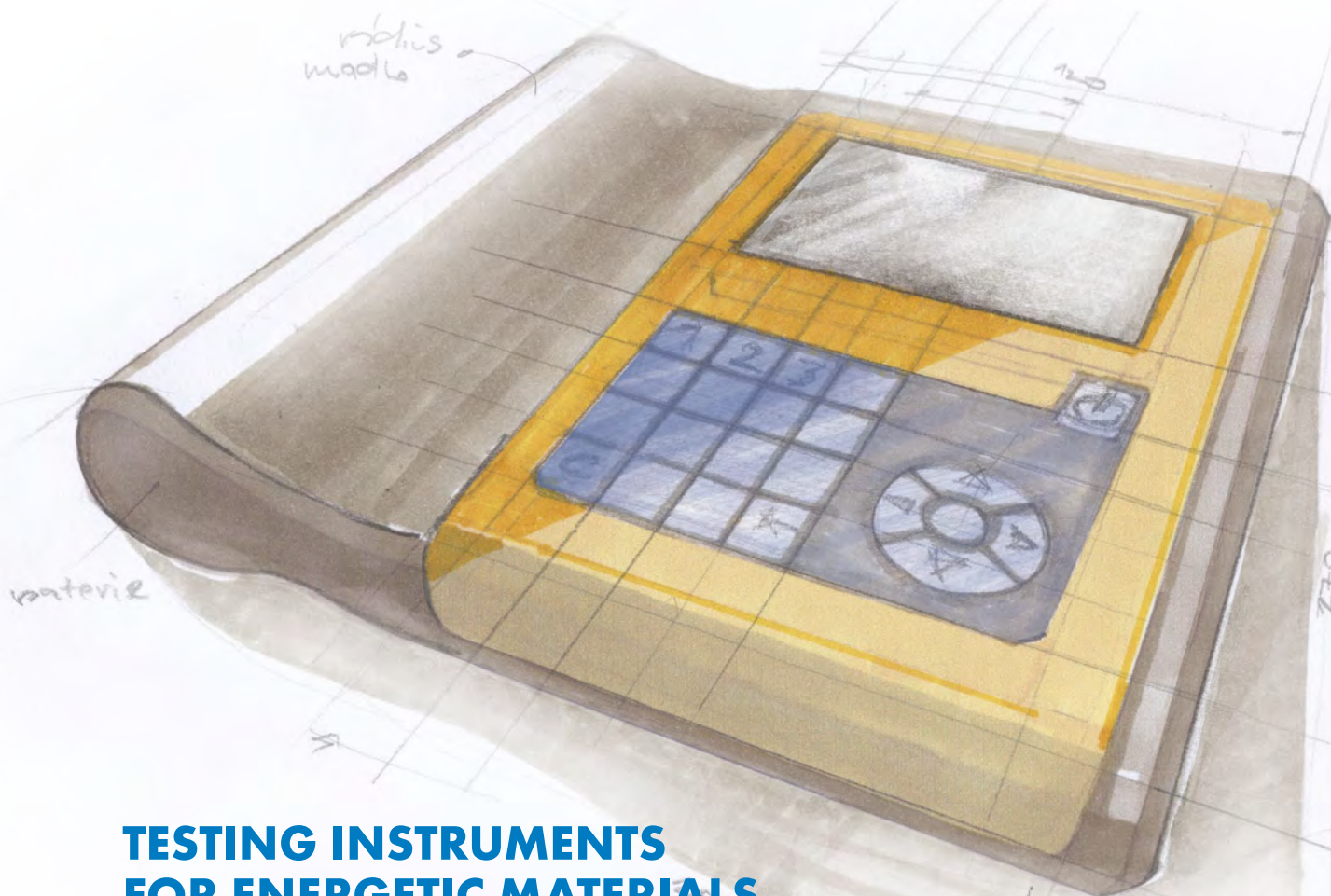


# OZM

RESEARCH



**TESTING INSTRUMENTS  
FOR ENERGETIC MATERIALS  
LABORATORIES**

designed by Jan ERMIS

ver. 2016



ABOUT US

OZM Research® is a knowledge-based company formed by experienced explosives scientists and engineers. The company’s core business model is to produce the best specialized testing instruments for the energetic materials using the latest technologies and to provide our clients the most comprehensive expert services for their applications.

CLIENT-FOCUSED

Our services do not just end with the sale and delivery of the instruments. Our product managers are PhDs in explosives science and technology with decades of experience in development and applications of new testing methods and instruments in academic, industrial and military domestic and international projects. We offer our clients our expertise throughout the entire process — from selecting an instrumentation for a specific application, to its installation and training, to preparation of testing methodologies and their implementation at the client’s laboratory.

JAN ERMIS  
Industrial Designer



Jan Ermis collaborates with OZM Research® since 2008 on the development and innovation of industrial design of the company's portfolio.

Jan Ermis graduated at the Academy of Architecture Art and Design in Pragerial Arts branch Industrial Design.

From the perspective of product designer is important to cultivate the visual aspect of devices, but also bring novel solutions to technological development.

I believe that our cooperation with OZM Research® will bring in the future an extraordinary solution for OZM customers and clearly separate ourselves from other commercial products.

TAILORED PRODUCTS

We offer not only standard testing equipment complying with the military or industrial standards as shown in this catalog. We often design tailored products meeting the client’s specific requirements. Please do not hesitate to challenge our engineers with a request for a new instrumentation if not finding the appropriate type in our catalogue.

EXPORT-ORIENTED

Since the company establishment in 1997, we have exported our products to more than 40 countries on all continents. Our major clients include military research & development centers, forensic institutes, international certification bodies, universities, explosives and ammunition manufacturers, nuclear power plants and other related industries. Our company is fully licensed for handling explosive materials and ammunition as well as for foreign trade with these materials.

OZM RESEARCH IS READY TO HELP YOU  
WITH YOUR TASKS IN ENERGETIC MATERIALS!



P. 14  
OPTIMEX\*64 NEW!  
Advanced Optical Analyzer of Explosion Processes



P. 13  
OPTIMEX\*8 NEW!  
Optical Analyzer of Explosion Processes

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# ENERGETIC MATERIALS

testing instruments for thermal stability, sensitivity and performance tests



# INSTRUMENTS APPLICATIONS

reference table

- ☒ **Applicable**
- ☐ **Limited usage**
- ☐ **Not applicable**

			EXPLOSIVE MATERIALS								APPLICATIONS					
			Primary Explosives	Military High Explosives	Industrial Explosives	Pyrotechnics	Gun Propellants	Rocket Propellants	Explosive Substances	Explosive Devices	Military Qualification	Military Surveillance	Product Quality Control	R&D	Storage & Transport	Safety Engineering
TEST METHOD	OZM INSTRUMENT															
Chemical and Thermal Stability Tests	Abel Test	ABT			x		x	x				o	x	o		
	Accelerated Ageing	HBA, heating blocks	x	x		x	x	x			x	x		x		
	Bergmann-Junk Test	BeJu					x	x				x	x	o		
	Differential Thermal Analysis (DTA)	DTA 552-Ex	x	x	x	x	x	x	x		x	x	x	x	x	x
	Dutch Weight Loss Test at 90 °C (Holland Test)	HOLLAND TEST					x	x				x	x	o		
	Explosion Temperature Test	AET 402	o	x	x	x	o	o	o		x	o	x	o	o	
	Heat Storage Test at 100 °C	CH100					x	x				x	x	x		
	Chemical Compatibility by DTA	DTA 552-Ex	x	x	x	x	o	o	x		x			x		x
	Chemical Compatibility by VST	STABIL VI		x	x	o	x	x	x		x			x		x
	Methyl Violet Test	MVT					x	x				x	x	o		
	Thermal Stability test at 75 °C	TST 75		x	x	x	x	x	x					o	x	
	Time-to-explosion Test	AET 402	x	x	x	x	x	x	x					x		
Vacuum Stability Test (VST)	STABIL VI	o	x	x	o	x	x	x		x	x	x	x		x	
Sensitivity to External Stimuli Tests	Cook-off Tests (slow, fast)	SCO, FCO	o	x	x	x	x	x	x		x			x	x	x
	Friction Sensitivity Test	FSKM-10 (BFST-BAM6A)	o	x	x	x	x	x	x		x			x	x	x
		FSKM-10 (BFST-PEX3)	x	o		x					x			x	x	x
	Gap Tests (shock wave sensitivity)	Water & UN GAP Test	o	x	x	o	o	o	x	o	x			x	x	x
	Impact Sensitivity Test	BFH-10, BFH-12	o	x	x	x	x	x	x	o	x			x	x	x
		BFH PEx	x			x					x			x	x	x
	Electrostatic Discharge Generator for Testing of Electroexplosive Devices	ESDEX 25								x	o	x	x	x	x	o
	Electro-explosive Device Analyzer	EDA								x				x	x	x
Large Scale Electrostatic Discharge Sensitivity Test	ESD LS30		x		o	x	x			x			x			
Small Scale Electrostatic Discharge Sensitivity Test	X SPARK 10	x	x	x	x	o	o	x	o	x	x	x	x	x	x	
Explosive Performance Tests	Minimum Burning Pressure	MBP			x									x	x	x
	Underwater Test	UWB		x	x						x			x	x	
	Explosive Strength (power)	Ballistic mortars BM 310,BM 765	o	x	x					o				x	x	
	Explosive Strength (power)	Trauzl test, detonation chambers	o	x	x					o				x	x	
	Explosive Brisance Tests	Hess test, Kast test, detonation chambers	o	x	x					o				x	x	
	Detonation Velocity, Burning Rate	VOD 815, detonation chambers	o	x	x	x				x	x	x	x	x	x	
	Detonation Velocity, Burning Rate	OPTIMEX	x	x	x	x				x	x			x	x	
	Laser Interferometry	PDV		x	x									x	x	
	Detonation Properties Calculation	EXPLO5	x	x	x	x	x	x	x						x	
	Heat of Detonation	DCA 5, DCA 50	x	x	x					x	x				x	
	Shock Wave Pressure and Heat Flow in Air Blast and closed Structures	PREWAQ, detonation chambers	x	x	x	x				x	x	x			x	
	Time-Pressure Test	TPT series	o	x	x	x	x	x	x						x	x
Interior Ballistic Performance Tests	NV series	NV series	x			x	x			x	x	x	x	x		x
		RB series					x				x	x	x	x		
	Heat of Combustion/Explosion	BCA 500		x	x	x	x	x	x		x	x	x	x		x
	Burning Rate Tests	STOJAN VESSEL SV-2						x			x	x	x	x		
	Sub-Scale Rocket Motor Tests	TRM 35						x			x	x	x	x		
	Rocket Motor Burning Parameters	RMM						x		x	x	x	x	x		

# XSPARK10

electrostatic spark sensitivity apparatus



The X SPARK 10™ is the newest generation of the universal testing instrumentation (originating from the ESD 2008A™) designed for precise measurement of the initiation energy of energetic materials by electrostatic spark in the range of discharge energies from 25 µJ to 25 J and voltages between 500 V and 10 kV. The X SPARK 10™ operates in the two discharge regimes – Oscillating and Damping – suitable for different classes of energetic materials (with shock wave or thermal mechanism of initiation).

## APPLICATION

Electrostatic discharge is one of the most frequent and the least characterized causes of accidental explosions of energetic materials. Reliable data on the electrostatic spark sensitivity of energetic materials is thus critical in their manufacture, quality control, explosives processing, loading, transportation, storage, demilitarization and research and development of the new explosive materials.

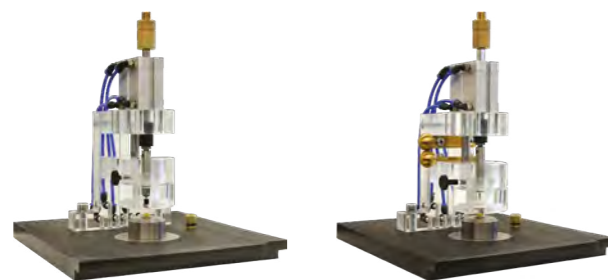
## COMPLIANCE

- EN 13938-2 Explosives for civil uses – Propellants and rocket propellants – Part 2: Determination of resistance to electrostatic energy
- STANAG 4490
- MIL-STD-1751A Safety and Performance Tests for the Qualification of Explosives - Methods 1031, 1032 & 1033

### Other available versions of spark testers:

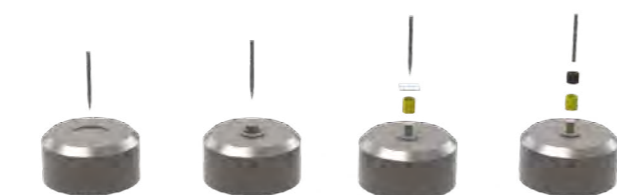
ESDEX25™ (Electrostatic discharge generator for testing of electro-explosive devices)  
ESD LS30™ (Large-scale electrostatic discharge sensitivity tester)

## ACCESSORIES



Fixed electrode testing stand

Approaching anode testing stand



Left to right:  
ESD-30133-TA Spark gap assembly acc. to MIL-STD-1751A methods 1031 & 1033  
ESD-FE-TA Spark gap assembly acc. to MIL-PRF-46676B (AR)  
ESD-32-TA Spark gap assembly acc. to MIL-STD-1751A method 1032  
ESD-OZM-TA Spark gap assembly acc. to OZM/TNO/DTTX

# FSKM10

BAM friction apparatus



- Designed in accordance with the BAM procedure to determine friction sensitivity in a wide range of friction loads (from 0.1 N to 360 N)
- Robust stainless steel design
- Two interchangeable loading arms are available – for sensitivity testing of highly sensitive explosives as well as less sensitive explosives at one apparatus

## APPLICATION

The friction sensitivity of a tested substance is determined in accordance with the BAM procedure. OZM Research® has designed the FSKM 10™ with a unique interchangeable loading arm mechanism: a light loading arm designed for testing highly sensitive primary explosives and pyrotechnics and a standard loading arm designed for testing high explosives, less sensitive energetic materials and other substances.

## ADVANTAGES & FEATURES

- Complete stainless-steel stand
- Unique interchangeable loading arm design
- Standard 6-position loading arm accompanied by two sets of weights generating loads from 0.5 N to 360 N
- Light 3-position loading arm, specially designed for testing highly sensitive substances, accompanied by two sets of weights generating loads from 0.1 N to 60 N
- Protective shield to protect personnel against potential fragments of porcelain plate or peg
- Digitally controlled step motor for the high precision movement of the porcelain plate
- Working table covered by an electrostatic conductive surface
- Wide range of accessories available
- Premium quality consumables at cost effective prices

## ACCESSORIES



Light 3-position Loading Arm in Storage Case

Porcelain Plate and Peg

Sets of weights for Light Loading Arm  
Set of Weights PEx-5  
Set of Weights PEx-14

## COMPLIANCE

- UN Recommendation on the Transport of Dangerous Goods, Manual of Tests and Criteria, United Nations, New York, 2003 [13.4.2 Test 3(b)(i)]
- EN 13631-3:2004 – Explosives for civil uses - High explosives - Part 3: Determination of sensitiveness to friction of explosives
- European Commission Directive 92/69/EEC, method A14: Explosive properties
- STANAG 4487
- MIL-STD-1751A: Safety and Performance Test for the Qualification of Explosives (High Explosives, Propellants, and Pyrotechnics), Method 1024: BAM Friction Test
- TB 700-2, DoD Ammunition and Explosives Hazard Classification Procedures (2012), Section 5-3d
- Energetic Materials Testing & Assessment Policy Committee Manual of Tests, Volume 1, Issue 4, Nov 2007 (EMTAP TESTING); Test No 44
- GB/T 21566-2008: Test method for friction sensitivity of explosives substance

### Other available versions of friction testers:

BAM Friction Apparatus FSA12™

# BFH12A

## BAM fall hammer

The BAM Fall Hammer (also known as BAM Impact Tester or Drop Hammer) is designed to determine the sensitivity to the impact stimuli of a fallen drop weight in accordance with the BAM procedure.

The BFH12A™ is equipped with an automated lifting mechanism for remote controlled positioning, dropping and collection of the drop weight. The BFH12A™ introduces a unique Drop Weight Exchange Window for safer, quicker and more convenient exchanges of the drop weights.

### APPLICATION

The sensitivity to impact stimuli is one of the most important characteristics of energetic materials defining their safety in handling, processing or transportation. Its determination is a necessary part of characterization of new explosives, modified formulations or manufacturing conditions, as well as for defining influences of impurities or ageing. It is also used in quality control of manufactured explosives, surveillance of in-service explosives and transport/storage classification of explosive materials.

### ADVANTAGES & FEATURES

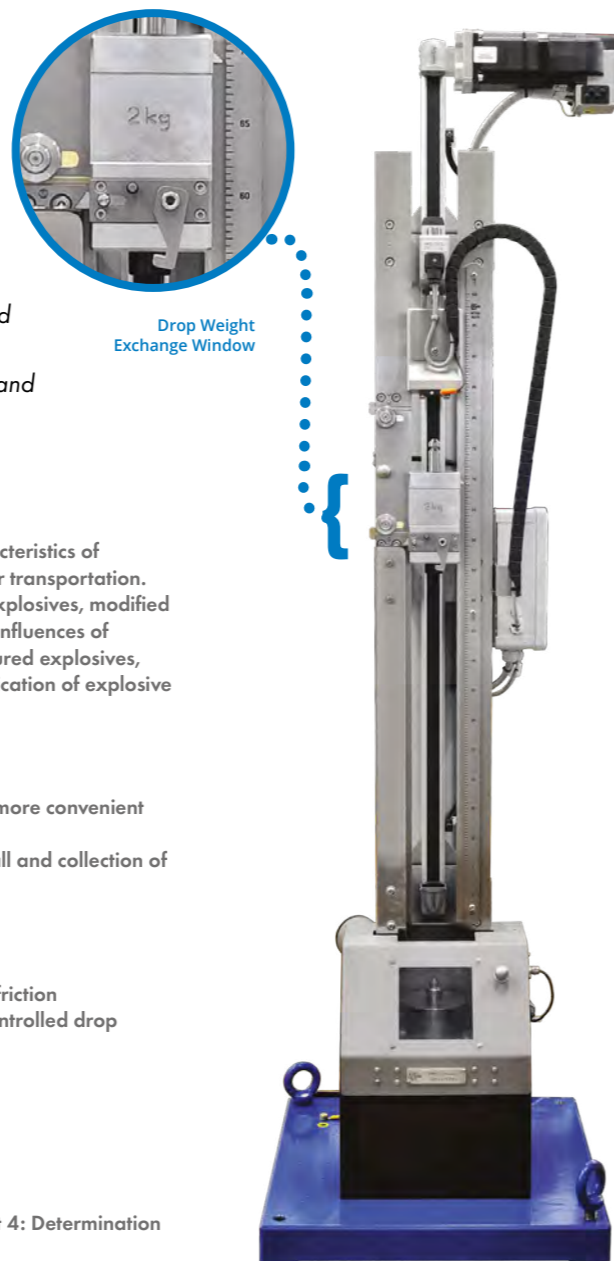
- Unique Drop Weight Exchange Window for safer, quicker and more convenient exchange of Drop Weights
- Automated Lifting Mechanism remotely operates positioning, fall and collection of Drop Weight
- Protective Housing
- Wide range of impact energies from 0.25 J to 100 J
- Six Drop Weights from 0.25 kg to 10 kg
- Drop weights equipped with brass grooves for reduced sliding friction
- Pneumatic or electromagnetic releasing devices for remotely controlled drop weight fall
- File Plates as alternative consumables
- Wide range of accessories
- Premium quality consumables at cost effective prices

### COMPLIANCE

- EN 13631-4:2002 Explosives for civil uses. High explosives Part 4: Determination of sensitiveness to impact of explosives
- European Commission Directive 92/69/EEC, Method A14: Explosive properties
- UN Recommendation on the Transport of Dangerous Goods, Manual of Tests and Criteria, United Nations, New York, 2010 [Test 3(a)(ii)]
- STANAG4489
- MIL-STD-1751A: Safety and Performance Test for the Qualification of Explosives (High Explosives, Propellants, and Pyrotechnics), Method 1015: BAM Impact Test Apparatus
- Energetic Materials Testing & Assessment Policy Committee Manual of Tests, Volume 1, Issue 4, Nov 2007 (EMTAP TESTING); Test No 43
- GB/T 21567-2008: Dangerous goods – Test method for impact sensitivity of explosive substance

#### Other available versions of Impact Testers:

- BFH10™
- BFH12™
- BFHPEx™
- BFH12R™ (comply with GOST 4545-88)



Drop Weight Exchange Window

### ACCESSORIES



Set of Drop Weights



Steel Guide Ring and Cylinder

# BFHPEx

## BAM fall hammer

Designed for determination of impact sensitivity of highly sensitive materials as primary explosives or pyrotechnics in accordance with the BAM procedure.

### APPLICATION

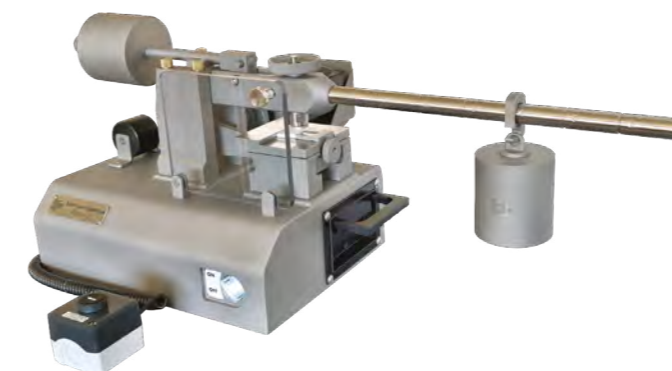
The sensitivity to impact stimuli is one of the most important characteristics of energetic materials. Small BAM Fall Hammer BFH-PEx™ is especially suitable for testing of the most sensitive materials with special emphasis to maximum operator safety.

### ADVANTAGES & FEATURES

- Entire corrosion-proof design
- Wide range of impact energies from 0.025 J to 10 J
- Six Drop Weights spanning from 25 grams to 1,000 grams
- Electroless nickel plated guide rails for reduced sliding friction
- Electromagnetic or Pneumatic Releasing Device for the remote controlled release of the Drop Weight
- File plates as alternative consumable
- Protective Housing
- Wide range of accessories for specialized testing
- Premium quality consumables at cost efficient prices

# FSA12

## BAM friction apparatus



FSA12™ is a portable version of the OZM's BAM Friction Apparatus FSKM10, which can be placed and operated on a standard laboratory working table. FSA12™ is used to determine the friction sensitivity of all types of energetic materials in accordance with BAM procedure. Due to the unique design of two interchangeable loading arms, the applicable load can vary from 0.1 N to 360 N (from 0.01 kg to 36 kg).

### ADVANTAGES AND FEATURES

- The same as for BAM Friction Apparatus FSKM10™ described on the previous page
- Integrated handles for easy moving
- Remote control

### COMPLIANCE

The same as for BAM Friction Apparatus FSKM10™ described on the previous page



# STABIL VI

vacuum stability apparatus



The STABIL® (Modernized Vacuum Stability Tester) is used for the determination of the chemical stability and compatibility (reactivity) of energetic materials. Electronic pressure transducers allow for the determination of the volume of evolved gases.

The unique design of the STABIL® VI completely replaces old mercury-containing apparatuses with non-toxic,

safe and easy-to-operate precise instrumentation. OZM Research® continues with long and proud tradition of the electronic vacuum stability testers – the first generation of STABIL® instrument was developed over 40 years ago in the Czech Republic. Today's STABIL® VI is the latest generation of this long innovation process and creates the standard of excellence in the VST testing equipment worldwide.

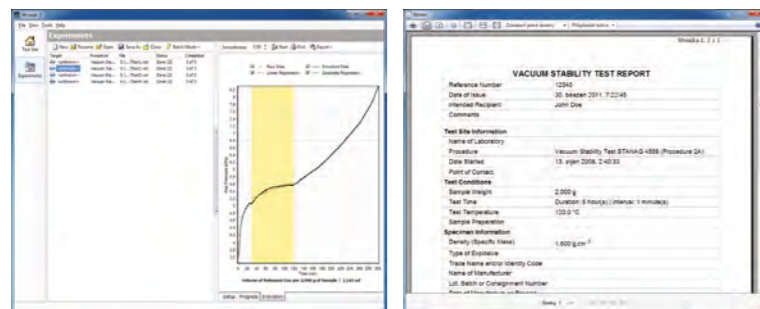
## APPLICATION

Vacuum stability test is frequently used for determination of chemical stability and compatibility of energetic materials and for quality tests of energetic ingredients. The test is able to discover chemical instability of energetic materials due to the presence of destabilizing impurities, incompatibility with surrounding materials, or ageing, with high sensitivity, precision and reproducibility. Vacuum stability test finds its wide application in qualification, surveillance, manufacture, quality control and research & development of a wide range of energetic materials.

## COMPLIANCE

- STANAG 4556, 4147, 4022/4, 4023, 4230, 4284 and 4566

## SW + ACCESSORIES



WINSTAB software: Examples of experiment evaluation



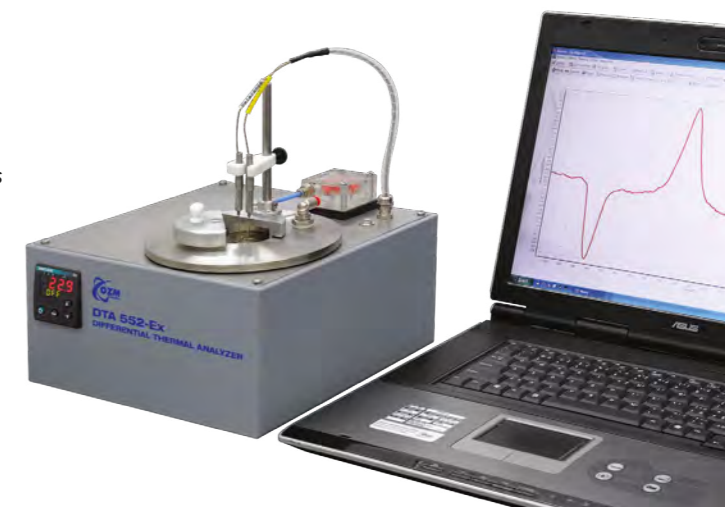
Pressure transducer and test tube

# DTA552-Ex

differential thermal analyzer

The DTA552-EX™ (Differential Thermal Analyzer) was developed specifically for the evaluation of thermal stability, purity (melting point), compatibility and decomposition parameters of all types of energetic materials including primary explosives or other hazardous exothermic substances.

Robust design of DTA552-EX™ makes the instrument the ideal choice for the characterization of explosive materials which explosions during the test would likely damage or destroy conventional thermal analyzers.



## APPLICATION

The DTA552-EX™ detects and analyzes thermal changes (melting, polymorph transformation, evaporation and thermal decomposition) occurring in the sample and allows for the evaluation of the thermal stability, purity, compatibility and the thermal decomposition parameters of all types of energetic materials.

The DTA552-EX™ is an essential instrument for quality control of energetic materials or raw materials, characterization and qualification of new compounds, in-service surveillance, research and development and many other testing programs.

## ADVANTAGES & FEATURES

- Robust design capable to withstand an explosion of up to several hundred milligrams of explosives
- Variability of applicable substance forms (paste, liquid, foam and corrosive)
- High sensitivity - direct contact of the thermocouple with the sample
- User-friendly software for data acquisition, analysis and archiving
- Low costs of investment and operation

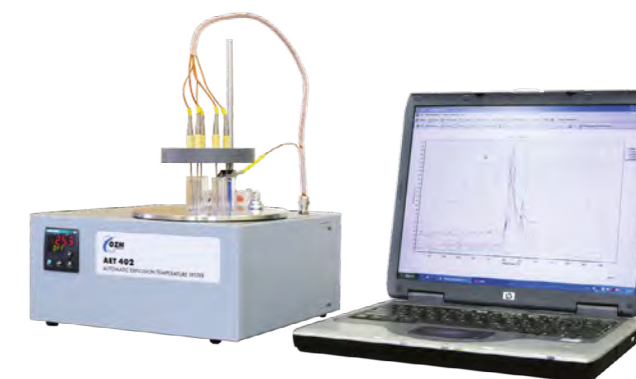
## COMPLIANCE

- STANAG 4515 Ed. 2

# AET402

explosion temperature apparatus

The AET402™ (Automatic Explosion Temperature Apparatus) is used for the determination of the explosion (ignition) temperature of energetic materials submitted to the thermal load (heat).



## APPLICATION

The AET402™ is the most frequently used as a quality-control instrument in the manufacture of explosives, pyrotechnic mixtures and propellants. The AET402™ can also be used for the determination of time-to-explosion data (time needed for the ignition of a sample at a given constant temperature). The AET402™ provides a fast and simple evaluation of the thermal sensitivity of energetic materials with up to 5 samples simultaneously tested. Compared to "classic" explosion temperature instrumentation, the AET402™ incorporates an automatic detection of the explosion temperature by means of thermocouples, avoiding necessity of the operators to visually observe the test for the whole time of its execution.

## ADVANTAGES & FEATURES

- Measures up to 5 samples simultaneously
- Robust heating block design
- Time-saving automatic determination of the explosion

## COMPLIANCE

- STANAG 4491
- European Commission Directive 67/548/EEC, Method A-15

# HEATING BLOCKS

for testing thermal stability

Thermal and chemical stability is vital for the safe manufacture, storage, transportation and use of energetic materials. OZM Research® offers a wide range of instruments for the determination of the thermal and chemical stability for all types of energetic materials. Whether concerning quality control, hazardous materials or in-service surveillance OZM Research® has the most reliable and highest quality thermal stability testing equipment.



Abel Heat Tester

## APPLICATION

Traditional tests for the determination of the chemical stability of energetic materials (mainly propellants) are based on heating samples at elevated temperatures and detecting their reactive decomposition products (NO<sub>x</sub>). This detection can be based on visual identification of colored gases above the sample (Heat Storage Test at 100 °C), a color change of indicator papers (Abel Test, Methyl Violet Test), the titration of acidity in a water extract of the gases (Bergmann-Junk Test) or with the determination of weight loss (Holland Test). Heating at elevated temperatures is also used in the artificial aging of propellants (STANAG 4117, AOP-48).

All devices for testing thermal stability consist of temperature controllers and heating blocks, each containing multiple (4 – 45) holder holes of appropriate size. Customized glass test tubes are supplied with each instruments.

## COMPLIANCE

The instruments comply with all relevant standards for its particular heat test and can be further modified upon client's request.

## ADVANTAGES & FEATURES

- Customized heating blocks available on request
- High precision and accuracy of the heating block temperature
- Fast operation time and proven testing procedures
- Independent alarm circuit (limit controller) for additional temperature control

## LIST OF AVAILABLE HEATING BLOCKS

ABEL HEAT APPARATUS - ABT™  
BERGMANN-JUNK APPARATUS - BeJu™  
METHYL VIOLET APPARATUS - MVT™  
HEATING BLOCK FOR ACCELERATED AGING - HBA™  
DUTCH WEIGHT LOSS TEST (HOLLAND TEST)  
INSTRUMENT FOR HEAT STORAGE TEST AT 100 °C - CH100™  
Others upon request



Bergmann-Junk Tester

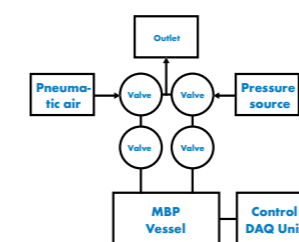
Instrument for Heat Storage Test at 100 °C



# MBP

minimum burning pressure apparatus

The MBP™ (Minimum Burning Pressure Apparatus) is used for the determination of the minimum burning pressure of emulsion explosives ignited by a hot wire in a closed vessel under high pressure conditions. The pressure and temperature of the sample are recorded. The MBP™ is a completely new approach to advanced stability and sensitivity testing of emulsion explosives, developed in cooperation between OZM Research® and Canadian Explosives Research Laboratory (CERL).



MBP Vessel basic scheme



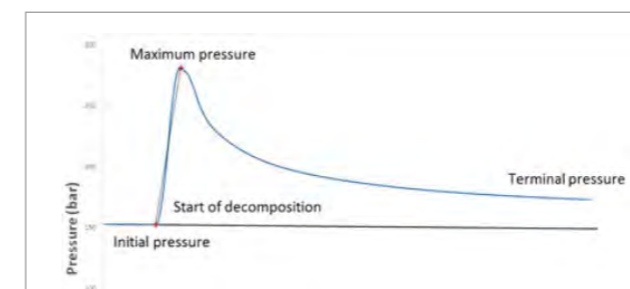
## APPLICATIONS

While emulsion explosives are normally quite safe for handling, accidents connected with them are however still occurring and conventional methods of stability or sensitivity testing are not representative enough to discover their risky behavior. It has been found that most of the accidents happened during pumping, manufacturing and transporting of emulsion explosives when the materials were subjected to elevated pressures and temperatures. The determination of the minimum burning pressure has therefore become one of the most important safety characteristics of emulsion explosives. The MBP™ is primarily designed for testing of emulsion explosives during both their development and industrial manufacture. Small testing trials with MBP™ can provide very important information about the emulsion explosive's safe pumping pressure. The MBP™ can also be used for other explosives, which are likely to be subjected to pressure and temperature loads.

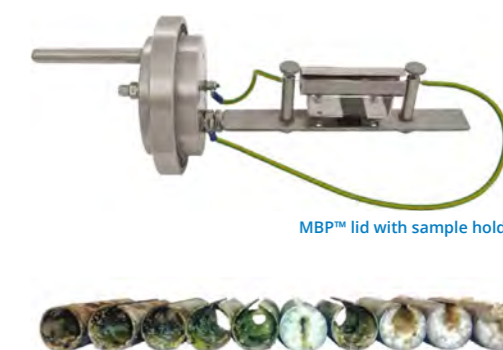
## ADVANTAGES & FEATURES

- Certified closed vessel from noncorrosive material
- Working pressure up to 500 bar (with remotely controlled pressure manifold)
- Precise constant current power supply for thermal ignition of the sample
- Measurement of time-to-decomposition, terminal pressure of decomposition and decomposition rate
- Easy to handle, one-box design with simple connectivity and user-friendly software for data processing

Additional equipment and consultation for the development and testing of emulsion explosives is available on request.



Typical results



Samples after test (from complete burning out to partially consumed to intact samples)

# VOD815

velocity of detonation tester



Optical signals can be used as a rich source of information on explosion processes and their effects on other materials. OZM Research® now offers complete solution for characterization of performance properties of energetic materials based on the optical methods. The optical probes are resistant to humidity and electromagnetic disturbances and allow our products to be used in almost any harsh and electrically noisy environment. High measurement precision is achieved by application of high frequency digitizers.

VOD815™ Velocity of Detonation Tester is a simple-to-use instrument designed for precise measurement of the velocity of detonation wave passing through the explosive charge or the burning rate of propellants using fiber optics. The detonation velocity is calculated from measured time intervals of light signals travelling between 8 optical probes positioned at known distances in the explosive charge.

## COMPLIANCE

- EN 13631-14 Explosives for Civil Uses – High explosives, Part 14: Determination of Velocity of Detonation

## APPLICATION

Detonation velocity of explosives or burning rate of propellants or pyrotechnics are some of the most important parameters characterizing these energetic materials. The VOD815™ can be used for quality control in the explosives manufacture, mining, research and development.

## ADVANTAGES & FEATURES

- 8 plastic optical fiber probes
- Impact resistant and waterproof transport case
- Battery charged instrument equipped with internal memory
- USB communication cable and software WinVOD for data acquisition

# OPTIMEX 8

optical analyzer of explosion processes



## APPLICATION

The instrument is designed for advanced measurement of detonation velocity in all kinds of energetic materials. High resolution of the optical data acquisition allows detonation wave curvature measurements and thus even non-ideal high explosives can be measured with sufficient data quality. OPTIMEX® 8 is a powerful tool for manufacturing quality control, blasting optimization in mining, education and field experiments at research and development projects, where more information on detonation wave profile is required than it could be obtained using simpler VOD815™ Velocity of Detonation Tester.

## ADVANTAGES & FEATURES

- 8 optical probes selected according to customer's application (plastic or glass fiber)
- Complete light intensity-time profiles available
- Automatic data evaluation
- LCD display
- Battery charged instrument equipped with internal memory
- USB communication cable and data evaluation software

## COMPLIANCE

- EN 13631-14 Explosives for Civil Uses – High explosives, Part 14: Determination of Velocity of Detonation

Optical analyzer of explosion processes is able to collect optical signals from exploding charges using 8 fiber-optic probes and to visualize light intensity of the signals in time. This allows detonation velocity to be measured more precisely and with better confidence for non-ideal explosives than ever before thanks to the advanced optical signal processing.

# OPTIMEX 64

advanced optical analyzer of explosion processes



OPTIMEX® 64 advanced optical analyzer of explosion processes uses from 8 to 64 fiber optic probes to visualize light intensity of the explosion or detonation wave in time. This allows detonation velocity and detonation wave curvature to be measured more precisely and with better confidence than ever before thanks to full light signal processing availability. The probe number and type can be selected according to the customer's needs.

## APPLICATION

OPTIMEX® 64 is a valuable scientific instrument for optical measurements in research and development of energetic materials. It can be used for detonation velocity and detonation wave curvature measurements with unprecedented confidence level. With high number of fiber probes, the instrument's capabilities resemble those of high speed streak camera. OPTIMEX® 64 may also find its use in measurements of strong shockwave velocities in inert materials, detonation temperature or timing of shock to detonation transitions. Using continuous optic probes, detonation velocity can be measured on millimeter scale, in multiple charges at once, or shock wave shape can be traced in explosive charges with complex shapes.

## ADVANTAGES & FEATURES

- Up to 64 optical probes selected according to customer's application (plastic or glass fiber)
- Full light intensity-time profiles available
- User adjustable light signal gain
- Continuous optic probes applicable
- Automatic or manual data evaluation
- PC with instrument control and data evaluation software

## COMPLIANCE

- EN 13631-14 Explosives for Civil Uses – High explosives, Part 14: Determination of Velocity of Detonation

## PHOTONIC DOPPLER VELOCIMETER

PDV is a laser interferometer system for determination of continuous velocity-time profiles of flying objects such as explosively accelerated expanding cylinders, metal plates, concrete walls, etc. The maximum velocity which can be measured lies typically in the range from hundreds to several thousand meters per second. Time resolution of velocity histories reaches 10s of nanoseconds. The system can be mounted in a durable 19" rack box or used as a tabletop apparatus with up to four measurement channels available.

## APPLICATION

The measurement of velocity profiles of explosively accelerated materials can be used for inferring key properties of high explosives such as particle velocity, detonation pressure, Gurney energy and parameters of Jones-Wilkins-Lee equations of state. Unlike Hess or Kast tests which are used for relative determination of brisance, PDV allows direct measurement without the need of comparison with standard samples. Typical testing procedures where the instrument can be used are cylinder expansion test and flyer plate test. The use of the PDV system is not limited to explosives but includes high energy physics, plasma physics, construction and engineering.

## ADVANTAGES & FEATURES

- Up to 4 active laser channels
- Velocity measurement in the range from 0 to 10 km/s with extreme time resolution
- Software for data evaluation included
- Eye safety thanks to all fiber optics design

# BCA500

oxygen calorimeter



BCA500™ (High pressure bomb calorimeter) is an advanced combustion calorimeter designed for the rapid determination of the calorific values of solid and liquid samples. Compared to other commercial calorimeters, the BCA500™ incorporates a high pressure bomb allowing to safely determine combustion heats of energetic materials under a wide range of conditions.

### SAMPLE MATERIALS

- Energetic materials – combustible high explosives, propellants, pyrotechnics and other ignitable explosives
- Fuels- oil, coal, wood etc.
- Waste material – plastics, water containing samples, PVC and others
- Polymers and other industrial materials
- Metal powders and high energy composite materials with AP

### APPLICATION

The BCA500™'s robust and precise design allows its use in the most demanding applications for determination of combustion heat of energetic materials during their research, development, manufacturing quality control, in-service surveillance. The BCA500™ is however not designed for the testing of materials in a detonation regime - see our detonation calorimeters DCA5 and DCA50 for this application.

### ADVANTAGES & FEATURES

- The compact design affords a small footprint requiring less space than other standard devices
- Easy operation with no special personnel requirements
- Superb resolution of thermometers as low as 0.00001 K
- -The BCA500™ needs no water supply—all process water is stored inside inner tanks
- Two tanks allow for non-stop testing and minimize the operation time
- Advanced water management with integrated chillers provides conditioning and precise dosing
- Easy to operate interface with LCD touch screen, wireless keyboard and mouse
- Fully automated data acquisition, evaluation and management with remote access features

### Testing conditions in BCA500™ bombs

Bomb	Conditions				Use (No detonation regime allowed)
	Vacuum	Air	Oxygen	Inert	
OX-1/2	NO	NO	YES	YES	Fuels and other combustible materials. Bayonet lock for fast and easy operation.
DC-1	YES	YES	NO	YES	Pyrotechnic mixtures. High pressure design.
EX-1/2	YES	YES	NO	YES	Fuels and other combustible materials. Ignitable explosives and propellants. Rigid design with thread lock.

### PRODUCT DETAILS AND ACCESSORIES



Inbuilt water conditioning system



Filling arrangement for vessels EX-1/2



Bomb OX-1



Bomb DC-1

# DCA5 & DCA50

detonation calorimeters



Detonation calorimeters DCA5™ and DCA50™ determine the heat produced by the detonation of energetic materials. Both utilize the classical constant volume arrangement combined with OZM Research®'s durable bomb design.

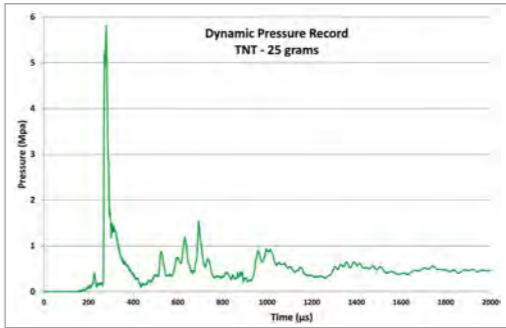
### APPLICATION

Detonation calorimeters DCA5™ (5.3-L volume, 25 g TNT capacity) and DCA50™ (14.5-L volume, 50 g TNT capacity) are well suited for characterization of performance properties of high explosives in their research, development, manufacture and in-service surveillance.

### ADVANTAGES & FEATURES

- Superb resolution of thermometers as low as 0.00001 K
- Built-in dynamic pressure sensor with a sampling rate of 2 MHz
- High strength stainless steel detonation chamber for testing in vacuum, air, nitrogen, argon, oxygen etc.
- Fully automatic operation, data acquisition and results evaluation
- Advanced water management system for conditioning, dosing and emptying
- All water tanks, valves, heaters, chillers, level and temperature sensors are included
- Built-in bomb manipulator and detachable cart for easy positioning
- Inbuilt manipulator for bomb positioning and detachable cart

### SW AND PRODUCT DETAILS



Dynamic Pressure Record of pressed TNT charge



DCA5™ on-site

# KV250

## laboratory detonation chambers

Laboratory detonation chambers allow to safely carry out detonation experiments directly inside explosives laboratories. They can be used for scientific investigations, research, development and testing in the area of energetic materials, confined explosions and related applications such as explosive forming of metals or safe disposal of laboratory explosive wastes.

Laboratory detonation chambers are designed to withstand repeated detonations of up to 250 g TNT. The explosive charges are installed on a working table inside the chambers (KV series) or hanged through the top lid (LDC series) and safely fired by electric detonators connected to firing contacts. Gas-tight valves on the chamber body enable creating different gas atmospheres within the chamber, as well as sampling, evacuation and flushing of the post-explosion gases. The chambers are furthermore equipped with multiple ports, which can be used for installing various optical or electrical measuring instruments for investigations of the detonation processes.

Several full-scale performance and sensitivity tests can be safely executed inside the chambers such as measurement of detonation velocity, pressure-time and temperature-time records of confined explosions, brisance and explosive power tests (Hess, Kast, PDT, Trauzl), high-speed optical and X-ray photography, gap tests, cook-off tests, electrostatic discharge sensitivity tests, large-scale thermal stability tests etc.



KV250M4 (250 g TNT)



Laboratory detonation chamber LDC25

### Laboratory Detonation Chambers

Type	TNT Equivalent (g)	Weight (kg)	Material	Atmosphere
LDC 10	10	30	Stainless steel	Vacuum, air, inert gas or oxygen (up to 30 bar)
LDC 25	25	60		
LDC 50	50	190		
KV 150M2	150	1100	Steel	Air or inert gas (up to 1 bar)
KV 250M4	250	2200		

### POLLUTION ABATEMENT SYSTEM (PAS) FOR DETONATION AND BALLISTIC EXPERIMENTS

Autonomous system for cleaning off-gases from experiments in detonation chambers and ballistic vessels before their releasing to the outside air, for the environmental protection and occupational hygiene.

#### Four-step gas filtration process involving:

- Separation of coarse particles (cyclone)
- Filtration of fine particles (particle filter with automatic dust-off)
- Absorption of sub-micron particles and acid gases (turbulent alkaline crubber)
- Adsorption of semi-volatile organic compounds and/or mercury vapors (adsorbers with surface-coated active carbon)

PAS design was proven in industrial operations at multiple installations since 2003 for serial disposal of ammunition elements with heavy metal content. Filtration effectiveness (>99.9% for heavy metals, >95% for acid gases) proven by repeated emission control tests by independent accredited laboratories. Fully automatic operation without direct presence of the operators. Containerized version available, built-in a 20 'HC shipping container.



Pollution abatement system (PAS)

# KV2

## industrial detonation chambers



Vertical detonation chamber KV2



Control panel of the detonation chambers

Industrial detonation chambers are automated machinery designed to withstand repeated detonations with equivalent of 2 - 16 kg TNT and applied in various programs, such as:

- Scientific detonation experiments
- Quality control tests in explosives or ammunition manufacture
- Explosive working of metals (hardening, cladding, welding, cutting, pressing)
- Environmentally friendly disposal of explosive wastes
- Forensic investigation and safe disposal of improvised explosive devices

During more than 40 years of service, these industrial detonation chambers have proven to have a long service life (> 100,000 detonations) and reliable, safe and simple operation with low investment and operating costs. The industrial detonation chambers are manufactured in two design lines – vertical and horizontal – both equipped with hydraulic systems, control panels for fully automatic remote operations and, where required, with appropriate pollution abatement systems for off-gases. Electrical and optical measuring equipment for investigation of the explosion processes can be installed in the multiple ports at the chamber body.

### VERTICAL DETONATION CHAMBERS

- For 2 kg TNT
- Open and close with back-folded cupola
- Suitable for compact charges
- Equipped with anti-fragment shields

### HORIZONTAL DETONATION CHAMBERS

- For 8 – 16 kg TNT
- Open and close by a cover moving on rails
- Suitable for elongated charges.
- Best for explosive metalworking operations

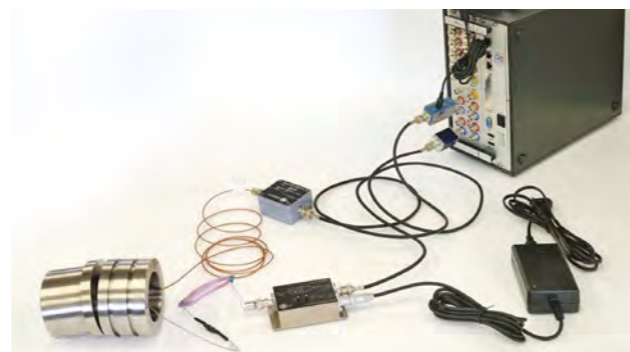


Horizontal detonation chamber KVG16

# PREWAQ

pressure wave analyzer and quantifier

- One unique system for measurement of various explosion parameters.
- Portable and simple-to-use design fulfilling specific customer's requirements.
- Measurement of explosion parameters for both detonation and deflagration.



Instrumentation for pressure and heat flux measurement in detonation chamber

## APPLICATION

The measuring system PREWAQ™ offers measurement of pressure wave parameters generated by any kind of explosion. This universal tool could be applied not only in the open field but could be also designed for measurement in closed spaces (e.g. explosion chamber).

The DT version of the system is used for measurement of extremely fast explosions driven by detonation mechanism and parameters change in order up to tens of nanoseconds for pressure and microseconds in case of temperature.

The DF version is intended for measurement of explosions driven by deflagration mechanism so the change of parameters happen in order of microseconds.

According to required measurements (type, speed and maximum measured values) the PREWAQ™ is equipped with the set of sensors together with appropriate cables and stands or holders.

## FEATURES

- Standard measurement on either 4 or 8 input channels according to user needs.
- Simultaneous measurement of pressure, temperature (heat radiation), velocity of detonation and/or light.
- System is intended for measurement, storage and evaluation of explosion parameters.
- Standard measurement rate is since 3 Msps per channel up to 25 Msps per channel.
- Graphical output of measured data in formats suitable for spreadsheet and database editors is a standard.
- User-friendly software for apparatus operation, data recording and evaluation.

# UWB

underwater pressure wave measurement system

## APPLICATION

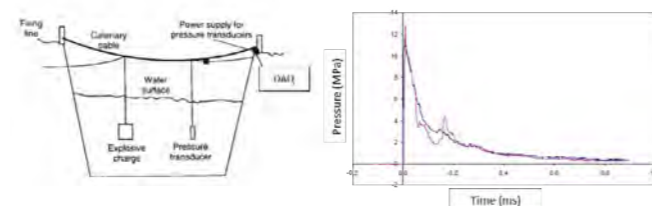
The UWB™ measurement system offers determination of pressure wave parameters generated by underwater explosions. The instrument is specifically designed for representative determination of working ability of industrial explosives with larger critical diameters, for which the classic Trauzl and ballistic mortar tests are not applicable. Compared to these classic tests, the underwater explosion test gives more reliable results and allows the user to calculate value of the explosive energy released.

System consists of three parts:

- 1) Water resistant pressure sensor and leading cables
- 2) Signal conditioning and data acquisition unit
- 3) Unit and software for data evaluation

## DESCRIPTION

Charge of tested explosive and one or two specially designed pressure sensors are placed underwater in specific distance and depth. Signal from pressure sensors is processed by means of precise high speed data acquisition system after explosion. Explosion parameters are evaluated from recorded p(t) dependence. The measurement system is calibrated by detonation of standard explosives with known parameters as TNT, PETN etc.



Scheme of testing site and example of results

## FEATURES

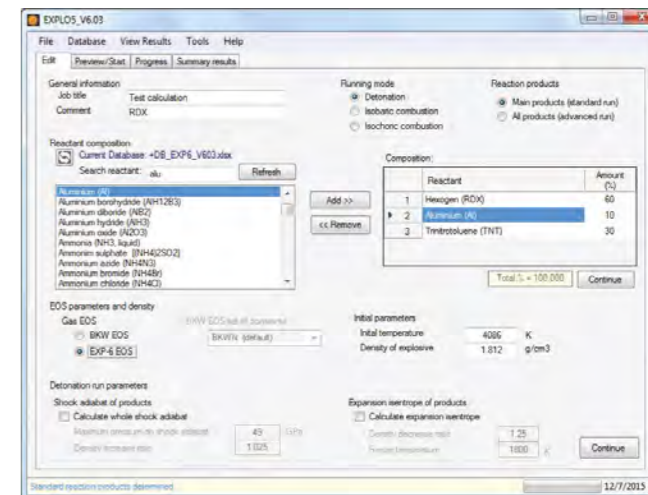
- Precise measurement and evaluation of the important explosion parameters
- Durable, simple and user friendly equipment for field measurement
- User-friendly software for system operation, data recording and evaluation
- Graphical output of measured data in formats suitable for spreadsheet and database editors
- Low operating expenses

# EXPLO5

software for calculation of detonation parameters



Current version: 6.03 THE EXPLO5™



Operation of EXPLO5™ is simple and run starts with only one edit window. The easy and intuitive program operation can be viewed via screenshots of the EXPLO5™'s Edit and the Preview/Start windows on the right picture.

## SOFTWARE IS DEVELOPED BY DR. MUHAMED SUCESKA

EXPLO5™ is thermochemical computer program that predicts the performance of ideal high explosives, propellants, and pyrotechnic mixtures on the basis of chemical formula, heat of formation, and density. As such, EXPLO5™ is a useful tool in synthesis, formulation, and numerical modelling of energetic materials.

EXPLO5™ calculates equilibrium composition and thermodynamic properties of state of products species at a specified temperature and pressure applying the free energy minimization techniques. These data, together with the Chapman-Jouguet detonation theory, enable calculation of detonation parameters such as *detonation velocity*, *detonation pressure*, *detonation energy*, etc.

From the equilibrium composition and thermodynamic parameters of state along the isentropic expansion the program calculates the coefficients in Jones-Wilkins-Lee (JWL) equation of state by a JWL fitting program built in, and energy available for performing mechanical work. By combining thermodynamic properties of the products and conservation equations under constant pressure combustion conditions, the program **predicts theoretical rocket performance (specific impulse, thrust coefficient, flow velocity, etc.)**, as well as the specific energy (or force, impetus) under constant volume combustion conditions.

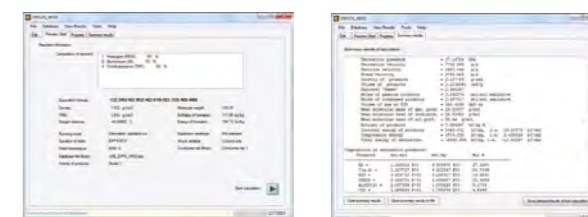
The program uses the Becker-Kistiakowsky-Wilson (BKW), modified Becker-Kistiakowsky-Wilson, and EXP-6 equations of state for gaseous detonation products, the ideal gas and virial equations of state of gaseous combustion products, and the Murnaghan equation of states for condensed products.

The current version of EXPLO5™ program (Version V6.03) has significant improvements over the previous (V6.02). **The most important improvement in the V6.03 version is incorporation of new equations state: Exp-6 EOS, based on the statistical mechanical theories and Exp-6 potential (instead of JCZ3 EOS), and so-called Modified BKW EOS.** Thanks to these, the accuracy of prediction of detonation parameters has been considerable improved.

The important characteristic of the program is possibility to treat a larger number of chemical elements that constitute reactants. The Database includes 35 elements: C, H, N, O, Al, Cl, Si, F, B, Ba, Ca, Na, P, Li, K, S, Mg, Mn, Zr, Mo, Cu, Fe, Ni, Pb, Sb, Hg, Be, Ti, I, Xe, U, W, Sr, Cr, and Br. This makes EXPLO5™ **capable of predicting detonation and combustion performance of wide variety of high explosives, propellants, and pyrotechnic formulations.**

EXPLO5™'s Database is updated with new reactants and products – it contains now around 350 reactants, more than 600 products (including different phases of the same product). The Database access can be customized for multiple users on one computer, and can be easily manipulated (add/remove/modified reactants and products).

## PRODUCT DATA



The progress of calculation can be followed from the Progress window

The most important calculation results are displayed in the Summary results window. A user can save detail calculation results in MS Excel file format (detonation run) or in Plain Text format (combustion runs).

# EDA

electro-explosive devices analyzer



Example of customized Electro-explosive Device Analyzer (EDA™)

The EDA™ (Electro-Explosive Devices Analyzer) is a measuring and control unit used for the ignition and measurement of the pressure profile of a burning sample of energetic materials-usually in a closed vessel. The EDA™ allows for the precise adjustment of ignition current level and time. Maximum pressure, burning time, ignition delay time, current and voltage level, pressure gradient, pressure rise time and/or the burning rate may be recorded and evaluated.

## APPLICATION

The EDA™ is the perfect device for quality control, safety testing, research and development of energetic materials. The EDA™ is commonly found in the testing of electric initiators like squibs, fuses, etc. The determination of ballistic properties of small-caliber gun powders can also be conducted. The explosive and automotive industry, research and development and quality control laboratories around the world rely on the EDA™ for its precision and reliability.

## ADVANTAGES & FEATURES

- Precise adjustment and recording of current pulse parameters
- Recording and evaluation of pressure/time dependence
- Simple operation and evaluation of results

# TPT SERIES

time-pressure test apparatus/test for oxidizing liquids



The TPT Series™ (Testing Pressure Vessel Series) is used for the classification of hazardous and dangerous substances (flammable and energetic materials) as required by UN testing standards by the means of the measurement of the pressure rise time inside a defined vessel.

## ADVANTAGES & FEATURES

- Universal testing pressure vessel provided with a set of adapters for varying standardized testing procedures
- Vessel constructed for general testing of different materials (surface coated by DLC- diamond like carbon)
- Customized testing vessels for specialized purposes are available on request
- Precise and robust measurement of pressure/time rise
- Simple operation and evaluation of results – software for control, measurement, calibration and results evaluation
- Bursting membrane for the safe testing of unknown samples
- Two modes if ignition (electric igniter or by hot wire by controlled impulse of current)

## APPLICATION

Identifying the pressure rise time is not the only function of the TPT series™; it can also be useful for the characterization and general testing of unknown energetic materials. The sample is properly situated and then it is heated or ignited in a closed pressure vessel via a hot wire or a fuse head while the pressure-time profile is being recorded. The burning rate, maximum pressure, pressure rise time, etc. are recorded by the TPT. Obtained results serve for hazard classification of energetic materials, pyrotechnic substances, oxidizing solids and liquids.

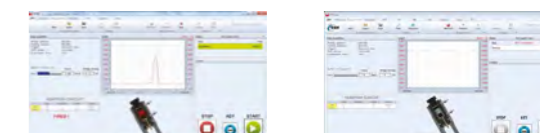
## COMPLIANCE

- UN Recommendation on the Transport of Dangerous Goods, Manual of Tests and Criteria, 2010 - Test 1(c)(i), Test 2(c)(i), Test C.1: Time/pressure Test, or Test O.2: Test for Oxidizing Liquids
- European Commission Directive 2004/73/EC - the Classification, Packing and Labeling of Dangerous Substances, Method A.21: Oxidizing properties (Liquids)
- UN Recommendation on the Transport of Dangerous Goods - HSL Flash Composition Test
- Power source for UN Recommendation on the Transport of Dangerous Goods -Test O.1: Test for Oxidizing Solids

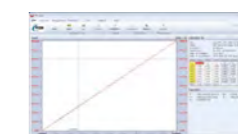
## SW + ACCESSORIES



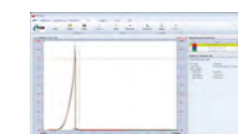
TPT vessel parts



Measurement module serves for measurement and record of pressure rise and to control MCU unit



Calibration module serves for calibration of a pressure transducer connected together with the MCU



Using TPT module - to create the test protocol

# NV SERIES

closed vessels



The Closed Vessels NV Series™ (Small Scale Manometric Bombs) is used for measuring, with constant volume conditions, the pressure profile of a burning sample not only powders and compact energetic materials but also igniters and electrical squibs-in a small closed vessel.

## APPLICATION

The typical internal volume range of the NV Series™ is 3, 5, 10 or 20 ccm with maximum pressure of up to 5000 bars. Maximum pressure, burning time, ignition delay time, pressure gradient, pressure rise time, or burning rate may be acquired from the test records.

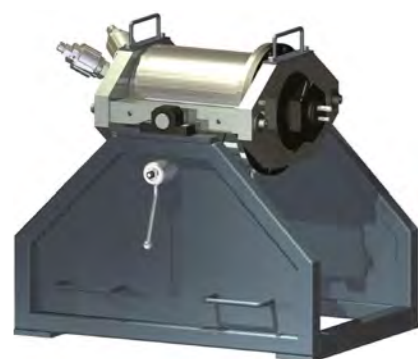
The Closed Vessels NV series™ is designed for quality control, safety testing, research and development of energetic materials including primary explosives, propellants and pyrotechnic substances. The Closed Vessels NV Series™'s typical application is found in the testing of electric initiators like squibs, fuses, etc., as well as the determination of ballistic properties of small-caliber gun powders. The Closed Vessels NV series™ is so versatile it is found in all manner of explosive and automotive, research and development and quality control laboratories.

## ADVANTAGES & FEATURES

- High-pressure vessel up to 5000 bars
- Standard volumes 3, 5, 10 and 20 ccm
- Electrical ignition
- EDA™ – Electro-Explosive Device Analyzer – control unit with adjustable pulse current supply and speed measurement
- Simple operation and evaluation of results – control and evaluation software
- Customization is typical
- A simpler and less expensive alternative for the determination of the ballistic properties of small-caliber gun powders

# RB SERIES

closed vessels



The Closed Vessels RB Series™ (Manometric bombs) is used for the measurement of the ballistic parameters of gun propellant in a closed vessel-up to 700 ccm volume.

## APPLICATION

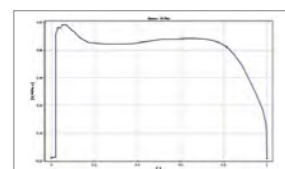
The Closed Vessel RB series™ is used for the measurement of the pressure increase curve during the burning process of various gun propellant types in a constant volume. The behavior of the propellant is predicted (e.g. max pressure, vivacity, pressure gradient, covolume, burning rate, etc). The Closed Vessels RB Series™ is designed for research and development, quality control, and safety testing of all kinds of gun propellants. Due to the maximized efficiency of the Closed Vessel RB series™ during testing the actual number of shots from a real weapon can be minimized-saving both lab time and money and limiting safety hazards.

## ADVANTAGES & FEATURES

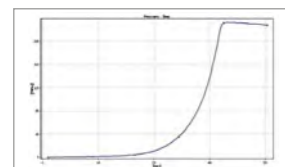
- High-pressure vessel up to 5000 bars
- Standard volumes 40, 80, 200, 400 and 700 ccm
- Two outlet valves, cooling jacket, temperature conditioning unit, temperature sensor and positioning stand
- Two modes of ignition-electrical or mechanical
- Precise and high-speed measurement of pressure/time rise
- Simple operation and evaluation of results
- Electrical or mechanical ignition
- Precise and high-speed measurement of pressure/time rise
- Simple operation and evaluation of results

## COMPLIANCE

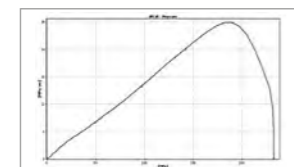
- MIL-STD-286
- STANAG 4115



Vivacity -  $p/p_{max}$  plots calculated from experimental data



Pressure - time  $p(t)$  plots measured



Pressure gradient  $dp/dt$  - pressure  $p$  plots calculated from experimental data

# CRUSHERS

ballistic measurement accessories

NEW!



The CPG (Crusher Pressure Gauges) are designed for the measurement the maximum pressure in a ballistic bomb, in the ballistic test barrels or in different closed vessels.

## APPLICATION

Crusher type pressure gauges are used to determine the maximum pressure in a ballistic bomb or in the ballistic test barrels. Preferably such tools can be used for measuring the maximum pressure in vessels when it is not completely known resultant pressure value and it may cause damage to the pressure sensor.

Copper crushers are in cylinder geometry in various dimensions. Threaded pressure gauges or insert pressure gauges are produced with different diameters of the pistons and several types of volumes of insert pressure gauges. The resulting pressure value is determined by measuring of the height of the compressed copper crusher, and comparing with the value of the static deformation calibration press.

## ADVANTAGES & FEATURES

- Measurement of pressure from 20 to 4.500 bars or more
- Standard volumes 4, 16, 35, 38 and 44 ccm of insert pressure gauges
- Standard diameter and height of cooper cylinders 3x4.9, 4x6.5, 4x8, 5x7, 5x8.1, 6x9.8 and 8x13 mm
- User-friendly
- Universal range of application
- Long service life
- Possibility of modification according to customer requirements

# PRESSING TOOLS



Pressing tools

## PRESSING TOOLS

Several sensitivity or performance tests (gap tests, brisance tests, detonation velocity, etc) require the use of samples of high explosives or pyrotechnics in a form of pressed pellets. OZM Research offers a wide range of pressing tools for preparation of the charges, ranging from 5 mm to 100 mm charge diameter and creating pellets with flat surfaces, detonator entries, central holes or conical shapes.

We can also provide a complete pressing station equipped with remote control hydraulic press and installed within an explosion-proof bunker. Design of the pressing tools and complete station originates from long-term experience with these manufacturing tools in the explosives and ammunition industry.

# STOJAN VESSEL SV-2

propellants burning rate apparatus

The SV-2™ (Stojan Vessel) is used for the effective measuring of the pressure dependencies of the burning rate of solid rocket propellants. The SV-2™ test is a single shot experiment saving lab time and material expense. A single shot is sufficient for plotting burning rates in the whole pressure range. Samples are similar to that of a Subscale Rocket Motor. The SV-2™ is also adept at the testing of propellants at constant volume conditions of up to 50 MPa. The SV-2™ is a simple-to-use instrument capable of fully replacing the old complicated Strand Burner equipment.

### APPLICATION

The SV-2™ is used for research and development and the production control of solid rocket propellants. Typically, the influence of components (catalysts, energetic additives etc.), homogeneity, initial temperature, etc. can be observed in the burning rate profile. The determination of the burning rate of solid rocket propellants is usually carried out in a Strand Burner or in a sub-scale rocket motor at constant pressures. With a Strand Burner, about 10 individual shots are necessary to get the required burning rate plot in the whole pressure range while using very complicated and expensive instrumentation. In the SV-2™ the sample is burnt in a constant-volume vessel while the pressure profile is measured. An advanced mathematical procedure based on the most modern computational and ballistic procedures is then applied to calculate the pressure dependency on the burning rate from the single shot experimental data. Such mathematical procedures have proved to be in a correlation with experimental results of multiple-shot measurements using the Strand Burner (Crawford Bomb) or a sub-scale rocket motor (as TRM35™). OZM Research® can readily supply all equipment and procedures for sample preparation and conditioning for both the SV-2™ and the TRM35™ instruments (hydraulic press, pressing tools, molds for casting, cutting machines, cutting tools, temperature and climatic chambers, etc).

### ADVANTAGES & FEATURES

- Quick assessment of burning rate of new or modified rocket propellant formulations for testing, research and development
- Laboratory sub-scale rocket motor available for validation of measurement

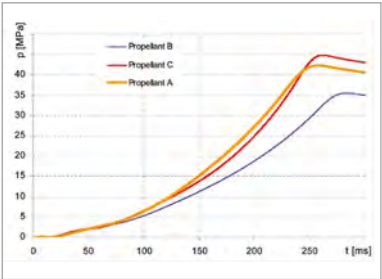
### PRODUCT DATA



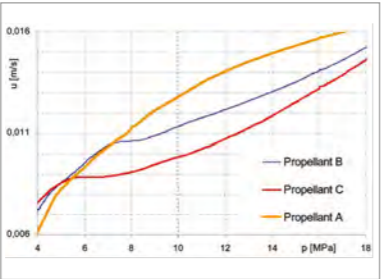
Detail of Stojan Vessel



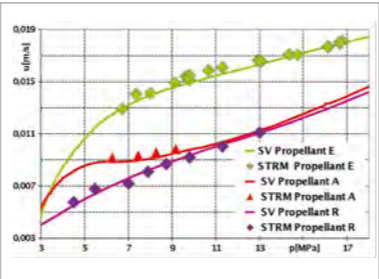
SV-2™ on movable stand



Pressure  $p$  - time  $t$  dependencies measured using STOJAN VESSEL



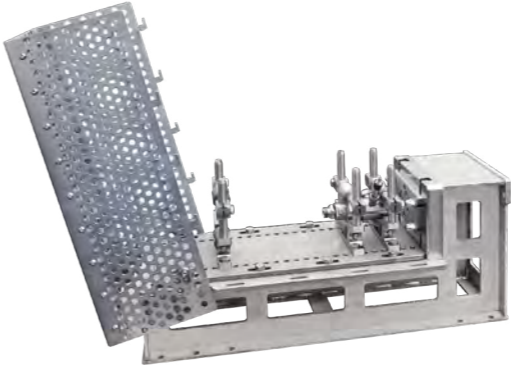
Burning rate  $u$  [m/s] - pressure  $p$  [MPa] dependencies calculated from experimental data measured using STOJAN VESSEL



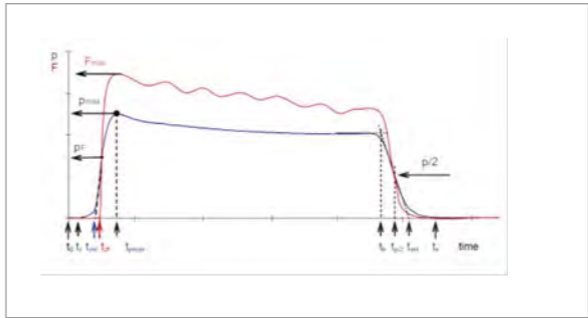
Comparison of burning rate/pressure curve obtaining by STOJAN VESSEL (line) and by Small Testing Rocket Motor (points)

# RMM

apparatus for rocket motor ballistic measurement



Rocket motor on stand



Measured pressure and thrust evaluation

The RMM™ (Rocket Motor Ballistic Measurement) is designed for the measurement of thrust and pressure profiles of solid propellant rocket motors (mounted on stand) during static testing.

### APPLICATION

The RMM™ is ideal for the research and development of new propellants, rocket motors and pyro-cartridges. The RMM™ is also an excellent tool for the verification of results obtained by both the Strand Burner test and/or the STOJAN VESSEL test. Ever adaptable the RMM™ is also employed for quality control and the assessment of rocket motors' service lives.. RMM™ can be also used for measurement of different types of closed vessels, pyro-cartridges for aircraft ejection systems, etc.

### ADVANTAGES & FEATURES

- Robust pressure and thrust measurement with time
  - Pressure up to 100 MPa Thrust up to 1000 kN
- Electrical ignition unit – safety switch, ignition current pulse
- Simple operation and evaluation of results
  - measurement and evaluation software
- Tailored modifications upon client's request (adapters, evaluation, data sheet, etc)

# TRM35

apparatus for subscale rocket motor measurement

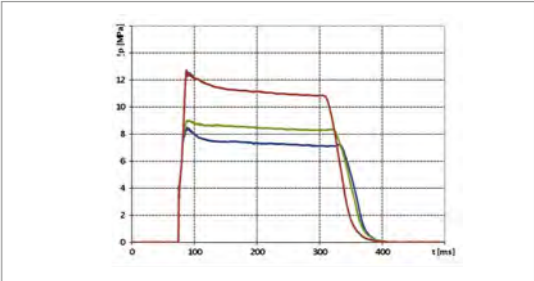
The TRM35™ (TESTING SUB-SCALE ROCKET MOTOR) is designed for the measurement of the burning parameters of solid rocket propellants in a small scale rocket motor. During static testing the, TRM35™ measures and evaluates the pressure and thrust profiles of solid propellant in small testing rocket motors. The TRM35™'s design and results are close to a real rocket motor. The TRM35™'s operation is simple and is capable of meeting a wide range of testing conditions.

### APPLICATION

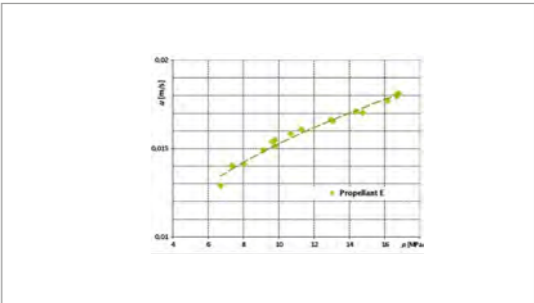
The TRM35™, and sub-scale rocket motors in general, are a relatively new approved procedure in NATO STANAG standards. More individual shots are necessary to get the required parameters (e.g. burning rate, erosion influence, etc.) in the whole pressure range. The Subscale Rocket Motor is recommended as more universal supporting method. Measurement and evaluation by RMM™ is generally supplemented.

### ADVANTAGES & FEATURES

- Wider assessment of ballistic behavior of new or modified rocket propellant formulations
- Pressure and thrust measurement with time
- Customizable according to client's needs
- The results mimic that of a real rocket motortesting



Example of pressure/time curves measured in Small Testing Rocket Motor



Burning rate/pressure dependence evaluated from Small Testing Rocket Motor measurement

# SAFETY ENGINEERING

testing explosibility of industrial explosive atmospheres



## MIE-D1.2

min ignition energy of dust dispersion apparatus



The Minimum Ignition Energy (MIE) of a combustible substance is the lowest value of the electrical energy stored in a capacitor which upon discharge is just sufficient to ignite a fuel/air mixture at atmospheric pressure and room temperature. The MIE of dust dispersions is one of the key parameters for an assessment of the hazard situation in plants with dust appearance establishing the extent and, hence, the cost of protective measures.

### APPLICATION

The MIE-D 1.2™ (Minimum Ignition Energy Tester) is used for the measurement of the minimum amount of energy required in a normal atmosphere - within a specified dust dispersion of a substance which will result in an ignition. The MIE-D 1.2™ is an essential part of a standard set of tests used for the assessment of potential industrial plant hazards and by certifying bodies, universities and other research organizations to characterize the hazards of dusts.

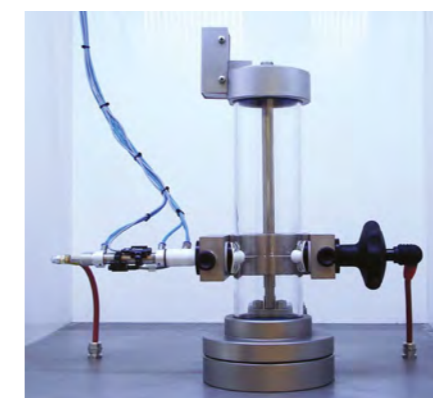
### ADVANTAGES & FEATURES

- Spark energy range of from 1 mJ up to 3 J
- MIE-D 1.2™ is able to be equipped for the measurement of the real spark energy
- Three modes of spark triggering (high-voltage switch and a moving electrode, by dust cloud itself)
- Pneumatically operated and automatically controlled
- Durable stainless steel case

### COMPLIANCE

- Minimum ignition energy of dust dispersions according to EN 13821

### PRODUCT DETAILS



# CA20L & CA1M3

explosion chambers for gas and dusts



Explosion Chamber 20 L™



CA 1M3™ Explosion Chamber

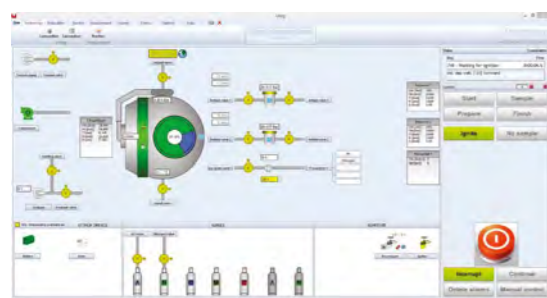
Explosion chambers are used for the measurement of the basic explosion characteristic of flammable dusts, gases and vapors. The characteristics measured are the maximum explosion pressure, the maximum rate of pressure rise, the lower and upper explosibility limits and limiting oxygen concentrations.

## APPLICATION

Two sizes of explosion chambers are mandated by international standards for dust explosion testing– 1 m<sup>3</sup> (our CA1M3™) and 20 l (our CA20L™). For gas and vapor samples which require a volume larger than 5 l the CA20L™ is recommended.

Testing methods using the CA1M3™ and the CA20L™ are an essential part of a standard set of tests used by certified bodies, Universities and other research organizations to characterize dust, gas and vapors. Design of mitigating and protective measures such as explosion venting devices, automatic suppression or partial inerting, without knowledge of these explosion parameters is unimaginable.

## PRODUCT DETAILS



CA1M3™ software

## ADVANTAGES & FEATURES

- Fully automated and remote-controlled machinery
- Robust design with 30 barg of operating and 40 barg of testing pressures
- Both the CA1M3™ and the CA20L™ may be equipped with heating for measurements under elevated temperatures up to 200 °C

## COMPLIANCE

- EN 14034 (1-4) sets up 1 m<sup>3</sup> explosion chamber (our CA1M3™) as a standard instrument for measurement of maximum pressure, rate of pressure rise, lower explosion limit (LEL) and limiting oxygen concentration (LOC) of dust dispersions. 20 l sphere (our CA20L™) is an alternative of 1 m<sup>3</sup> explosion chamber given by EN 14034 (1-4)
- Both CA1M3™ and CA20L™ could be delivered with instrumentation for measurement of explosion parameters of gases and vapors according to EN 15967 (maximum pressure and rate of pressure rise), according to EN 14756 (LOC) and EN 1839 (explosion limits)



CA1M3™ software

# AIT551

autoignition temperature of liquids apparatus

Autoignition temperature is the lowest temperature at atmospheric pressure at which a substance will burst into flame in the absence of an external source of ignition (spark or flame). The AIT (Auto-Ignition Temperature Tester) is used for the determination of the auto-ignition temperature of both liquid and solid chemicals through means of visual observation and sample temperature measurement.

## APPLICATION

The measurement of the autoignition temperature of substances is essential for industry and technologies employing any high temperature operations. Liquid materials after exposure to temperatures may cause flammable vapors which in turn may lead to an explosion. The AIT is ideal for emerging technologies, operational safety control, research and development among many other applications. The results obtained are used for the classification of temperature class.

## ADVANTAGES & FEATURES

- Dynamic mounting thermocouples allow for the use of several different types of banks
- Automatic detection of ignition of the sample in the flask
- Specially designed oven door for easy handling of the flask
- Software evaluation of temperature records
- Corrosion resistant stainless steel case



## COMPLIANCE

- ASTM E659 – 78: Standard Test Method for Autoignition Temperature of Liquid Chemicals
- EN 14522: Determination of the auto ignition temperature of gases and vapours
- EN 15188: Determination of the spontaneous ignition behaviour of dust accumulations
- NF T 20-036: Chemical products for industrial use. Determination of the relative temperature of the spontaneous flammability of solids. ASTM E659 – 78: Standard Test Method For Autoignition Temperature of Liquid Chemicals

# RSIT

relative self-ignition temperature of solids apparatus

When a solid spontaneously ignites at elevated temperatures this phenomenon is called self-ignition.

The RSIT™ (Relative Self-Ignition Temperature for Solids) device is used to measure a solids self-ignition temperature. The RSIT™ is preliminary used for screening tests for the lowest possible ambient temperature at which a substance will spontaneously combust.



## APPLICATION

The self-ignition temperature of a substance is a very important parameter for safety in handling, storing and transporting solid materials. This parameter is used to set the proper security conditions not just for chemical materials but other substances as well. The results of the measurements are used as data for comparison with other methods of detecting the parameters of flammable substances.

## COMPLIANCE

- Regulation (ec) no 1272/2008 of the European Parliament and of the Council on classification, labeling and packaging of substance and mixtures, amending a repealing (CLP)
- NF T 20-036 (September 85). Chemical products for industrial use. Determination of the relative temperature of the spontaneous flammability of solids

## ADVANTAGES & FEATURES

- A simple sample application and preparation of measurement using an external stand
- The possibility of forced ventilation up to 8.5LPM
- Testing container constructed from resistant steels for reuse
- Safety features (pressurized dampers, locking system) ensure a high level of safety operation
- Software evaluation of temperature records
- Resistant stainless steel case

# SHT150

self heating substance apparatus

The SHT150™ is a vital instrument used for the determination of a substance's self-heating due to self oxidative heating and then decompose.

The SHT150™ operates on the determination of the exothermal decomposition of sample being directly exposed to hot air at elevated temperatures.



## APPLICATION

Spontaneous combustions and the destructive fires resulting from them have plagued all manner of industries from hotels, to construction and painting, to manufacturing and transportation and so on.

The outcomes the SHT150™ provides are used for the flammability classification of solid substances and/or mixtures. This classification is necessary for carriage by rail or other such transport of energetic materials throughout the EU, the USA and the UN.

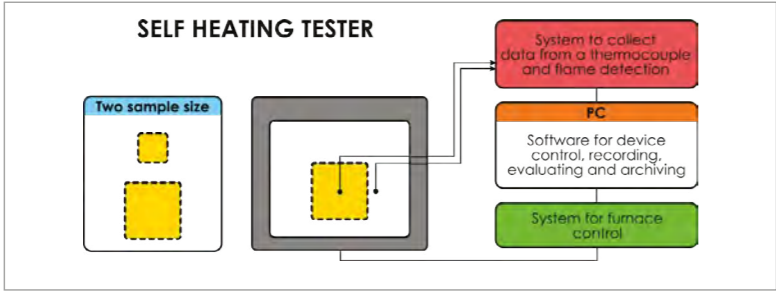
## ADVANTAGES & FEATURES

- Testing container made of resistant steels for reuse
- Stand for mounting the thermocouple in a defined position in the container
- A sight glass in the oven allows for optical control
- Software evaluation of temperature records
- Resistant stainless steel case

## COMPLIANCE

- Regulation (ec) no 1272/2008 of the European Parliament and of the Council on classification, labeling and packaging of substances and mixtures, amending and repealing (CPL)
- UN Recommendation on the Transport of Dangerous Goods, Manual of Tests and Criteria, United Nations, New York, 2010, chapter 32.5.2 Test L.2 European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) (2013)
- European agreement concerning the international carriage of dangerous goods by inland waterways (ADN) (2013)
- Convention concerning International Carriage by Rail (COTIF) Regulations concerning the International Carriage of Dangerous Goods by Rail (RID) (2013)

## PRODUCT DETAILS



A schematic arrangement of the tester in accordance with UN Recommendation

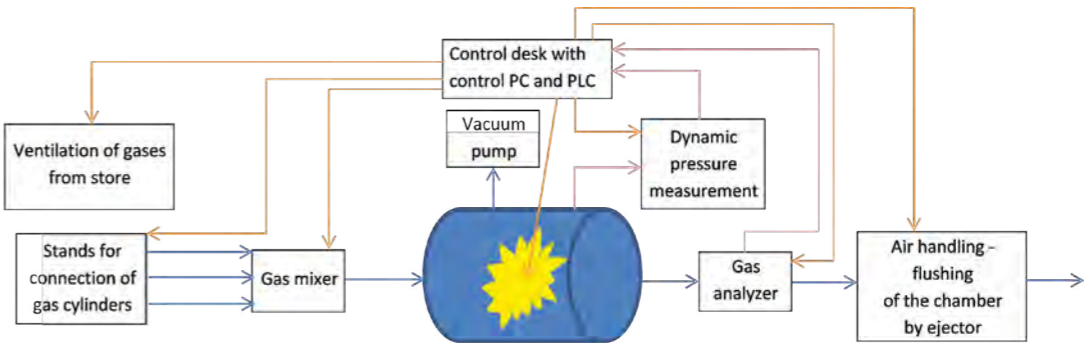
# ATEX CHAMBERS



## APPLICATION

Ensuring the usage of certified compliant electrical equipment is vital for health and safety officers; operation directors; and any other decision makers in quality and safety control who play a role in inspecting or maintaining electrical installations in an explosive atmosphere.

A schematic representation of the offered technology; the blue arrows indicate the direction of the gas flow; the purple arrows indicate the collection of data from the measuring device to the control PLC and PC; the orange arrows show the direction of control commands.



A schematic arrangement of the system is shown in the picture above

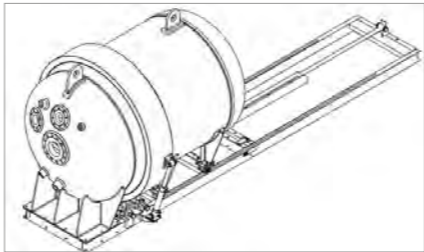
## ADVANTAGES & FEATURES

- Robust design of chamber with testing pressure of up to 70 barg
- Fully automated system equipped with the Swagelok instrumentation
- Sizes of the chamber can be customized according to client's requirements
- Automatic generation of explosive atmosphere without loss of material through the PLC control

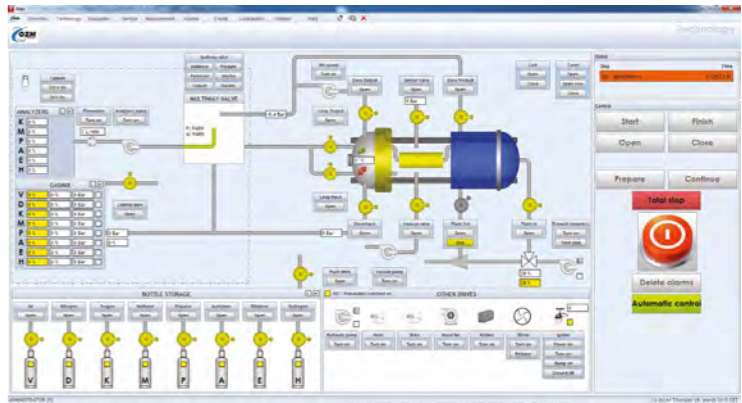
## COMPLIANCE

- EN 60079-1. Technology enables testing of electrical device, which are intended for use in explosive gas atmospheres according to EN 60079-1 Electrical Apparatus for Explosive Gas Atmospheres - Part 1: Flameproof enclosure "d"

## PRODUCT DETAILS



Print Screen of SW



# GASmix™

precise concentrations of gas mixtures apparatus

The GASmix™ apparatus is an universal tool for both laboratory and industrial purposes. The GASmix™ prepares gas mixtures of precise concentrations for the purpose of testing. It is an essential instrument for technologies or tests which require diluting or mixing different gas mixtures with a specific desired flow, pressure and temperature.

## APPLICATION

The GASmix™ apparatus is an universal tool for both laboratory and industrial purposes. The GASmix™ prepares gas mixtures of precise concentrations for the purpose of testing. It is an essential instrument for technologies or tests which require diluting or mixing different gas mixtures with a specific desired flow, pressure and temperature.

## ADVANTAGES & FEATURES

- Customized design for a wide range of industrial and laboratory applications including portable instruments
- Easy automatic and remote adjustment and control of parameters of the output gas mixture using the PLC software and touch panel for fast settings of desired parameters (within 2 s)
- High precision of parameters for the output gas mixture (concentration 0,5%; gas flow 1%, pressure 0,25%, temperature 0,2%, repeatability 0,5%) independent of the pressure of input gases
- Wide range of gas flow from 10<sup>-3</sup>L/min to 10<sup>3</sup>L/min
- Unlimited number of inputs gases and output positions
- Distribution of gas mixtures of different concentrations to different areas
- High quality materials of components made only from special stainless steel
- PTFE allows for the preparation of different gases mixtures including the combustible (H<sub>2</sub>, O<sub>2</sub>, C<sub>2</sub>H<sub>2</sub>) and the toxically and corrosive (Cl<sub>2</sub>, NH<sub>3</sub>)
- Automatic detection of gas leaks for improved safety
- Fluent adjustment of concentrations (changes of concentration)
- Possible synchronization of GASmix™ with client's existing technology and instruments

## PRODUCT DETAILS



Gas	Bottle	Path Pressure [Bar]	Path Min [Bar]	Remaining [lrs]	Required Flow Rate [lrs/min]	Current Flow Rate [lrs/min]
Air	0.0	1.0				
Nitrogen	2.9	1.0	57	100.0	50 %	100.7 50 %
Oxygen	0.0	1.0				
Methane	0.0	1.0				
Propane	0.0	1.0				
Acetylene	0.0	1.0				
Ethylene	0.0	1.0				
Hydrogen	0.0	1.0				

Running... STOP

Print Screen of SW



# SCT-100

sustained combustibility apparatus



The measurement of ignition temperature is essential for industrial plants or technologies dealing with fuels, oils, and other combustible liquids. The SCT-100™ (Sustained Combustibility Tester) determines the ability of a substance to sustain combustion after ignition by flame.

## APPLICATION

In the SCT-100™ a metal block with a concave depression (sample well) is heated to a specified temperature. A specified volume of the substance is transferred to the well and an ignition attempt is conducted. The SCT-100™ can test paints (including water-borne paints), varnishes, paint binders, solvents, petroleum or related products and adhesives. However it is not applicable to assessing the potential fire hazards of dried painted surfaces.

## ADVANTAGES & FEATURES

- Measuring the flammability of liquids ranges from 25-75 °C
- Remote control ignition flame and burner shift
- Safety ignition of the burner flame
- Resistant stainless steel surface

## COMPLIANCE

- UN Recommendation on the Transport of Dangerous Goods, Manual of Tests and Criteria, United Nations, New York, 2009, chapter 32.5.2 Test L.2

# MIT1000

minimum ignition temperature tester

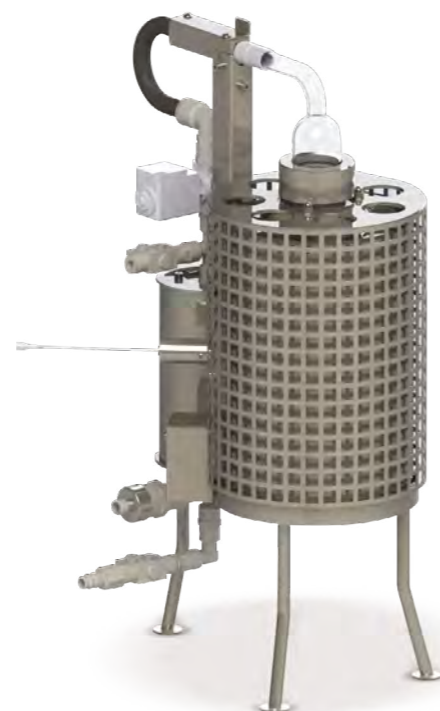
The MIT 1000™ (Minimum Ignition Temperature Tester) is used for the determination of the minimum temperature of a hot surface which leads to the degradation or the ignition of suspended dust particles.

## APPLICATION

Knowing the minimum temperature of a hot surface which will lead to a dust cloud ignition provides invaluable information for the safety and prevention of fires/explosions in industries where unwanted dust production is found. With the aid of the the MIT 1000™—risk analysis can be performed to identify areas of increased surface temperature, assess the risk level of a dust ignition and then finally suggest preventive measures.

## ADVANTAGES & FEATURES

- Dust sample container designed OZM Research®
- After measurement the reservoir remains are less than 5% of the sample
- Dosage air pressure via an automatic electronic system and control software
- Identification of the ignition of dispersed dust is realized using a flexible mirror
- Recording, archiving and measured data analysis on PC
- Resistant stainless steel case

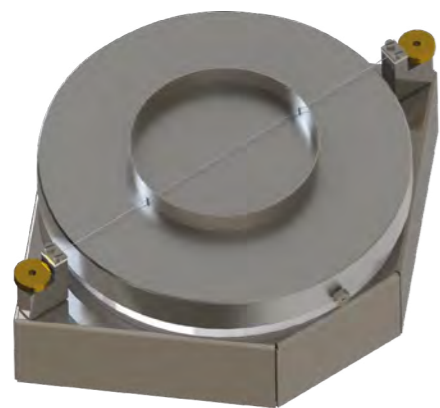


## COMPLIANCE

- EN 50281-2-1 Methods of determining minimum ignition temperature

# LIT400

dust layer ignition temperature tester



The LIT 400™ (Dust Layer Ignition Temperature Tester) is intended for the determination of the minimum temperature of a hot surface leading to the degradation or ignition of dust layers of a defined thickness.

## APPLICATION

Spontaneous dusty layer ignition is a great fear in any industry where unwanted dust particles are accumulated. Knowing the minimum temperature a hot surface must be to ignite a dust layer provides important information for the prevention of fires in process industries. The LIT 400™ detects the thermal resistance of occurring dust to thermal stress. Potentially dangerous areas of possible dust ignition in manufacturing plants (with surface temperature increases) are identified during risk analysis continuing with assessing the level of risk generated by ignition of dust. Preventive measures against the ignition are then able to be identified and taken.

## ADVANTAGES & FEATURES

- Hotplates designed with a non-corrosive abrasion resistant surface
- Ceramic and stainless steel ring as sample holder for a dust layer
- Dosing and cleaning stainless steel set for easy application of the sample
- Recording, archiving and measured data analysis on PC
- Resistant stainless steel case

## COMPLIANCE

- EN 50281-2-1 Methods of determining minimum ignition temperature

# FRTA-I

concentration limits of flammability apparatus



The FRTA—I™ (Instrument for Concentration Limits of Flammability Determination) is designed to determine both the Lower Flammability Limit (LFL) and the Upper Flammability Limit (UFL) of various flammable gases or volatile liquids.

The FRTA—I™ operates on high voltage electrical ignition and visual observations of flame propagation. It disperses flammable liquids in air at atmospheric pressures via vapor pressure.

## APPLICATION

The FRTA—I™ is used to measure and describe the response of properties of materials, products, or assemblies to heat and flame under controlled laboratory conditions. The LFL and UFL of gases and vapors define the range of flammable concentrations in air. The flammability limits rely on the test temperature and pressure. The limits of flammability may be used to determine the guidelines for the safe handling of volatile chemicals and fire risk/hazard assessment—particularly end use.

## ADVANTAGES & FEATURES

- Precise settings of experimental conditions (high voltage, pressure and temperature)
- Recording and display of pressure time curve after ignition for easy evaluation of results
- Safe operation of FRTA equipped by safety glass window and bursting membrane for the evacuation of fragments and pressure wave generated by explosion/implosion of glass testing vessel
- Remotely controlled firing (high voltage spark ignition)
- The maximum operating temperature of FRTA is 150 °C
- Autonomous operation with no PC requirement

## COMPLIANCE

- ASTM E 681 – 01

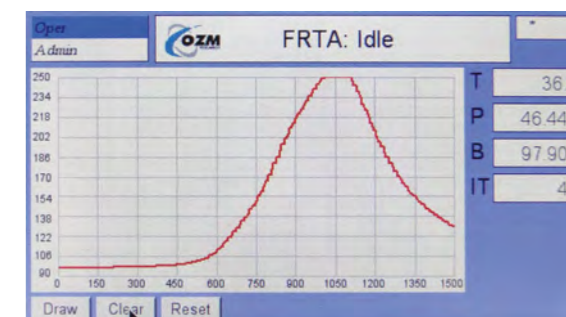
## SW + PRODUCT DETAILS



FRTA-I™ Detail



FRTA-I™ Electrodes



FRTA-I™ Software

# SAFE LABORATORY

for safe storage of explosives from small samples to larger stocks



# PORTABLE CONTAINERS

gas-tight explosion-resistant  
safe laboratory storage of small explosive samples

## ADVANTAGES & FEATURES

- Safe storage of sensitive or unstable samples
- All explosion effects contained inside, no release of shock wave, fragments, flame or toxic gases
- Overpressure safely released through manually opened valves
- Full protection of life and property in case of accidental explosion of stored explosive samples
- Zero safety distances: they can be stored directly inside laboratories
- Portable for transport of the explosive samples outside laboratories
- Interior made of antistatic rubber for eliminating risks of friction or spark discharge
- Quick opening and closing mechanisms
- J-025G and J-500G are certified for international transport of dangerous goods according to ADR/RID treaties



J-120G2

Product Name	J-025G	J-120G2	J-200G	J-500G
Capacity [g TNT]	20	120	200	500
Weight [kg]	7	25	90	400
Outside dimensions L x W x H [mm]	159 x 170 x 455	325 x 325 x 767	600 x 600 x 960	1250x792x852
Internal space L x W x H [mm]	175 x Ø 40	335 x Ø 72	450 x Ø 120	500 x 300 x 300

# STORAGE MODULES

for expanding capacity of storage rooms (10 – 1000 kg TNT eq.)  
containers for safe storage of larger stocks of explosive samples

## ADVANTAGES & FEATURES

- Storage modules protecting against transfer of explosion (sympathetic detonation)
- Safety distances corresponding to the content of one module only (up to 2.5 kg TNT) despite total stored amount in the storage room (up to several tons)
- Minimization of safety distances / maximization of storage capacity of existing storage rooms
- Storage of otherwise incompatible classes of explosive materials in one room (e.g. detonators together with high explosives)
- Modules designed for mounting to sets with variable heights and widths
- Non-sparking and water-tight lids, antistatic rubber seals



Product Name	ISS
Capacity [kg TNT]	2 x 2.5 kg
Weight [kg]	245
Outside dimensions L x W x H [mm]	588 x 400 x 803
Internal dimensions of one tube Ø x L [mm]	300 x 500

# EXPLOSIVES HANDLING TABLE NEW!

### APPLICATION

A working table designed for safer handling with highly sensitive explosive substances and devices such as primary explosives, pyrotechnic mixtures, detonators, primers or fuzes. The reinforced steel working table structure and the front ballistic safety glass are protecting the head, body and legs of the operators against explosion and fragmentation effects of up to 10 g TNT charges. The table also provides the ESD protection necessary for safe handling the sensitive explosive materials.

### ADVANTAGES & FEATURES

- Reinforced steel plates as a shock-wave and fragment-resistant worktop
- Removable fragment-resistant ballistic glass with protective film
- Leg protection by reinforced steel plate
- Adjustable working height
- ESD protected worktop
- Grounding points



# PROTECTIVE TESTING CONTAINER

lightweight stainless steel protective container for safe execution of ballistic tests and disposal of explosive samples by burning



Testing container for intra-laboratory experiments protecting against explosion effects (flame, high temperatures, flying fragments and residues, shock wave, overpressure) up to 10 g TNT eq.

### APPLICATION

Safe execution of ballistic tests (small-scale rocket motors testing, closed vessel tests) with an elevated risk of vessel rupture during the test. Intra-laboratory burning tests of rocket propellants and pyrotechnics. Safe disposal of explosive sample after tests by burning inside laboratories. Temporary storage of unstable or sensitive explosive samples.

### ADVANTAGES & FEATURES

- Free volume of 50 L
- Designed and tested to resist explosions up to 10 g TNT eq.
- Static pressure resistance up to 16 bar
- Explosion-proof sandwich windows
- Equipped with bushings for firing cables, measuring cables, inert gases etc.
- Chimney to be connected to the lab ventilation system

# EXPLOSIVE processing of metals

## Processing of metallic and non-metallic materials using explosives



# EXPLOSIVE processing of metals



Explosive Processing belongs to the realm of experts in energetic materials. In explosive welding such a tremendous amount of force is applied that metals (and in some cases nonmetals) which are typically difficult or even impossible to weld by conventional means are completely joined. With explosive hardening the power of the explosives' shockwave is used to enhance metal structures such as railroad crossing frogs.

## APPLICATION

Explosive processing requires mastery. OZM Research® is focused on developing and manufacturing explosion-clad bimetallic and multilayer metallic materials, explosive hardening and, to a lesser degree, explosive forming-compaction of powder materials and other applications. Intermediate products, structural elements and components are produced in cooperation with the respective client. OZM Research® offers its consultation services for the applicability of explosive processing of metallic and nonmetallic materials.

## MAIN FOCUS OF ACTIVITIES:

- Bimetallic or multilayer sheets
- Semi-products for manufacturing tube plates for heat exchangers
- Workpieces to be rolled down
- Bearing materials and wear resistant materials
- Structural transition joints
- Semi-products for glass molds
- Alignment of the socket pipes and the sheathing of rods or shafts
- Tube to tube-plate explosive welding and fixing
- Labyrinth coolers
- Explosive hardening of manganese-steel construction elements



# SELECTED references

## Albania

- Ministry of Defence

## Algeria

- Ministry of Defence

## Australia

- ORICA

## Austria

- Austin Powder
- Josef Köhler Pyrotechnik
- Schaeffler

## Azerbaijan

- Ministry of Defence

## Belgium

- Royal Military Academy

## Brazil

- IBQ Industrias Quimicas
- Institute of Aeronautics and Space

## Bulgaria

- Arcus Co.

## Canada

- Canadian Explosives Research Laboratory
- General Dynamics
- ORICA
- Public Works and Government Services Canada

## China

- Beijing Institute of Technology
- China Academy of Safety Science and Technology Beijing
- National Registration Center for Chemicals, SAWS (NRCC)
- Shenhua Group Zhungeer Energy Co.
- Xi'an Modern Chemistry Research Institute

## Croatia

- Ministry of Defence
- University of Zagreb

## Czech Republic

- Austin Detonator
- Explosia
- Indet Safety Systems
- Ministry of Defence
- Nuclear Research Institute
- Zeveta Ammunition

## Egypt

- Ministry of Defence

## Finland

- PVTT

## France

- CEA Le Ripault
- CNRS
- French-German Research Institute of Saint-Louis
- Herakles - Groupe Safran
- INERIS
- ONERA - French Aerospace Lab
- OUTREAU TECHNOLOGIES
- STAC

## Georgia

- Express Diagnostic

## Germany

- BWB
- DIEHL
- Dynitec
- Fisher-Scientific
- Fraunhofer-Institut für Chemische Technologie ICT
- Ludwig-Maximilians University of Munich
- Rheinmetall

## Greece

- National Technical University of Athens

## Hungary

- HM Arzenal
- TÜV Rheinland Intercert Kft.

## India

- HEMRL
- TBRL
- VSSC

## Italy

- AVIO Aerospace Propulsion

## Japan

- National Institute of Advanced Industrial Science and Technology (AIST)

## Jordan

- Ministry of Defence

## Kazakhstan

- Ministry of Defence

## Malaysia

- STRIDE Weapons Technology Division

## NATO

- NAMSA

## Netherlands

- TNO Prins Maurits Laboratory

## Peru

- EXSA
- FAMESA

## Poland

- Bumar Amunicja
- Instytut Przemysłu Organicznego
- Military Institute of Armament Technology
- Warsaw University of Technology
- Zakłady Chemiczne "Nitro-Chem"

## Portugal

- Ministério da Defesa Nacional

## Romania

- Military Technical Academy

## Russia

- Altai State Technical University
- Central Scientific Research Institute of Chemistry and Mechanics

## Serbia

- Evaco International
- Ministry of Defence

## Singapore

- Advanced Material Engineering
- Advanced Technology Research Centre
- Nanyang Technological University
- National University of Singapore

## Slovakia

- Konštrukta Defence
- Ministry of Defence
- ZVS Holding

## South Africa

- African Explosives Limited
- Denel Land Systems

## South Korea

- Agency for Defence Development
- Hanwha
- Poongsan

## Spain

- IBATECH Technologia
- Pirotecnia Ricardo Caballer

## Sweden

- Dyno Nobel Sweden
- Fisher Scientific GTF
- FOI
- Nammo LIAB
- Swedish Defence Research Agency

## Switzerland

- Armasuisse

## Taiwan

- Precision International Corp.

## Turkey

- Roketsan Missile Industries
- Tubitak Mam
- Tubitak Sage
- Yavascalar

## UK

- BAE Systems
- BREXCO
- Chemring Energetics UK
- Eley Limited
- University of Cambridge
- University of Warwick

## UN

- International Atomic Energy Agency

## USA

- Air Force Research Laboratory
- Alliant Techsystems Inc.
- ATK
- Fauske & Associates
- Los Alamos National Laboratories
- McAlester Army Ammunition Plant
- University of Southern California
- US Army ARDEC Picatinny Arsenal
- UTC Aerospace Systems

## Vietnam

- Military Technical Academy
- Ministry of Defence
- Institute of Propellant and Explosive
- Chemical Manufacture 21
- Industry Explosive Material Centre

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