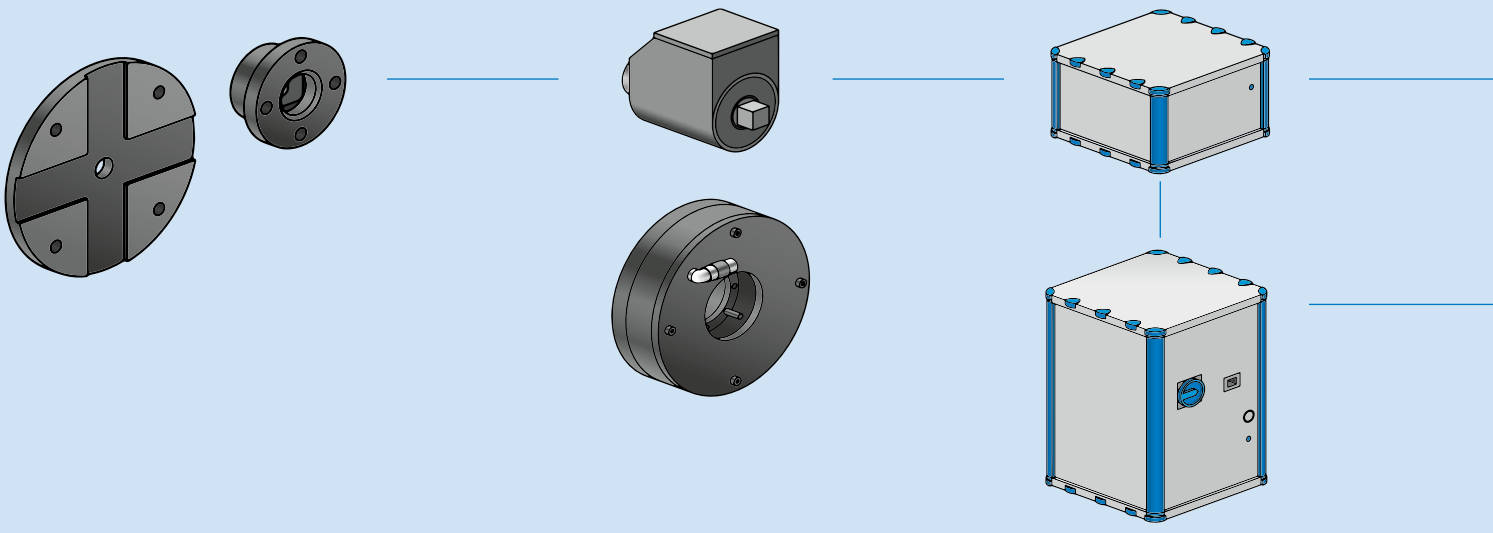
Sensors
Exact, reproducible measurement values call for reliable sensors that measure precisely in each and every application case.

In our development department, our inhouse sensor production facility and our DAkkS-accredited calibration laboratory, we develop, produce and calibrate highly sensitive sensors with guaranteed and traceable quality. Our portfolio comprises sensors for torque, torque/rotation angle, preloading force and preloading force/thread torque, in various sizes and designs.

In Kistler's systems, the torque/rotation angle sensor measures the rotation angle directly on the test object, instead of a measurement via the drive unit's resolver system. This method ensures that the drive shaft torsion does not falsify the measured rotation angle.

Measurement and control technology
Kistler's measurement and control unit is a highly integrated, high-precision modular measurement and control device that can measure a diverse range of measurands. It captures all the measurement values and handles downstream processing as well as control tasks. Measurement and control tasks are performed in real time, and the testXpert software generates graphic displays of the measurement profiles in near-real time. Once inspection has begun, the unit handles all the measurement and control tasks autonomously. The PC system with the measurement and evaluation software is used solely for visualization of the test, and is not required for calibration.

The control unit with servo regulator handles control of the various drive units in conjunction with the measurement and control unit.



Drive units
The servo gear motors and servo drive spindles used by Kistler are controlled by the power and control unit. They are high-quality, maintenance-free components with high efficiency and excellent dynamics. Thanks to these attributes, they have no problems in meeting complex testing requirements specified by customers or standards.

Servo drive spindles with a minimized mass moment of inertia make it possible to change speed very quickly, with minimal overrun of the target value.

Specific production spindles can be connected directly to the Kistler system thanks to cooperation arrangements with manufacturers of servo fastening spindles for use in production lines. The production spindles are controlled by the control unit with servo regulator, so users can perform tests with the real influence of the fastening spindles used in actual production.

Mechanical units
The basic mechanical unit of the test system that accommodates the sensors and test specimens has a major impact on the results achieved.

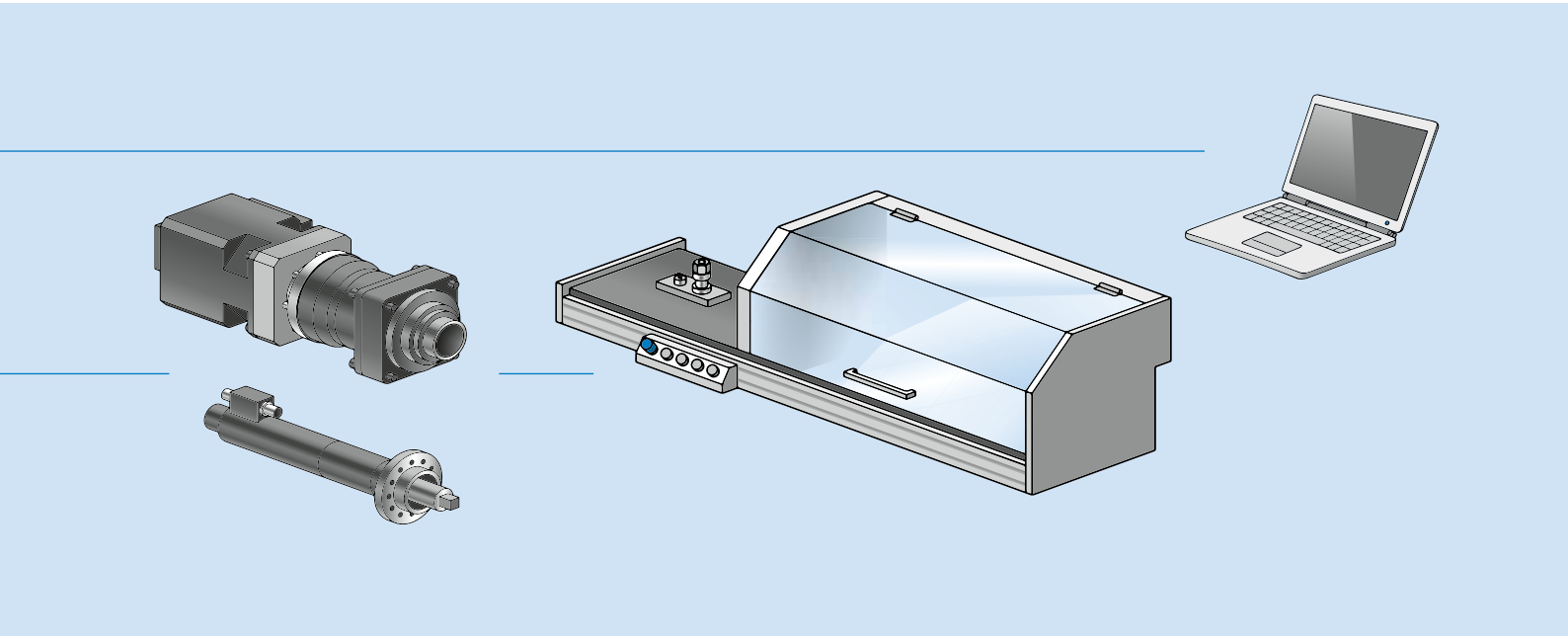
The basic mechanisms feature high torsional rigidity so as to exclude any influence on the results obtained.

Computer-aided design of the mechanical units is tailored with absolute precision to customers' needs and requirements specified by the standards. The result: our systems meet the requirements for maximum torsional rigidity – while combining maximum functionality with attractive design.

Software
In one single software platform, the testXpert operating and evaluation software combines all the functions needed for testing.

It maps all the procedures for the individual substeps: from setting up a customized or standard-compliant test sequence with any desired number of substeps through to defining target values and speeds for the substeps, as well as handling the machine control for the actual testing. Everything is combined in our software, including evaluation of the results with statistical parameters and complex graphic presentations.

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



System up to 1 000 Nm.

Easy access to test objects in horizontal ANALYSE systems

Application scope
With the Kistler horizontal ANALYSE system, fast and precise tests and analyses of fasteners are possible in conformity with international or customer-specific standards – especially as regards determining friction coefficients.

System structure
One or two drive units are mounted on the basic horizontal mechanical unit; with the help of a torque/rotation angle sensor, they introduce the tightening torque into the test specimen via a suitable tool. The preloading force/thread torque sensor is mounted on a slide that can be moved and fixed; it captures the adaptations of the test specimen for the specimen's bearing surface and the counterthread in the thread dimension required for the test, without any risk of rotation. The horizontal

Sensor with built-in test specimen.

System up to 8 000 Nm.

System up to 40 000 Nm.

configuration of the test system components ensures easy, barrier-free access to the test specimen. The system can be equipped with a gas spring to test prevailing torque nuts with a clamping element. In this case, the slide moves with the sensor during the test, and contact between the tool and the test specimen is guaranteed during tightening and loosening.

Key data
- Standard torque range up to 40 000 Nm
- Friction coefficient tests in the standard range up to thread sizes of approx. M72
- Test of the prevailing torque of nuts with clamping element
- Horizontal configuration ensures easy, barrier-free access to the test specimen

Options
- Additional drive units on a system allow a wide range of different requirement profiles
- Measurement of applied pressing force
- Ultrasonic measuring system captures the preloading force by measuring the elongation of the bolt

System up to 200 Nm.

Vertical systems for small thread dimensions and tests in vertical assembly positions

Application scope
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.

System structure
A drive unit is mounted on the basic vertical mechanical unit, on a movable slide with a smooth-running linear guide; this unit fixes the torque/rotation angle sensor with the help of a click mechanism, so as to secure it against rotation and prevent it from falling. The sensor introduces the tightening torque into

System up to 50 Nm.

Tightening test.

Friction coefficient test.

the test specimen via a suitable tool. As this happens, the slide with the drive unit is kept in a "floating" state by a weight balancing mechanism. A manual lever allows vertical movement of the system during tightening. Optionally, movement of the slide and defined loading of the test specimen in the vertical direction can be implemented with additional weights or via pneumatic operation.

Key data
- Standard torque range up to 200 Nm
- Friction coefficient tests in the standard range up to thread sizes of approx. M12
- Tightening tests on wood screws, self-forming and self-tapping screws
- Torque tests on rotating components

Options
- Measurement of the insertion depth
- Measurement of applied force by defined axial loading
- Additional weights for defined applied axial force
- Pneumatic operation

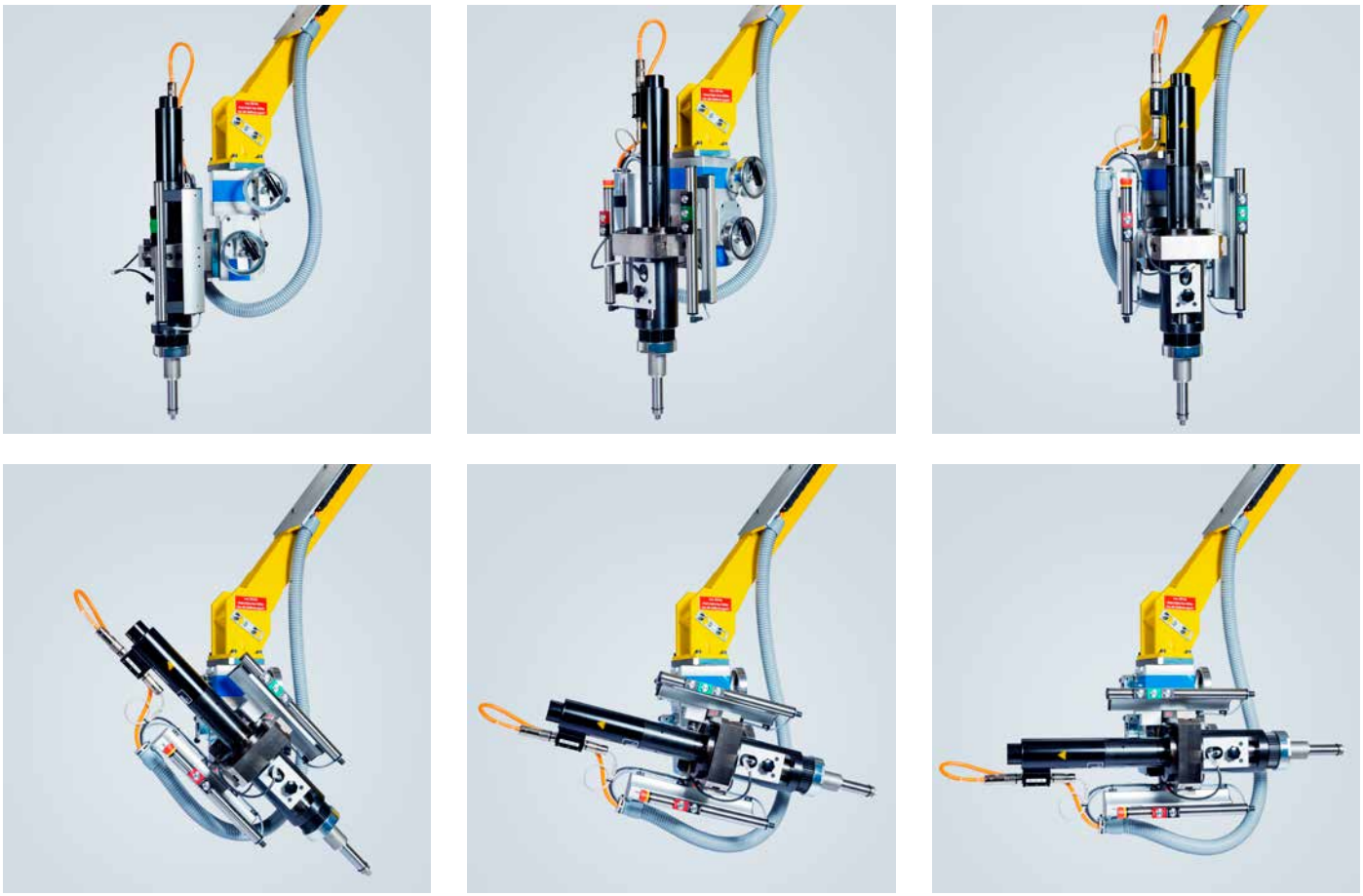
System up to 500 Nm.

Handling systems for perfect measurements under challenging conditions

Application scope
Handling systems by Kistler are used to test threaded joints for direct analysis of the test specimen under real application conditions.

System structure
It is essential to avoid falsification of the test results – and this is especially important if installation conditions at the fastening position on the component under test are challenging, e.g. in the chassis area or the vehicle's engine compartment. To ensure that this does not happen, the system must not only be highly rigid but must also offer the desired flexibility. For this purpose,

Setup for friction coefficient tests.



a handling system is used with degrees of freedom that can be fixed electropneumatically: a swivel gear that can be manually adjusted and fixed, with a spindle changing unit, is mounted on the system. The spindle changing device allows changing of the drive unit to meet the test requirements in each case. The torque/rotation angle sensor that introduces the tightening torque into the test specimen via a suitable tool is adapted on the drive unit with the help of a sensor changing unit.

Key data
- Standard torque range up to 1 000 Nm
- Tests on original components
- Flexible structure ensures easy, barrier-free access to the test specimen
- Multiple drive units on one system are possible thanks to the spindle changing unit

Options
- Measurement of friction coefficient with additional adaptation
- Connection to a vibration test bench
- Ultrasonic measurement system captures the preloading force by measuring the elongationof the bolt

Standalone system with drive unit.

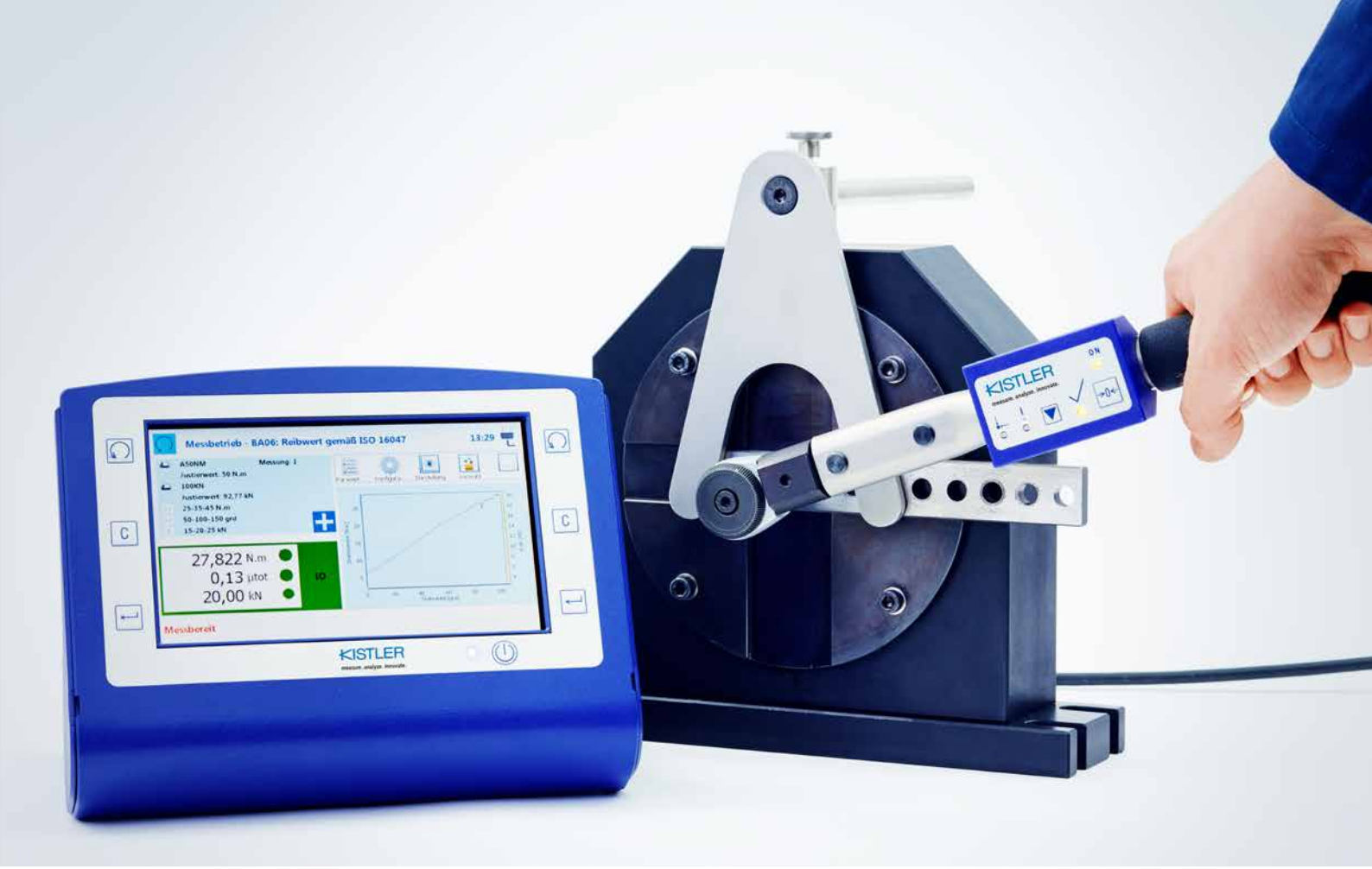
Vibration test benches to simulate real stress

Application scope
The vibration test bench from Kistler simulates real stress conditions for threaded joints with transversal alternating loads. On this test bench, fasteners can be subjected to transversal shear loads that act externally.

System structure
The test equipment for the vibration test consists of a special low-maintenance mechanical device with drive units; displacement can be adjusted during operation, and the test frequency can be adjusted during the test. Other components of the system include a sensor to measure the transversal shear force applied to the test specimen, a contactless sensor to measure the transversal slide displacement, and a changeable transducer to measure the preloading force and (optionally) the thread torque. The test specimens are accommodated in special backlash-free adaptations to minimize backlash influence on the test. Special vibration dampers isolate the vibration device from the base frame, ensuring minimal environmental pollution due to vibrations and noise.

Key data
- Dynamic testing of the securing behavior of threaded joints under transversal shear loads
- Standard amplitude during operation: adjustable in the range up to +/- 2 mm
- Standard testing frequency during operation: adjustable in the range up to 20 Hz
- Zero point stored in the system as the parking position
- Kistler preloading force sensors and preloading force/thread torque sensors are used

Options
- Tightening can be measured with a torque/rotation angle sensor or wrench
- Friction coefficients can be determined
- Drive units can be adapted for controlled and reproducible tightening
- Connection to horizontal ANALYSE systems is possible
- Connection to a handling system is possible



INSPECTpro.

Portable systems for flexible use

Application scope
Kistler's INSPECTpro measurement system is used for quality assurance in goods receiving departments, and for quick checks on fasteners to determine the overall coefficient of friction of the fastener.

System structure and testing procedure
A torque/rotation angle sensor or wrench and a preloading force sensor are connected to the INSPECTpro measuring system, and the test object is adapted with the help of appropriate devices for this purpose. While the test object is being tightened, the measurands are shown on the screen in real time. The overall coefficient of friction is then determined automatically and outputted to the screen.

Key data
- Determination of the total friction coefficient
- Portable system powered by a rechargeable battery
- Data export for advanced evaluations and documentation

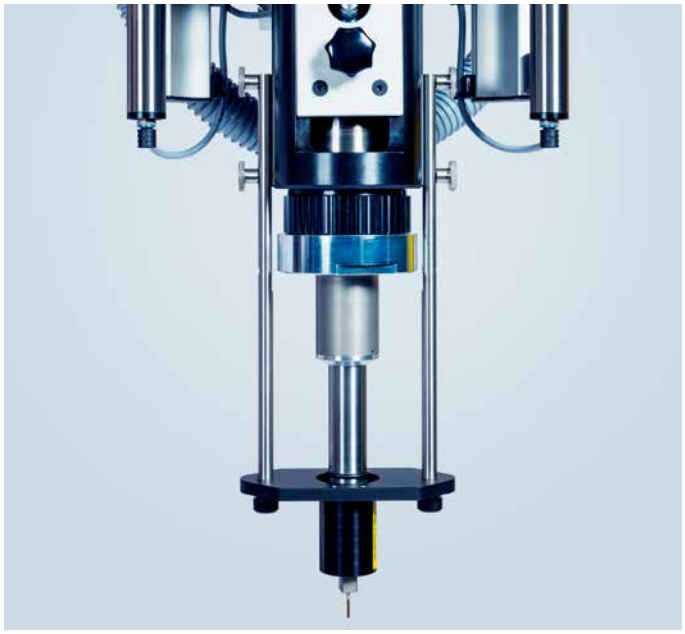
Options
- Connection to testXpert software for advanced evaluations and documentation
- Software modules for individual system configuration to perform a variety of additional measurement tasks

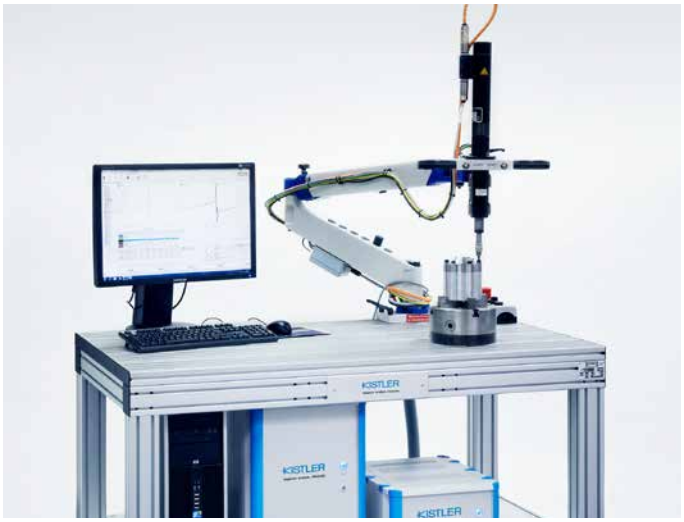
Systems for special requirements

In addition to our Kistler standard systems, we offer a vast array of special solutions based on requirements specified by customers or standards, with individual planning and design of each system. This service is available for all components including sensors, mechanical units, drive units, measurement and control technology, software, mechanical adaptations, and so on.

Example of a special solution:
extension with an ultrasonic measuring system to measure the preloading force

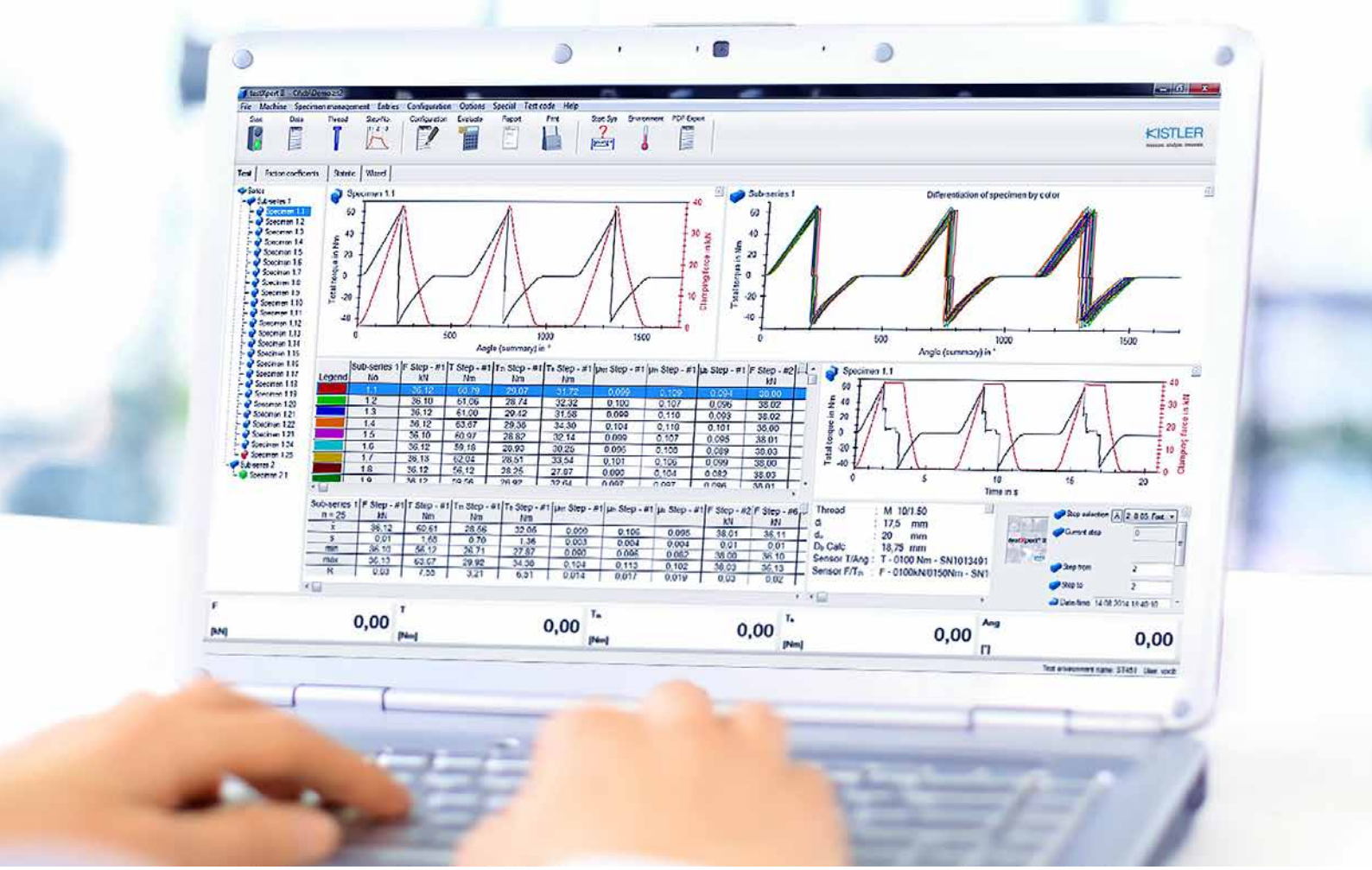
The ultrasonic measuring system determines the preloading force of a threaded joint by comparing the times taken for an ultrasonic wave to pass through a bolt in the unloaded and loaded conditions. The change in the time taken for the ultrasonic wave to pass through is used to measure the applied preloading force. The relationship between the time taken and the applied preloading force can be determined in a laboratory test using an ANALYSE system with multi-axial stress loading; this relationship (even beyond the elastic range) can be stored in the autonomous measuring device. In this way, the preloading force can be measured on the real joint at a later stage.





Example of a special solution:
horizontal ANALYSE system with heat chamber
System with heat chamber and special sensor equipment, with suitable thermal loading capability. Friction coefficient and loosening behavior tests are carried out under thermal loads of up to 150 °C. This system is also available as an add-on solution (similar to the vibration test bench), to upgrade existing horizontal ANALYSE systems from Kistler.

Example of a special solution:
"small" handling system (up to 200 Nm)
Flexible system for component and friction coefficient tests in the torque range up to 200 Nm. It captures the tightening curves on threaded joints in the original component, with a 2-axis swivel head for any desired fastening positions. Pneumatic clamping for the handling system is available as an option.



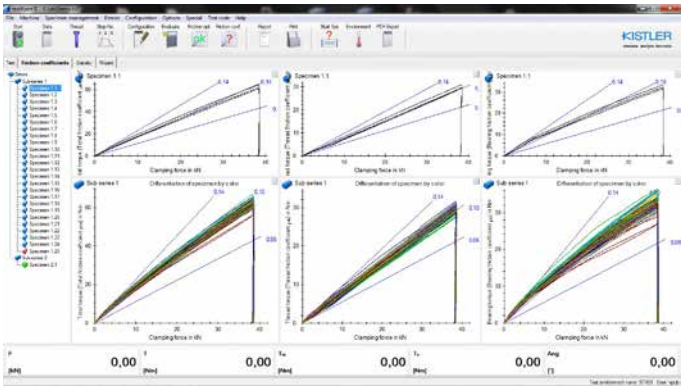
Display of results.

Control and evaluation with testXpert software

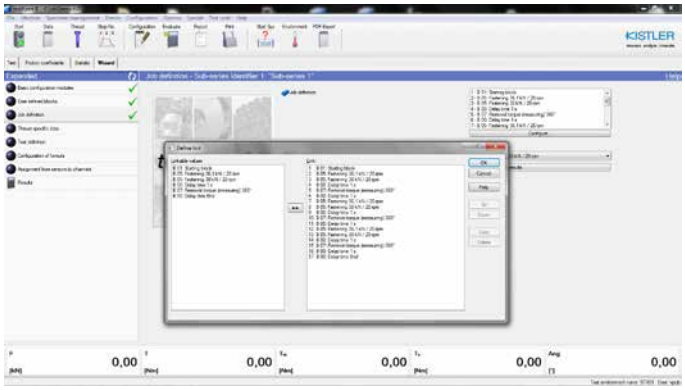
The all-in-one software solution
The freely configurable Windows testXpert software used by Kistler carries out all the tasks required before, during and after the tests needed for standard-compliant and documented inspection.

Defining the test procedure
Thanks to the block-based structure of the test sequences, users can freely define the procedures they require according to their own specifications and requirements, either to meet specific customer requirements or to comply with standards. Each individual block can be freely configured by the operator for starting value, switch-off value and specified speed. Multiple switch-off values can even be selected, for example to integrate safety functions. If the integrated repeat meter is used, this means that multiple tightening operations can be implemented and testing can be aborted if a safety value is exceeded.
The software is not tied to predetermined test program structures.

Benefits of testXpert
- Tests are compliant with all known standards for threaded joints
- Test sequences and procedures are specified on the basis of the block structure
- Data is conveniently organized and documented
- Extensive graphic analysis of measurement profiles
- Diverse test report and layout options
- Optional video documentation



Evaluation of friction coefficients.



Input assistant.

Data input
An input assistant makes it easy to select and enter all the key data required for testing. This includes the test procedure, thread data, calculation formulas specified by various standards for friction coefficients and bearing face diameters, the sensors to be used, descriptive parameters and results. For this purpose, the sensor and thread data is stored in a global database system with traceable documentation.

Evaluation
Based on the test procedure, the operator can view a tabular display of multiple results from the measurement data memory for each block, and the results can then be evaluated statistically. For complex evaluations such as those required for certain standards, the software provides predefined results.

Another possibility is to set up freely programmable results according to your own preferences. During and after the test, the measurement curves are shown in freely configurable graphs. As an additional option for advanced evaluations, a video can be recorded and stored during the fastening process: later on, it can be evaluated with the rest of the data.

Test reports and data export
In order to generate test reports, all the results, tables, graphics and user-defined parameters can be integrated into any test report form specified by the customer, with the help of an assistant; this data can be outputted as a test report (via the integrated export interface, for example) or automatically transferred to higher-level software platforms.

Let our specialists test your products

Test requirements
Threaded joints come in a variety of different forms; they are to be found everywhere, and they call for extensive expertise when it comes to performing tests and evaluating the results obtained from testing. As well as specialist knowledge and continuous training on the requirements set by the standards, testing in compliance with standards calls for application-specific test systems.

Kistler: an independent service provider
Kistler – as an independent specialist – offers customers the opportunity to have tests carried out at our premises. As well as our application-specific test systems, we also place our extensive service know-how at your disposal. We are your professional partner for threaded joint development work, verification and troubleshooting. The actual service we offer is only one of the benefits: projects that we undertake jointly with you lead to a positive exchange of knowledge, so our customers' know-how is augmented.

Our range of services for threaded joints
- Tests in the torque range from 0.02 Nm to 8 000 Nm
- Tests in the force range from 40 N to 1 000 kN
- Tests on vertical systems
- Tests on horizontal systems
- Vibration testing
- Tests using portable systems at the customer's premises

- 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

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

Find your local contact at
www.kistler.com

KISTLER
measure. analyze. innovate.