KISTLER

measure. analyze. innovate.

Reliable air blast testing solutions for extreme environments

Blast pressure measurement

Sensors and systems for accurate detection of blast pressure profiles

Absolute Attention for Tomorrow's World

Kistler develops measurement solutions consisting of sensors, electronics, systems and services. In the physical border area between emissions reduction, quality control, mobility and vehicle safety, we deliver excellence for a future-oriented world and create ideal conditions for Industry 4.0. We thereby facilitate innovation and growth for – and with – our customers.

Kistler stands for progress in motor monitoring, vehicle safety and vehicle dynamics and provides valuable data for the development of the efficient vehicles of tomorrow.

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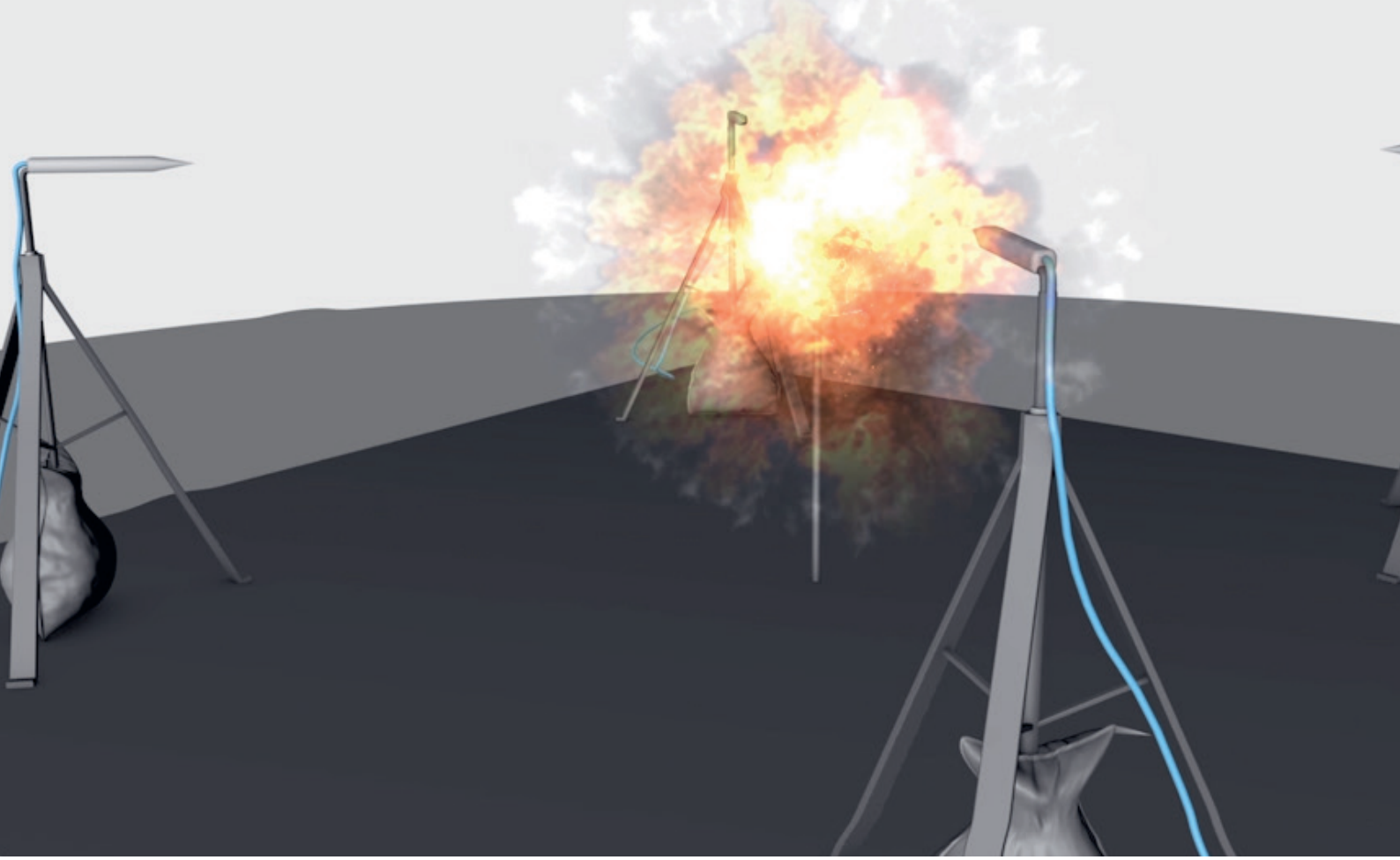
Kistler measurement technology ensures top performance in sport diagnostics, traffic data acquisition, cutting force analysis and other applications where absolute measurement accuracy is required.

Kistler systems support all steps of networked, digitalized production and ensure maximum process efficiency and profitability in the smart factories of the next generation.

Content



Schematic of free-field testing setup with pencil probes on tripod fixations.

Meeting the highest requirements – air blast testing solutions from Kistler

Measurements of pressure waves in explosions provide knowledge that is crucial in the fields of energetics research, safety engineering and testing of protective vehicles and structures.

Free-field blast testing
Both energetic material chemists and shockwave physicists perform free-field blast tests to study explosions. Based on the measurement of blast pressure profiles, they can analyze the chemical reaction and the propagation of the resulting shockwave. Such data are also required for the validation of computational models of explosive processes. Pencil probes from Kistler deliver highly reliable data in every environment.

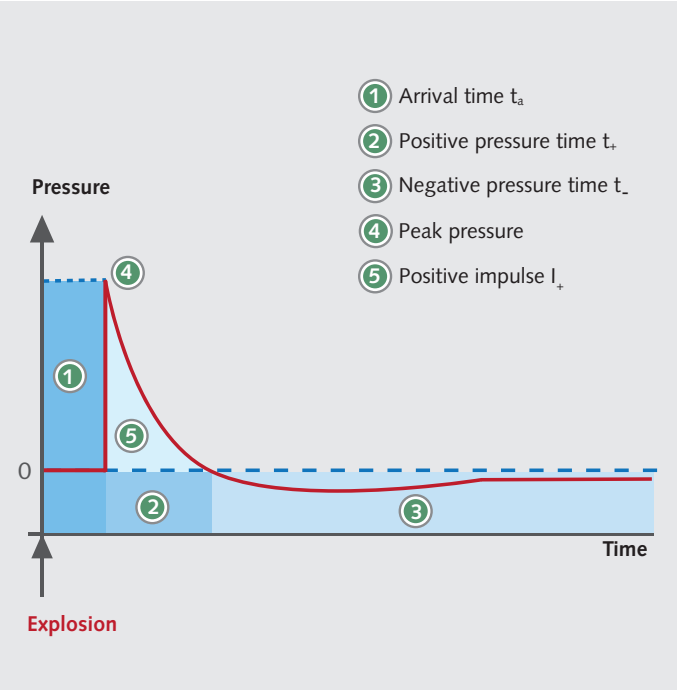
Blast impact testing
Blast-protected vehicles and buildings are designed to ensure the safety of their occupants in case of explosions. During blast impact tests, protective structures are subjected to detonations. Dummies equipped with piezoelectric acceleration and force sensors are used to estimate the resulting injuries due to the effects of blast waves. Additionally, blast pressure sensors are used to measure the blast pressure magnitudes outside as well as inside.

Monitoring of blasting operations
The demolition of structures and the disposal of explosive ordnance (EOD), such as land mines and bombs is frequently done by controlled detonation. Such blasting operations must be conducted without putting the involved personnel and the surroundings at risk. Pencil probes are used to monitor the blast pressure levels.

Testing of industrial safety technology
Numerous industrial processes result in potential hazards due to explosive liquids, gases or powders. Safety systems such as relief valves are designed to mitigate the destructive effects of a detonation. The development and testing of such components often require highly dynamic and reliable blast pressure measurements.

Qualification of hearing protection
Environments with repetitive detonation noise pose a serious risk for hearing loss for working personnel. Highly sensitive blast pressure sensors are used to characterize the noise levels and determine the maximum number of detonations a person can safely experience using different kinds of hearing protection.

Benefits
- Signals with high pressure and time resolution
- Transmission of voltage signals enables long cable lengths
- Practical accessories ensure user-friendly operation



Always the perfect signal
Kistler blast measuring solutions guarantee the best possible signal quality in challenging conditions. Our sensors and systems provide highest pressure and time resolution. Practical accessories assist the user in taking reliable measurements from the first try on.

Robust signal transmission
Voltage output sensors (IEPE) allow signal transmission without distortions even under highly vibrating conditions and through long cables.

Triggering and detonation time
Knowing the exact detonation time is important for calculation of the blast wave propagation velocity as well as for triggering the measurement. Kistler provides a ready-to-use triggering solution based on the break-wire principle.

Endless possibilities for advanced systems
In cooperation with our Swiss partner company Elsys, Kistler offers advanced system solutions for blast measurements. The synchronization of multiple devices enables the creation of smart distributed measuring systems. In order to minimize the cable lengths, the transient recorders can be operated in autonomous mode in close proximity to the blast site.

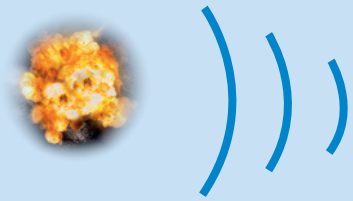
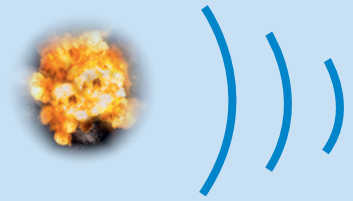
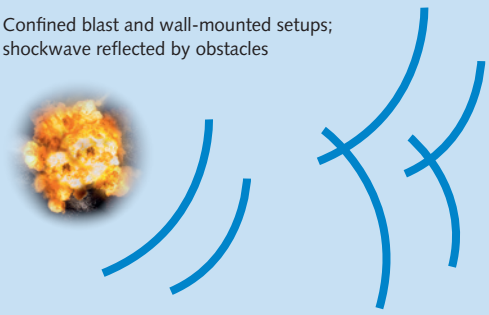
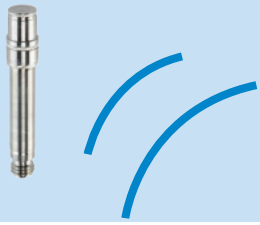
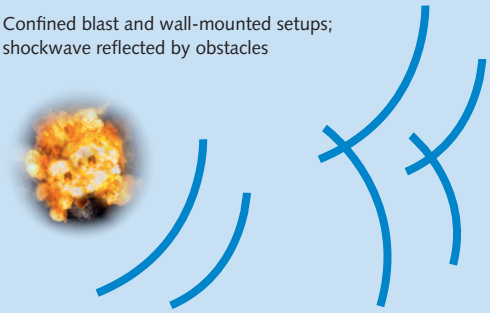
Key Features
- Integrated sensors with a high resonance frequency and segmented ranges
- High sensor sensitivity up to 200 mV/psi
- Integrated impedance converter electronics (IEPE)
- Complementary accessories portfolio for pencil probe fixation, thermal protection and triggering
- Outdoor-protected, modular high-speed data acquisition solutions (DAQ)
- Synchronization of multiple data acquisition systems

Measuring chains

Kistler offers complete measuring chain solutions. Place your trust in a complete system from a single company specialized in pressure measurement technology and calibration services.

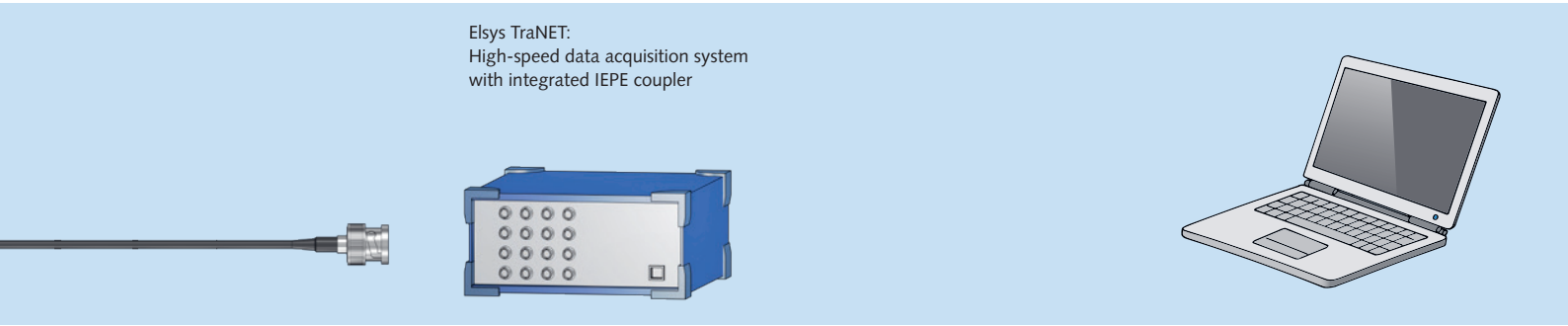
Blast scenario
Due to the physics of blast wave expansion, the measuring setup strongly depends on the blast scenario.
In free-field tests or very close to the blast source, the direction of shockwave propagation is well-defined. Pencil type sensors can be accurately aligned to measure the primary shockwave or Mach stem. In confined scenarios with complex shockwave reflections, standard miniature pressure sensors are used to measure the overall pressure level.

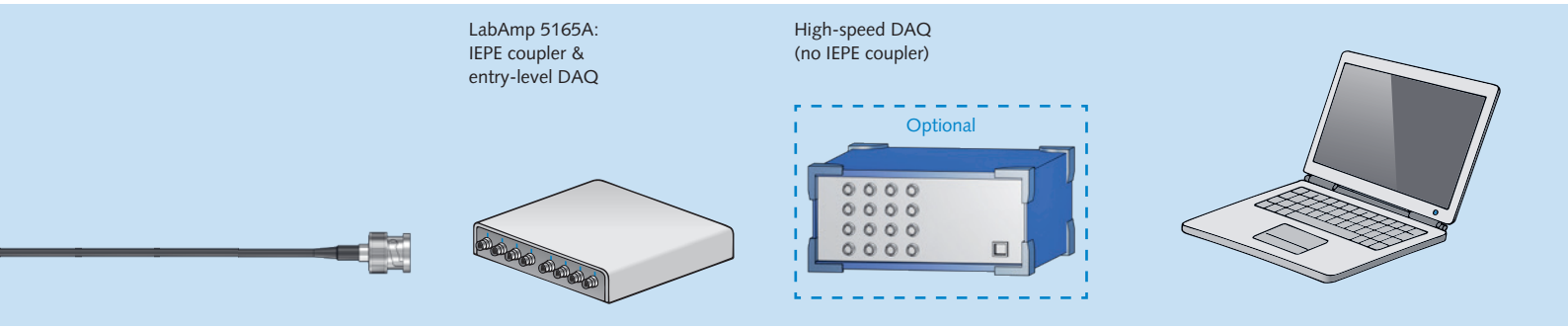
Sensors & accessories
Pencil probe Type 6233A… is positioned radially to a well-defined blast source and measures the side-on pressure.
For confined blast scenarios and wall-mounted situations, the miniature sensor Types 603CBA and 601CBA are recommended.
All blast pressure sensors have integrated charge amplifier electronics (IEPE). Their voltage outputs can be transmitted through long cables. Dedicated fixation and thermal protection accessories ensure high signal quality.

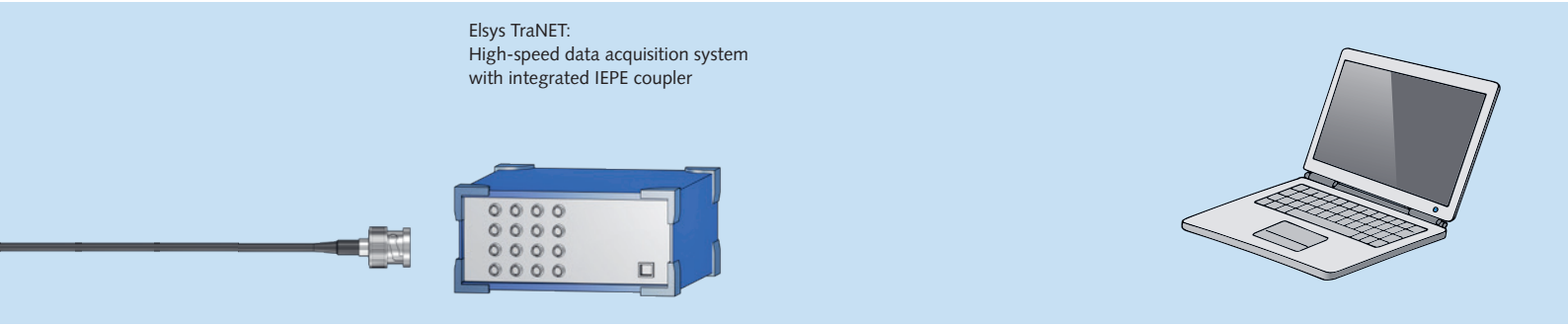
Free-field blast; direction of shockwave propagation well-defined	IEPE sensor: Pencil probe Type 6233A…	Cable BNC - BNC Type 1601B
		
Free-field blast; direction of shockwave propagation well-defined	IEPE sensor: Pencil probe Type 6233A…	Cable BNC - BNC Type 1601B
		
Confined blast and wall-mounted setups; shockwave reflected by obstacles	Miniature IEPE sensor: Types 603CBA… or 601CBA…	Cable BNC - BNC Type 1601B
		
Confined blast and wall-mounted setups; shockwave reflected by obstacles	Miniature IEPE sensor: 603CBA… or 601CBA…	Cable BNC - BNC Type 1601B
		

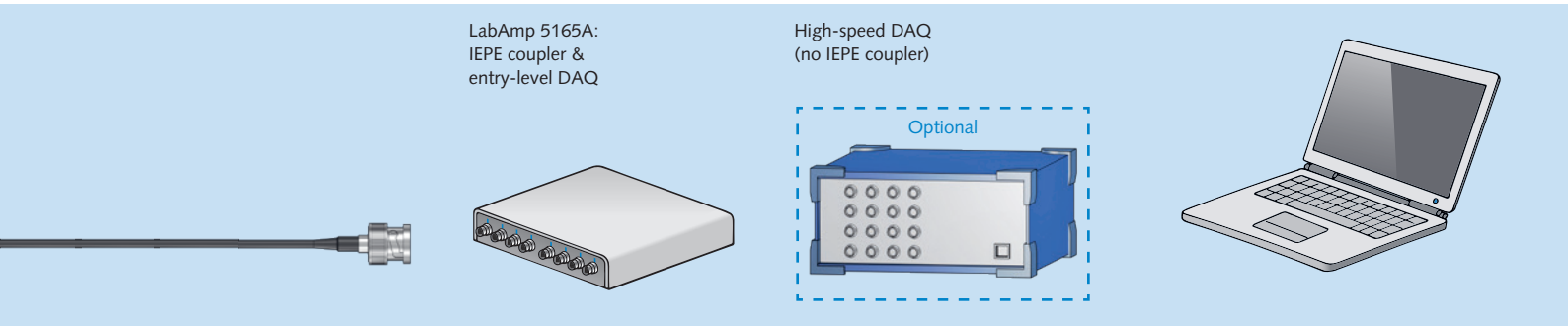
Signal transmission & conditioning
Standard BNC cables are used for transmission of the voltage signals. For optimal signal dynamics, the cable lengths shall be minimized.
LabAmp Type 5165A may be used as an external IEPE coupler to supply the excitation current for the IEPE sensors and decouple the signal from the bias voltage. Additionally, it can serve as an entry-level data acquisition system for sampling rates up to 265 kSa/s.

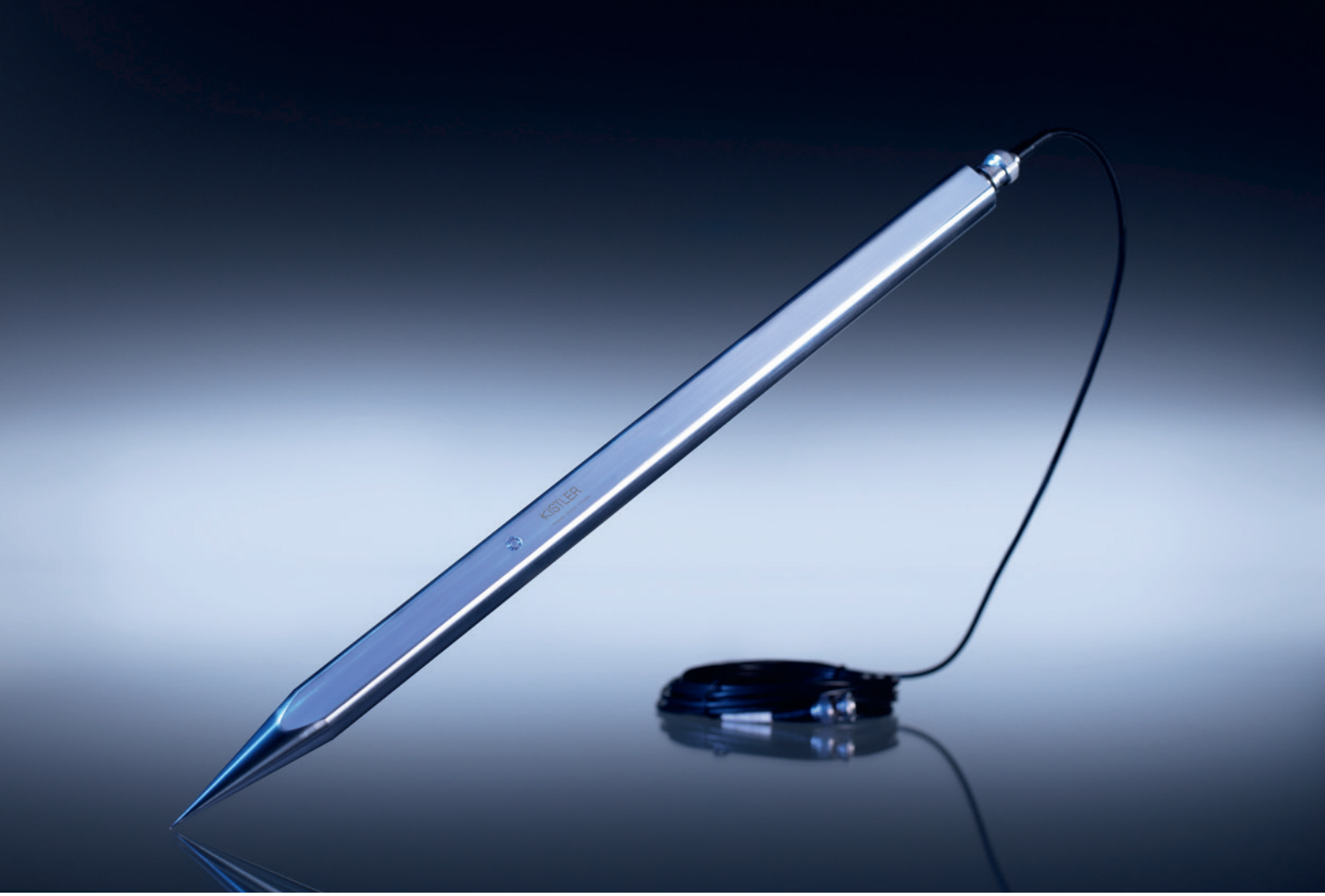
Data acquisition & analysis
For very dynamic signals, high-speed data acquisition systems with a minimum sampling frequency of 1 MSa/s are recommended. In cooperation with the Swiss company Elsys, Kistler offers a range of high-end transient recorders. The instruments of the Elsys TraNET and RODAS series feature integrated IEPE coupling. For large measuring setups multiple devices can be synchronized and operated autonomously in close proximity to the blast zone.











Blast pressure sensors

Pencil Probe Type 6233A…
Pencil type blast sensors are most effectively used in testing scenarios where the direction of shock wave propagation is clearly defined. The characteristic pencil shape minimizes the influence of the sensor geometry on the blast wave propagation and the measured pressure signal. Type 6233A… is pointed radially towards the center of the explosion and effectively measures the side-on pressure of the propagating blast wave. It is available with measuring ranges from 0 … 25 psi, 50 psi, 250 psi, 500 psi and 1 000 psi. With its rugged design, acceleration compensation and minimal bending sensitivity, it is tailored to provide very accurate pressure signals even in very hostile environments.

High-frequency Sensor Type 603CBA
For wall-mounted and confined blast measurement setups, type 603CBA is recommended. With its high natural frequency and acceleration compensation, it is ideally suited for measuring highly dynamic pressure transients. For further mechanical isolation against high-frequency vibrations, it may be mounted into the soft polymer mounting adapter Type 6581.

High-sensitivity Sensor Type 601CBA
In applications where very small pressure pulses need to be measured, this highly sensitive sensor is ideally suited. At the core of the all-welded, hermetically sealed 601C series there is a high performance PiezoStar® crystal grown by Kistler.
This PiezoStar crystal gives the sensor a much higher sensitivity than an equivalently sized pressure sensor based on synthetic quartz, which results in a lower noise level and more accurate measurement of very low pressures. Possible areas of use include the qualification of hearing protection devices (e.g. according to Pfander method) and the detection of supersonic projectiles based on their acoustic shockwave.

* PiezoStar® is a registered trademark of the Kistler Group.

Pencil probes for free-field, side-on measurements

Technical data	Type	6233A...
		
Range	bar psi	1,7 … 69 25 ... 1 000
Maximum pressure	bar psi	350 5 075
Sensitivity	mV/bar mV/psi	2 900 … 72 200 … 5
Mounting	Adapter	Types 6550A10 and 6550A20
Natural frequency	kHz	~300
Rise time	µs	<1 < 6 side-on
Linearity for all ranges	%FSO	≤±1
Sensing element		Quartz
Output		Voltage (IEPE)
Acceleration compensation		Yes

Miniature IEPE pressure sensors for confined and wall-mounted measurements

Technical data	Type	601C...	603C...
			
Range	bar psi	0 … 250 22 … 3 626	0 … 1 000 200 … 14 500
Maximum pressure	bar psi	250 3 626	1 000 14 500
Sensitivity	mV/bar mV/psi	3 333 … 20 230 … 1,4	357 … 5 25 … 0,3
Sensor diameter	mm	5,5	5,5
Thread type		M10 (with Adapter 6503C0A)	M10 (with Adapter 6503C0A)
Natural frequency	kHz	>215	>500
Rise time	µs	<1,4	<0,4
Linearity for all ranges	%FSO	<0,5	≤1,0
Sensing element		PiezoStar®	Quartz
Output		Voltage (IEPE) or charge (PE)	Voltage (IEPE) or charge (PE)
Acceleration compensation		No	Yes

Accessories and signal conditioning

Fixation adapters
In order to obtain reliable blast pressure measurements, a suitable fixation needs to provide accurate alignment and support of the pencil probe, as well as damping against ground shocks. A mobile tripod fixation may be used for small detonations or at larger distances when measuring big detonations. Tripod adapter Type 6550A10 features a standard ¼-inch UNC thread which is compatible with most commercial tripods.
For large detonations or in close proximity to the charge, a fixed pipe installation is recommended. The pencil probe may be fixed to an extension pipe using pipe adapter Type 6550A20 featuring an M22x1 thread.

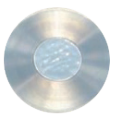
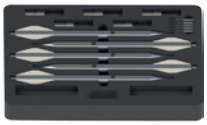
Transport
For safe transport and storage, Kistler developed rugged cases which will secure the pencil probes, as well as the standard accessories.

Thermal protection foil
In close range of an explosion, the pressure sensor membrane is subjected to considerable infrared irradiation. The resulting deformation of the membrane leads to a distortion of the pressure signal. Thermal protection foil type 1911AAA10 is designed to reduce this thermal shock by a factor of 10. For pencil probe Type 6233A... this leads to a minimal and reproducible increase of the sensor sensitivity by only 2 % ± 0,5 %.

Fixation adapters

Technical data	Type	6550A10	6550A20
			
Description		Tripod adapter	Pipe adapter
Sensor types		6233A...	6233A...
Applications		• Small detonations • Medium or large distance to explosive charge • Mobile or variable setups on level or rough ground	• Large detonations • Short distance to explosive charge • Delays and dampens reflected pressure waves and ground shock
Pressure impulses / level		<1000 mbar.ms	>1000 mbar.ms
Thread type		• Standard ¼-inch UNC thread compatible with commercial tripods for photography	• M22x1 thread • Fixed installation with extension pipe

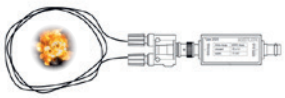
Thermal protection and storage

Technical data	Type	1191AAA10	Z21537
			
Description		Thermal protection foil	Storage case
Key features and application		• Reduces thermal shock of sensor membrane due to radiation and contact heat • Recommended for all measurements • Characterization using pulsed laser: 10 times less signal due to thermal shock	Space and protection for: • 5 pencil probes Type 6233A… • 5 tripod adapters Type 6550A10 mounted on pencil probes • 5 pipe adapters Type 6550A20 • Various small items

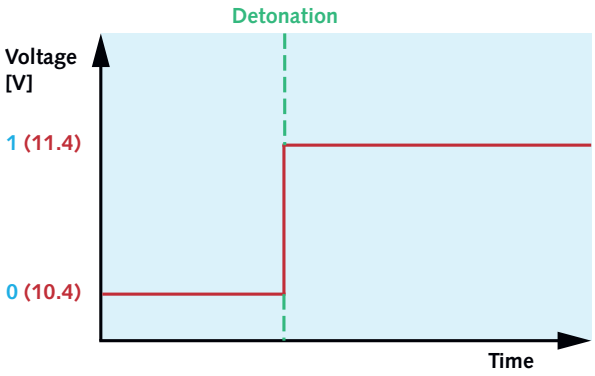
Trigger Box
Knowing the precise detonation timepoint is important for triggering of the measurement and for analyzing the time of arrival of the blast wave. Kistler recommends using a low current break wire wrapped around the explosive charge. This method is very safe, because the measuring chain is electrically decoupled from the detonation chain.

Signal conditioning
In IEPE measuring chains, the integrated electronics of the sensors need to be powered by a constant current. A coupler is used to supply this excitation current and to decouple the signal from the bias voltage. For measuring of slow blast events, LabAmp type 5165A may serve as an IEPE coupler and entry-level data acquisition (DAQ) system for sampling rates up to 265 kSa/s. Alternatively, it may be used as an external IEPE coupler in combination with existing user-supplied voltage input DAQ systems.

Triggering

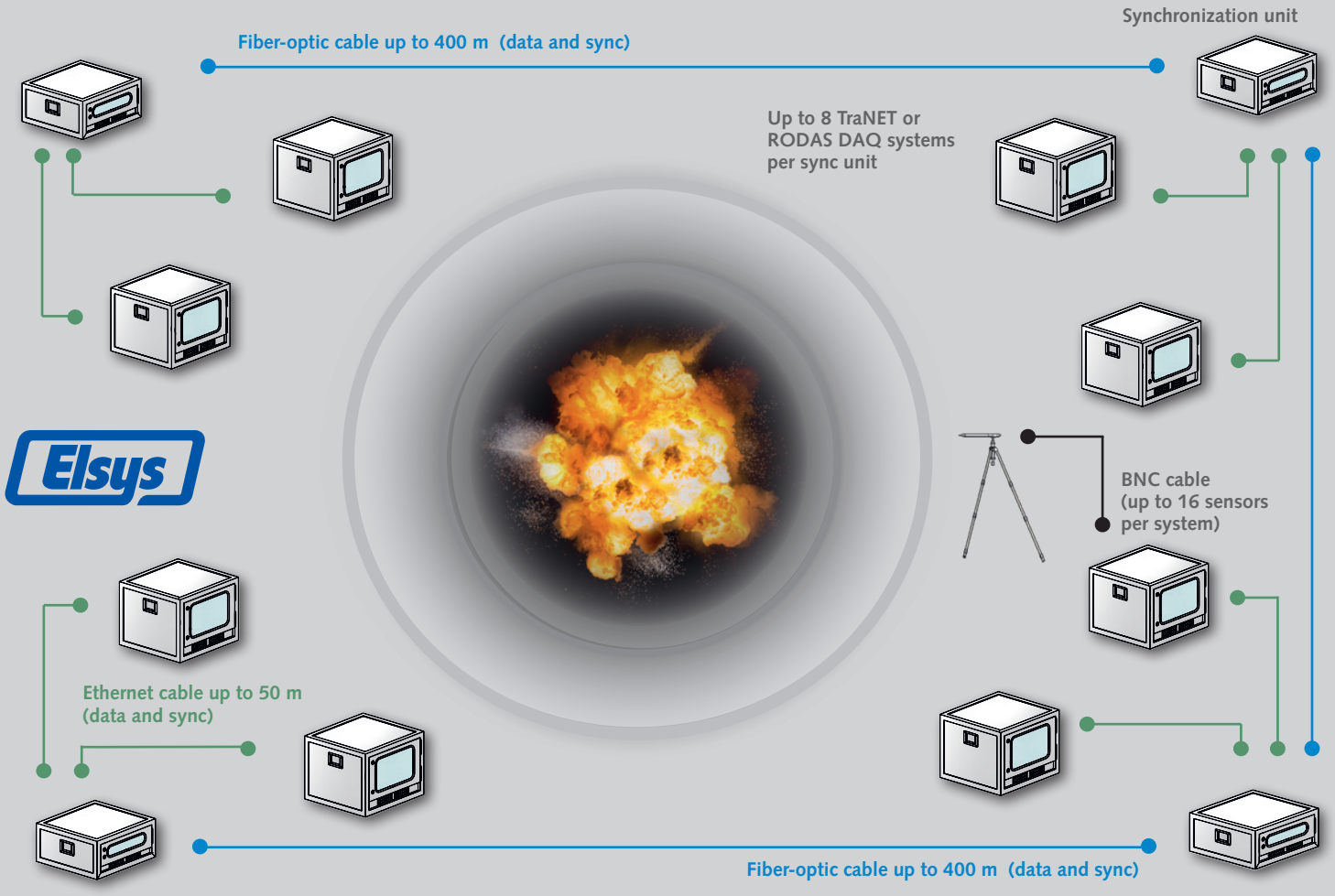
Technical Data	Type	2525A04
		
Description		Trigger Box
Key features and application		• Trigger wire around explosive charge is destroyed upon detonation • Trigger box generates voltage step which can be used for triggering of measurement / determination of detonation time point • Powering / decoupling of trigger signal using IEPE coupler: excitation current 4mA

Voltage step:
after (before) subtraction of bias voltage



Signal conditioning

Technical Data	Type	5165A
		
Number of channels		1 or 4
Connector type		BNC negative
Input		Charge, voltage or IEPE
Frequency range (-3 dB)	kHz	100
Constant current power supply	mA	4 or 10
Maximum input voltage	V	±30
Group delay (filters off)	µs	≤12
Operating temperature range	°C	0 … 60
Degree of protection (EN 60529)		IP20
Key features		• Internal data acquisition: 265 kSa/s, 24 bit • Interface: web browser via ethernet RJ45 • LabVIEW driver • Synchronization of multiple devices possible



Blast measuring systems in cooperation with Elsys

For reliable measurement of high-quality signals during blast testing, robust and flexible data acquisition systems are required. The product portfolio of our Swiss partner company Elsys AG provides unique solutions for small to large scale blast measurements.

High-speed capability
Most highly dynamic blast pressure signals should be sampled with a minimum rate of 1 MSa/s. Elsys data acquisition cards are available with sampling rates between 2 and 240 MSa/s.
Constant current power supply for IEPE type sensors is optionally available.

Robust outdoor solutions
For maximum signal dynamics and convenient handling, the cable lengths between the sensors and the DAQ system need to be minimized as much as possible. Thus, the DAQ system must be robust against vibrations, high / low temperatures and moisture in order to be placed close to the blast site.

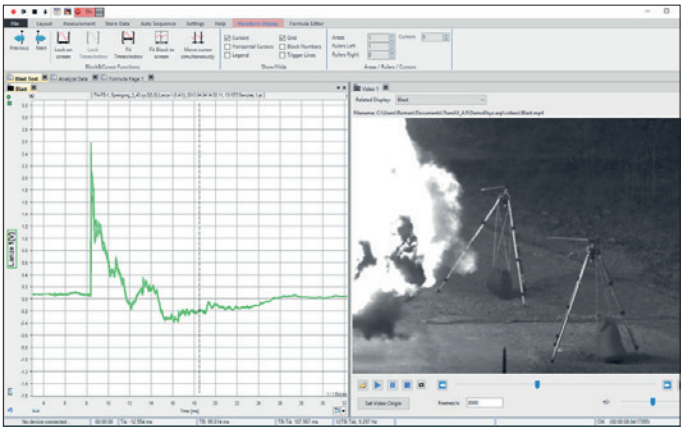
Synchronized multi-channel setups
On large blast test setups, distributed measuring systems allow to reduce the cable lengths significantly. Up to 8 Elsys DAQ systems may be linked and phase-locked by a Synchronization Unit. Additionally, up to 8 Sync Units may be daisy-chained around the blast site using fiber optic cables.
Autonomous, battery-powered operation of the entire DAQ system is possible, while the control computer and test engineers stay at a safe distance.

Benefits
- High-speed sampling for optimal time resolution
- Minimized cabling for high bandwidth and convenient handling
- Maximum flexibility for distributed multi-channel systems
- Outdoor-protected data acquisition systems
- Autonomous system operation close to blast site

System components

Technical Data	Type	TraNET® FE	RODAS
			
Description		Compact DAQ systems	Outdoor-protected DAQ systems
Key features and application		• Ethernet-based, portable DAQ systems • 4 to 16 channels single-ended, 8 channels differential • Stand alone operation for remote unattended capture of elusive signals • Harddisk streaming for longtime monitoring • Internal 200 GB Solid State Drive (SSD) • Optional: DC powering 10 – 36 V • Optional: dust-proof housing	• Same configuration possibilities as TraNET® FE series • Ruggedized outdoor housing, IP65 including cable glands • Active heating and cooling for temperature range from -40 to 50 deg C • Optional: integrated Synchronization Unit • Optional: integrated UPS (uninterruptible power supply) • Dimensions depend on internal system configuration

Data analysis software TranAX®



- Immediate visualization of signals
- Comprehensive library of analysis functions for computation of scalar values (e.g. peak values, gradients, time intervals, impulses)
- Script-based signal processing and analysis
- Synchronization of measured signals with high-speed video footage
- Generation of customized test reports
- API, LabVIEW and IVI-drivers available

Customized solutions

Special requirements need special solutions. The Elsys engineering team is looking forward to finding the optimal setup for your measurement task.

Key Features

- Sampling rates 2 – 240 MSa/s
- Resolution 14 – 16 bit
- Integrated IEPE constant current power supply
- Sampling precision synchronization of multiple DAQ systems with up to 1024 channels
- Powerful data analysis software TranAX

Information

Visit the Elsys website at
www.elsys-instruments.com
and ask your Kistler sales engineer for further information.

* TraNET® and TranAX® are registered trademarks of Elsys AG.

Kistler service: customized solutions from A to Z

Kistler has been setting standards in highly dynamic pressure measurement for more than 50 years. We are at your side as an experienced partner with vast technical and application-specific know-how.

Many blast and blast impact test scenarios also include acceleration measurements on vehicles and structures. For such applications Kistler offers a wide range of accelerometers: **www.kistler.com/accelerometer-sensors**

In addition to blast pressure and acceleration measuring systems, Kistler also offers instrumented dummies for blast impact testing on vehicles. Learn more at **www.kistler.com/vehicle-safety**

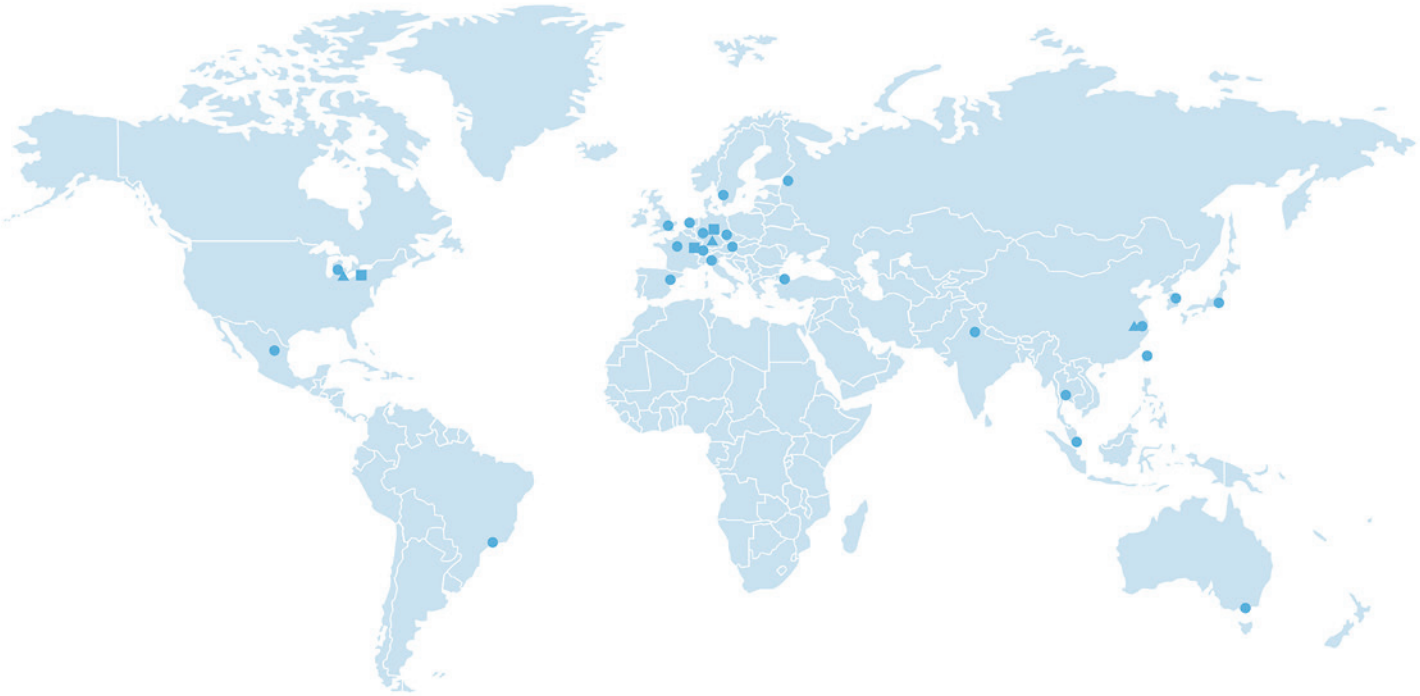
To get access to additional restricted, defense-related content on the Kistler website, please contact your local Kistler sales representative.

Kistler services at a glance

- Advisory
- Installation
- Commissioning support
- Periodic calibration
- Training/workshops

www.kistler.com/accelerometer-sensors

www.kistler.com/vehicle-safety



● Sales center
▲ Tech center
■ Production center

Worldwide presence for our customers

As well as to sensors and systems for highly dynamic blast measurements, Kistler offers a wide range of services. These include expert advice on our solutions, professional support and calibration services, as well as speedy deliveries of spare parts worldwide. To enhance its technical support, Kistler establishes Tech centers worldwide to deliver the specialized service that manufacturers and government agencies expect in order to obtain fast and reliable testing results.

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

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

Find your local contact on
www.kistler.com

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