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Technology Focus

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Ammunition Systems and Warhead Technologies

From the Desk of Guest Editor

Terminal Ballistics Research Laboratory (TBRL) came into existence in the year 1961 as one of the modern armament research laboratory, with an aim to provide facilities for applied research and technology development in the fields of high explosives, detonics, shock dynamics, blast and damage, immunity, lethality and fragmentation, defeat of armour performance evaluation of warheads, and other armament systems. The laboratory is well equipped with sophisticated instrumentation facilities like high speed photography and flash radiography, warhead arena test facility, fragment launching guns, blast measurement facility, detonics laboratory, etc. Over the years many new facilities like two stage light gas gun, environmental test facilities, shock tube, linear accelerator facility, drop test facility, ballistic test facility, explosive production facilities, etc. were added at different stages to keep pace with the latest developments in the field of armaments. One of the unique facilities which has been created in the laboratory is the Rail Track Rocket Sled, i.e., RTRS facility which is being used extensively by different national scientific programmes of the country for the dynamic test and evaluation of the components, sub-assemblies, and fully assembled systems under captive flight conditions. These test facilities helped in generating the design data of warheads at various stages of their development. TBRL is playing a vital role as a nodal lab for performance evaluation of body armour, vehicle armour, and other protection system against small arm ammunition and explosive blast. The test facilities in TBRL are unique to this laboratory in this country and also the spectrum of test article and test specifications are very wide.

The quest of learning, innovative thinking, and sincere efforts of our scientists led to the development of few important technologies which made the TBRL presence felt at national and international levels. Dynamic shock compression of materials, magnetic flux compression, shaped charges, and explosively formed penetrator and high voltage pulse power, are the few technologies which made India self-reliant in certain requirements for the national security. TBRL scientists demonstrated professional approach to master these technologies into product development which were successfully tested. Over the years, TBRL has developed various products for armament applications which include multi-mode grenade, bund blasting device, exploder for torpedo, multi-EFP based directional warheads, mechatronic fuse, safety and arming mechanism, baffles range, and riot control less lethal bullets. These products have undergone TOT to ordnance factories and private industries.

The laboratory has diversified into few ambitious projects on design and development of electronic fuses, off-route mine system, high power microwave system, directional and tactical warheads for defeat of bunkers, tank armour, naval targets, and many explosive devices for low intensity conflict applications. The laboratory has also initiated a number of collaborations with academia like IITs, NITs, Universities, and other national research laboratories in many futuristic systems like green energetic materials, nanotechnology based armour systems, photonics for detonics, etc. Over the last 55 years TBRL has transformed itself from a humble test and evaluation centre to one of the best equipped R&D laboratory in the field of missile warhead technologies. I am sure, we at TBRL, would be able to meet the challenges of design, development, and testing of warhead systems and ammunitions to meet the requirements of new age warfare.

The indigenous warhead technologies, ammunitions, and test methodologies developed by TBRL have been covered in two issues of Technology Focus. I hope this issue of Technology Focus will be useful in generating awareness about the R&D activities of the laboratory.

Dr. Manjit Singh
DS & Director
TBRL, Chandigarh

AMMUNITION SYSTEMS AND WARHEAD TECHNOLOGIES

Terminal Ballistics Research Laboratory (TBRL), one of the establishment of Defence Research & Development Organisation (DRDO) envisages self-reliance in the development of technologies related to various kinds of warhead systems and provides state-of-the-art diagnostic facilities for assessment of terminal effects of armament systems. The thrust areas of the laboratory in its pursuit for self-reliance in critical technologies have been identified as:

- Development, production, processing, and characterisation of different high explosive compositions
- Applied research on detonics
- Impact, penetration, and characterisation of materials at high strain rates
- Blast evaluation of armament ammunition in free air, underground, and underwater explosions and quantitative evaluation of blast protective systems
- Technology for design and development of shaped charges and explosively formed penetrators for anti-tank, anti-ship, and anti-submarine applications
- Technology for generation of high energy electrical pulse power through explosive driven magnetic flux compression
- Performance evaluation of missile warheads and other ammunitions using instrumented range facilities under static conditions
- Test and evaluation of components and other sub-systems of bombs, missiles, and airborne systems under captive conditions
- Lethality and fragmentation studies for providing design inputs for anti-personal/anti-material and anti-armour warheads
- Ballistics evaluation of various protective systems like body armour, vehicle armour, and helmets against small arms ammunition
- Design of baffle ranges for army and paramilitary forces
- Development of riot control less lethal plastic and frangible bullets for law enforcing agencies
- Design and development of
  - Bund blasting devices
  - Multi-mode hand grenade
  - Exploder system and warhead for advanced experimental torpedo
  - Mechatronic impact-cum-time-delay fuze for grenades
  - Air-breathing multi-tube cycle pulse detonation engine
- Technology for earth penetrator and bunker buster
- Insensitive munitions compliance methodology
- Environment test facility for warheads and electronic system
- Development of photonic sensors and diagnostic techniques for detonics, shock, and blast measurement
- Laser initiation of explosives

AMMUNITION SYSTEMS

Bund Blasting Device

Canal bank and Ditch-Cum-Bunds (DCB) are the typical obstacles for the movement of mechanised forces. To launch equipment, bridges and to enhance the mobility of mechanised infantry in the war-field, it is essential to reduce the height of canal banks and DCBs. TBRL has designed and developed Bund Blasting Device (BBD), based on the principle of hollow charge and a rocket assisted high explosive filled follow through projectile (Bursting charge).

On activation, main bursting charge moves down with the help of a rocket motor and on the way, it activates a specially designed hollow charge initiation device. Hollow charge created a pilot hole in the ground. Main bursting charge enters to the base of the pilot hole, detonates after a preset delay of 3 sec and creates the required breach/crater.

User assisted technical trials of BBD Mk-II was carried out in May 2014 at TBRL Ramgarh Range. After successful user trials, Transfer of Technology (ToT) has been done with private industry for limited series production of BBD device for Services.

Salient Features

- Man portable
- Gross weight 21 kg (single BBD)
- No power back-up is required for operation
- Time taken for deployment is 15-20 min

Bund Blasting Device

An Array of Three BBDs

BMP Passes Through the Breach

Bridge Laid Down on DCB

Bag Harness

FRP Box for Transportation

Multi-mode Hand Grenade

Grenades of natural fragmentation type have been in use by the infantry world over for a long time. TBRL has developed a multi-mode hand grenade as a potential replacement of 36 M grenade. It uses preformed cylindrical mild steel fragments to achieve uniform distribution. After successful development of multi-mode hand grenade,ToT has been done with OFB and private industry. Production has been established in the premises of private sector ToT holder and 2000 nos. have been produced for user's trials. DRDO internal trials from the production lot has been completed, which meets all GSQR requirements.

Salient Features

- Modular in design: Two modules, i.e, fuze and main body; light in weight: Gross weight is 490 g in defensive mode and 260 g in offensive mode
- Offensive and defensive grenade. Lethal radius of 3 to 5 m from point of burst in offensive mode. In defensive mode, it incapacitates human being with in the radius of 8-10 m from the point of burst
- Uniform fragmentation pattern
- Less safety distances: Safe beyond 20 m radius from the point of burst
- More number of fragments (>4000) embedded in plastic matrix to provide higher splinter density of fragments
- Time delay 3 sec and arming delay of 0.5 sec provides additional safety to the thrower
- Maintenance free and highly reliable
- Operational temperature range of -20 ºC to 55 ºC and storage temperature range of -50 ºC to 75 ºC

Less-lethal Ammunition—Plastic Bullets, Frangible Ceramic/Metallic Ammunition

To counter the political and social unrests expressed by the people in the form of demonstrations which are traditionally dealt with lathi charge, tear gas, firing, and end up in killing, etc. TBRL has designed and developed riot control ammunitions for police and law enforcing agencies.

It is best suitable for training purposes and can be safely used in indoor shooting ranges.These

Multi-mode Hand Grenade

deter unruly situations by inducing fear and using non-lethal techniques.

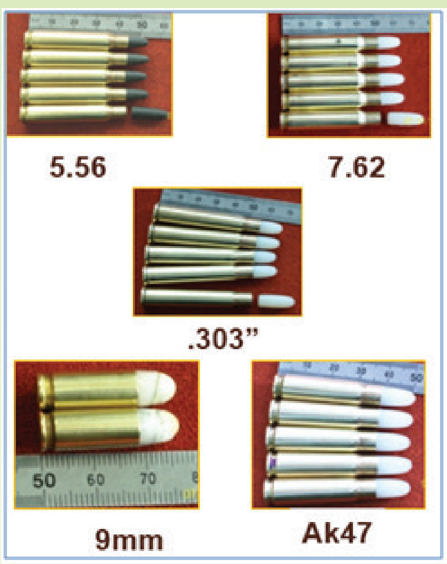
Plastic Bullets

Salient Features

- A non-expanding bullet which does not expand after penetration
- Induces similar sound effect as that of ball ammunition upto 150 m range
- Causes only superficial injuries at 60 m and above range
- Ammunition available in two calibers, i.e, .303" and 7.62 mm
- Can be used by in-service weapons without any modification

Frangible Ceramic/Metallic Ammunition

- Non-toxic,eco-friendly, available in 9 mm caliber
- Can be fired from standard service weapons without any modification
- Disintegrates into powder on hitting hard targets like walls, metallic plate, etc.



Plastic Bullets, Frangible Ceramic/Metallic Ammunition

Less-ethal Plastic Bullet in Auto Mode

Baffle Range—Smart Solution for Small Arms Practice Firing

The conventional firing range for small arms firing practices require about 500 acres of land. Due to population pressure, services find it difficult to acquire such a huge area near cantonments. TBRL has developed concept/layout design of a range with reduced danger area requirements, termed as baffle range, as an alternative safe facility for small arms practice firing without compromising on training objectives. It uses improvised concepts of a system of ground barriers, side walls, baffle walls, and stop butt to arrest the misdirected bullets. The land required for a baffle range can be reduced to 15-20 acres by providing suitably designed ballistic protection structures at specified locations, properly conditioned impact surfaces, regular upkeep of impact area and strict enforcement of safety rules/ precautions in the range. Such a great saving of land creates a possibility of having practice firing ranges at cantonments with small availability of land due to increasing population and very high estate cost.

Salient Features

- Baffle range accommodates six firers in lying, kneeling, and standing-in-trench firing positions from firing points at 500 m, 400 m, 300 m, 200 m 100 m, and 50 m (standing position only)

Baffle Range

- Safe against firing error of 14.2^0 in the horizontal plane and 12^0 in the vertical plane from the intended line of fire
- Weapons authorised on the baffle range include 9 mm carbine and pistol, 5.56 mm INSAS carbine, rifle and LMG 7.62 gun machine MAG 58, 7.62 mm subcaliber for 106 RCL, 9 mm subcaliber for 84 mm RCL, 7.62 mm SLR and AK-47

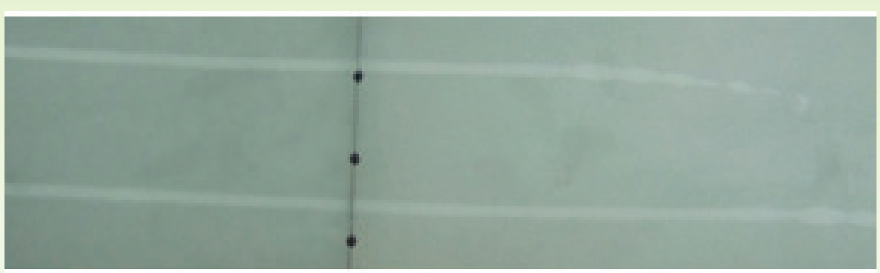
First baffle range (Mk I) was constructed at infantry school, Mhow in 1995. It comprises of 19 baffle walls, one stop butt. It is used by six firers at a time. It has firing points at 100 m, 200 m, and 300 m. This design has been modified (Mk II) and number of baffles has been reduced from six per 100 m to two per 100 m making it cost-effective. This improved version consists of ground barriers, side walls, baffle walls, and stop butt which provides improved performance with reduced risk, ricochet reduction, reduced overall construction cost. ToT of baffle range has been carried out with CRPF and BSF.

WARHEAD TECHNOLOGIES

Shaped Charges and Explosively Formed Penetrator

The laboratory is involved in design and development of shaped charge and Explosively Formed Penetrator (EFP) based warheads. The research aims at more lighter and smaller shaped charge and EFP warheads with higher damage capabilities. To keep pace with the advancements in the field of shaped charge warheads against MBT's, modern ships, submarine, etc., advanced state-of-the-art shaped charge and EFP warhead designs have been evolved and tested at TBRL. These warheads are suitable for use in different weapon systems, like anti-ship, anti-missile, and anti-submarine systems, besides sea mines, missiles and hard kill based Active Protection System (APS). The warhead is the most vital and essential component of a missile system or any other weapon system. Infact it is the warhead which is intended to be carried to the target to inflict damage to it and rest of the subsystems of the missile act only as a carrier vehicle for the warhead. Therefore it becomes imperative to design a warhead in such a manner so that it inflicts maximum damage to the target with as minimum weight as possible. A typical shaped charge warhead of diameter 118 mm for ATGM is shown as. The warhead consists of conical oxygen free copper liner, casing, explosive fill, wave shaper, and precision initiation system. The shaped charge jet formed on warhead initiation has been recorded using flash x-ray system having tip velocity of 9500 m/s. The warhead has been tested in field trials as per set-up to see the penetration performance of shaped charge jet. The penetration performance of 880 in rolled homogeneous armour has been achieved. Shaped charge are very effective against concrete targets too.

Shaped Charge Warhead Assembly



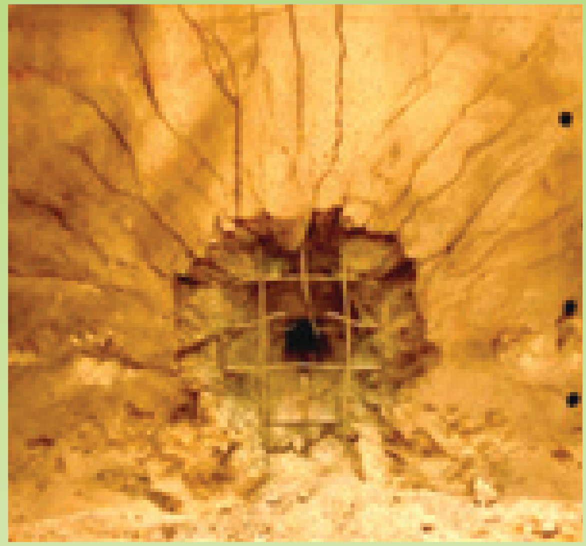
Flash x-ray Record of Shaped Charge Jet

Trial Set-up

Penetrated Armour Target Blocks

Test Set-up for Evaluation

Trial Results

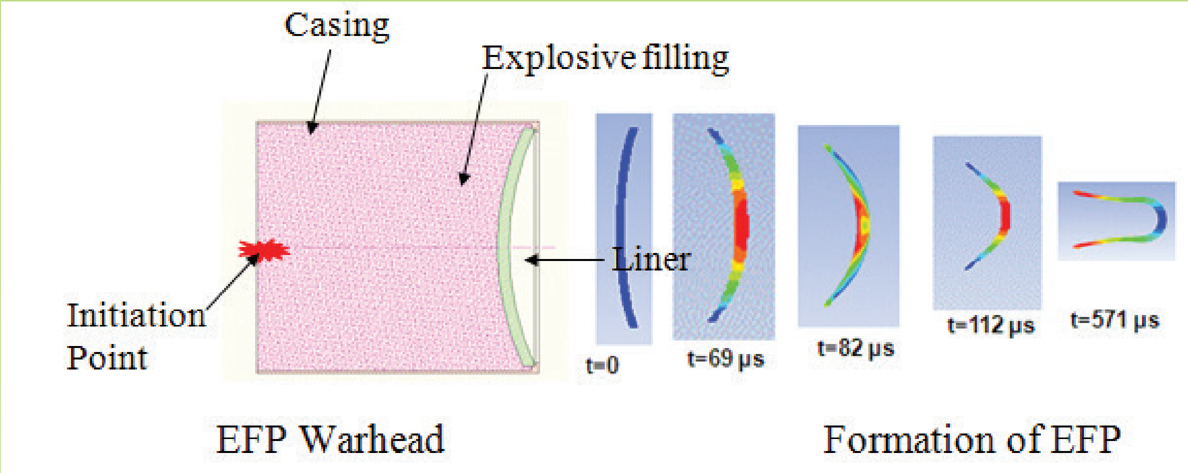


Trial Results

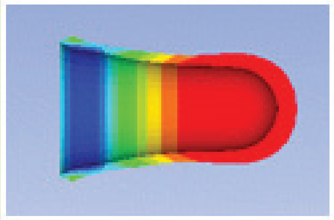
Explosively Formed Penetrator

The EFP technology has been developed by advanced countries for various applications such as top attack anti-tank precision guided munitions, and off-route anti-tank mines, etc. The EFP technology developed by TBRL is at par with global scenario as far as performance of single EFP is concerned. The generic EFP warhead consists of liner, casing, and explosive filling.

The liner under explosive action inverts inside out or deformed and elongates to the shape of a penetrating projectile. The formation of EFP by deformation of liner due to detonation of explosive. Images of EFPs from numerical simulation, and flash radiographic technique are shown in figure. A typical 200 mm diameter EFP warhead with hemispherical section OFE copper liner developed at TBRL for use in off-route anti-tank mine is as shown.This warhead developed has been tested in field trial at 100 m stand-off distance against 100 mm thick steel plate target as per/layout. The penetration of 100 mm at 100 m stand-off distance has been achieved with EFP formed from warhead. The EFP formed has impact velocity of 2000 m/s. The pictorial view of hole created on target plate is as shown.



Generic EFP Warhead

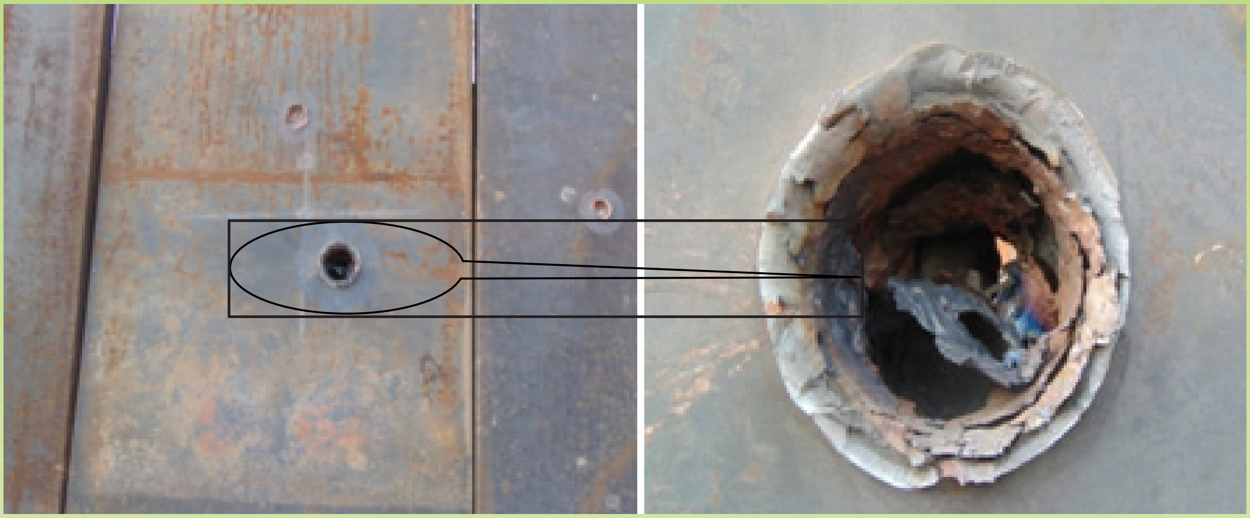


Numerical Simulation Record

Flash Radiographic Record of EFP

EFP Warhead Assembly

Trial Set-up for Testing of EFP Warhead

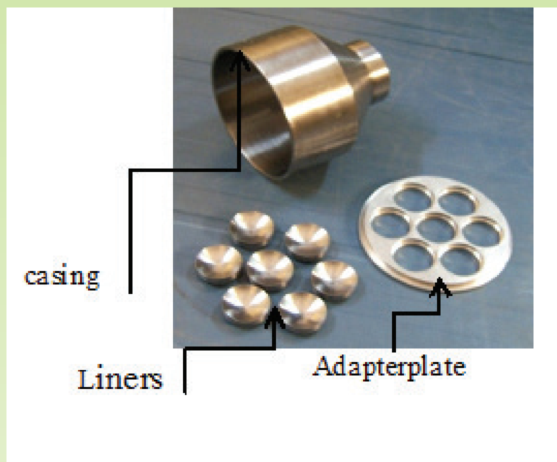


Perforated Target Plate

Multi-EFP Based Warheads

Conventional designs of warheads which are in use in various missiles around the world are based on the principle of fragment generator. These warheads on detonation of explosive either produce naturally formed fragments from warhead casing or launch preformed fragments in the direction of target. These warheads give reasonable hit density and depth of penetration in soft skinned targets and are suitable for ground targets. However, the fragment generator warheads are not best suited for an interceptor missile as very high velocity of fragments is required to compensate the large stand-off distance and very short travel time available due to high relative velocity of two missiles.

To overcome the limitations of fragment generator warhead, a very innovative EFP technology has been developed for the first time to design a multi-EFP warhead for the interceptor missile. Multi-EFP is a new concept in the area of directional warhead technology. This warhead works on the principle that a large number of hemispherical section liners of ductile material like soft iron, backed by high explosive, invert inside out on detonation of high explosive in the form of projectiles. These projectiles possess very high velocity in the range of 2-3 km/s



EFP Warhead Assembly

EFP Warhead Components

and high penetration in comparison to fragmenting type of warheads to defeat the high velocity aerial targets.

World over preformed fragmenting type of warheads are being used for anti-missile role. TBRL has developed multi-EFP warheads based on EFP technology for the first time to defeat adversary missiles. Warheads based on multi-EFP concept have superior performance in terms of hit density, projectile velocity, and target penetration.

A prototype small scale multi-EFP warhead consisting of multiple liners, casing, and adapter plate is shown. The multi-EFP warhead assembly fabricated for design evaluation using flash radiography facility available at TBRL is also shown.

Directional Multi-EFP Warhead

Test Set-up for Directional Multi-EFP Warhead

Based on this study directional and omni-directional multi-EFP warheads for interceptor missile and anti-ship missile has been designed and demonstrated in field trial with superior performance.

These warheads forms EFPs with impact velocity of 2 to 3 km/s and are more effective at longer stand-off compared to pre-formed fragments launched from pre-formed fragment type of warheads.

Facilities Available

- Flash radiography for experimental test and evaluation for shaped charge warheads, EFP warheads, and multi -EFP warheads.
- Modeling and simulation facility for design of warheads

Warhead and Exploder of Torpedo Advanced and Light and Varunastra

Warhead

Warhead of Torpedo Advanced and Light (TAL), designed for use against a submarine target, is a conventional blast type warhead. The shell of the warhead was designed by NSTL, Visakhapatnam where as selection of explosive composition by comparing various aluminised explosives, filling of explosive, test, evaluation, and comparison of blast effect with existing torpedo warhead of the same class have been carried out by TBRL.

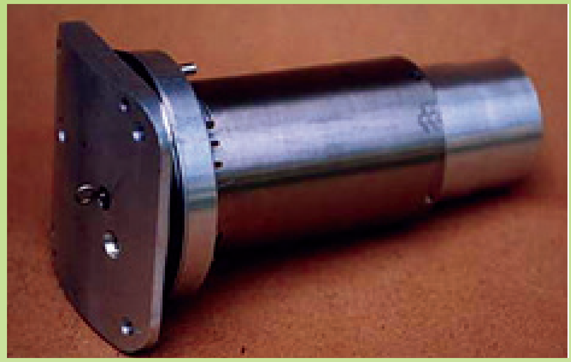
Exploder

Exploder is a critical subsystem of torpedo warhead, which ensures safety of the warhead in transportation, handling, storage, and operations. Exploder prevents inadvertent arming and detonation of warhead by removing all safety interlocks and initiating explosive train only when intended. As part of the Torpedo development program taken up by NSTL, TBRL has designed and developed exploder and warhead for light weight torpedo, TAL and exploder for heavy weight torpedo, Varunastra. Exploder for TAL warhead incorporates depth sensors that power up exploder electronics only after torpedo dives to certain depth. Other safety interlocks are sequentially removed only after torpedo has travelled safe distance from launch platform. Exploder initiates the explosive train on impact to the target. TAL exploder has qualified user assisted technical trials and is in production at BDL, Vishakhapatnam.

Exploder for HWT Varunastra is a new generation exploder system that besides incorporating various safety interlocks, houses a high voltage unit for initiating high energy detonators. It has modular design with no moving component and significant reduction in number of components as compared to traditional exploder system. It is immune to spurious stimulus pulses and initiates the warhead on proximity or impact to the target. Exploder has qualified all qualitative test and acceptance test level tests and ready for war shot trials. As this exploder uses state-of-the-art technology, it can be used in all future naval weapons warhead, like multi-influence ground mine and electric HWT.

Vrunastra Warhead Static Trial with Integrated Exploder

Warhead with Integrated Exploder



Exploder for TAL Warhead

Exploder for Heavy Weight Torpedo, Varunastra

Performance Evaluation of Warheads/Shells

All the conventional warheads are evaluated against their blast and fragmentation performance. At TBRL, separate test facilities are available to evaluate them. At warhead facility, dedicated experiments are carried out to evaluate performance of small and big size warhead for their fragmentation pattern and perforation capability at varied distances. In addition to this, life extension trials of the old warhead lots are performed at this test facility.

For all kind of infrastructure and diagnostics, this facility carries hundreds of such kind of trials within a year. Due to long legacy in warhead testing there is treasure of data on the basis of which new refined tactical warheads are also being designed and developed.

A Typical Low Caliber Warhead Being Tested

A Warhead Being Placed at Gallows

Low Caliber Missile Warheads

Fragment Velocity Measurement

Performance evaluation of shells is an important factor for design and development as well as its usage in services. TBRL has instrumented facilities for generation of data for computation of lethality in terms of Mean Area of Effectivness (MAEF).

Vertical Strawboard Layout

The data is generated for artillery shells by firing the munition in vertical strawboard layout.

- Mass distribution of fragments
- Spatial distribution of fragments
- Velocity of fragments

Vertical Strawboard Layout

Arena Layout

Horizontal Layout

Evaluation of aircraft bombs and missile warheads are conducted in horizontal strawboard layout to assess the following parameters in one firing.

- Mass distribution of fragments
- Spatial distribution of fragments
- Velocity of fragments
- Blast parameters
- Penetration performance of fragments in simulated targets

Horizontal Strawboard Layout

- This data is used for assessing beam width, hit/perforation density, percentage perforation, and spallation/deformation level of preformed fragments

Sand Pits

For computation of absolute safety distance, fragmentation trials are carried out in sand pit layout and in underwater fragmentation tank for determination of heaviest fragment and mass distribution of fragments.

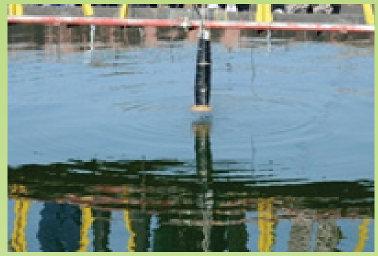
Underwater Trials

To retrieve all the fragments in less time and efforts, water can be used as trial medium which retards the fragment velocity very quickly and all the fragments settle down at the bottom of the tank making it quite easy retrieving all the fragments.

Sand Pit Fragmentation Chamber

Inside View

Sand Pit Layout



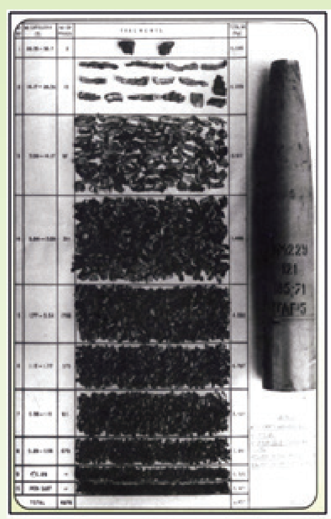
Deployment of Shell

Fragments Recovered After Trial

Underwater Fragmentation

However caution has to be taken to ensure that shell is exploded inside a container filled with air which is then submerged in the water tank, to ensure the fragmentation takes place in its natural surroundings. Blast effects can also be measured through underwater trials and can be translated to equivalent loading of atmospheric trials. TBRL has a self-sufficient underwater test facility which has 10 m depth, 16 m diameter and explosive upto 6 kg can be safely fired into it. The data generated in these trials is used for computation of following parameters

- MAEF
- Absolute safety distance
- Normal safety distance
- Safety distances based on casualty criterion



Fragmentation Pattern of HE Rocket Warhead

Development, Production, Processing, and Characterisation of High Explosive Compositions

TBRL is equipped to process different compositions of TNT based melt cast explosives for inhouse development requirements as well as for detonics studies. Pilot scale processing plant has been set-up for β-HMX explosive, octol, and plastic bonded explosive compositions. The laboratory is equipped with hydraulic presses of different capacities to process plastic bonded explosives. Capabilities to machine explosive devices to different shapes using conventional and CNC machines has been developed. A state-of-the-art characterisation lab has been set-up for sensitivity analysis, thermo-mechanical characterisation, morphological studies, and thermal stability studies of the explosive compositions and formulations. Processing capabilities to produce fine explosive particles by different methods like solvent, anti-solvent, ultra sonication, and other advanced processing techniques has been developed. The fine explosive particles have been characterised for use in propellant formulations.

TBRL has the following facilities for processing of explosive compositions:

- β-HMX Plant: A pilot production plant with installed capacity of 3 MT per annum
- Fine β-HMX/RDX plant: Pilot scale production plant for experimental studies
- Octol plant: Octal plant is operational to meet the inhouse developmental trials
- PBX plant: PBX plant to meet laboratory requirements for inhouse developments and field trials
- Pressing: Pressing facility is equipped with hydraulic press capable of pressing PBX charges
- Casting: TBRL is equipped with sedimentation casting. This facility is capable of production of TNT based cylindrical charges of upto 400 mm diameter
- Machining: The facility is in regular use for machining and casting of TNT based charges and PBX charges with precision for explosive devices required for inhouse development projects as well as detonics studies
- Quality assurance: The laboratory is equipped with the modern particle size analyser, SEM, FTIR, High Performance Liquid Chromatography (HPLC), image analyser, GC-MS, LC-MS, UV-Vis, and other latest facilities required for research, and analysis

Major Achievements of TBRL in explosive related systems are:

- Production/processing of HMX at the pilot production plant
- Established the processing of fine HMX and RDX particles with batch production capacity
- Explosive formulations development using polymers and additives for various performance applications including detonation wave shaping and miniaturised detonation devices
- Processing and production of wide varieties of formulations of explosive/polymer combination
- Casting and machining of explosive devices of different compositions for inhouse requirements
- Insensitive explosive formulation development and physiochemical, thermal, and sensitivity characterisation of entire range of explosives, and explosive formulations

TBRL aims to strengthen the R&D work in the field of explosive formulations with following identified thrust areas

- Casting, pressing, and machining of different formulations for various explosive devices for experimental studies

- Processing of explosives to meet sensitivity and performance requirements
- Shelf life evaluation of energetic materials and formulations
- Studies on enhanced blast explosive compositions
- Advance production and processing methodologies-green and modular
- Waste explosive processing-recovery, recycle, and reuse

Experimental Plant

Particle Size Analyser

Explosive Processing Facility

Thermo Mechanical Analyser

Scanning Electron Microscope

Machining of Explosive

DIAGNOSTIC TEST FACILITIES

Environmental Test Facilities

Verification of design and quality of newly developed system/store is ensured by its un-degraded performance during its operation under the influence of simulated environmental stresses (such as radiated immunity, low temperature, high temperature, humidity, vacuum, dynamic test conditions of vibration, acceleration or shock, etc.). TBRL has established environmental test facility for qualification of design and acceptance of warhead systems. The facilities have been planned to enable conduct of 500 kg class explosive filled warheads.

It is also used extensively for accelerated ageing tests of explosive devices and electronic systems. The facility is also intended for various types of EMI/EMC tests.

Climatic Test Facility

Facility	Technical Features	Typical Applications
Microprocessor based manually controlled humidity, hot and cold climatic test chamber	Size of chamber : 1x 1 x 1(m) Loading capacity: 150 kg max Temp. range: -50 °C to +125 °C ±1 °C Rate of change of temp.: 4 °C/min Humidity range: 15 ± 3 % upto 98 % RH Size: 600 x 600 x 600 (mm)	Climatic tests like high and low temp., humidity on various electronic/mechanical subsystems/systems
Thermal shock chamber	Payload capacity: 100 kg Temp. range: Cold cabinet: Ambient to -60 °C Hot cabinet: Ambient to +125 °C Rate of cooling/heating: 5 °C per min on avg	To simulate the temp. over a range of ambient to -60 ^{0}C (cold zone) and ambient to +125 ^{0}C (hot zone)
Vacuum, hot and cold climatic test chamber	Size: 0.9 x 1.0 x 1.2 (m) Payload capacity: 250 Kg Temp. range: -70 to +180 ^{0}C Vacuum: 1 mbar Humidity: 15±3 % upto 95 % RH	High and low temp., altitude, humidity tests on various electronic/mechanical subsystems/systems
Vacuum equipment	Size: 1 x 1 (m) Vacuum: 1 mbar Payload capacity: 250 kg	Vacuum tests at room temp. on electronic/mechanical systems

ISAT Facility

Intensive storage accelerated test	Temperature range: 0 ^{0}C to 100 ^{0}C ± 1 ^{0}C Avg rate of heating: 3 ^{0}C per min Avg rate of cooling: 3 ^{0}C per min Humidity: 20 ± 3 % upto 97 % RH	Tests on armament stores for life evaluation of armament and explosive devices

Thermal Shock Chamber

Vaccum, Humidity Hot and Cold Climatic Chamber

Electro-dynamic Shaker

Dynamic Test Facility

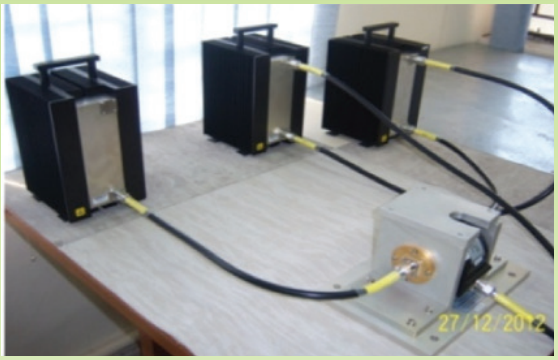
Facility	Technical Features	Typical Applications
3500 KgF electro-dynamic vibration shaker	Frequency range: 10 to 2000 Hz Maximum Force rating: 3500 KgF Payload capacity: 250 kg Max displacement: 50.8 mm peak-peak	Random/sine vibration tests on equipment consisting of HV units, explosive based mechanical subsystems
Bump test	Bump duration: 6 to 60 msec Payload capacity: 250 kg Max acceleration: 40 g peak Bump rate: 60 to 180 bumps/min	Bump tests on various systems/ subsystems as per required specifications
Pneumatic shock test machine	Shock duration: 6, 11, 18 and 30 msec Payload capacity: 450 kg Max. acceleration: 100 g peak Pulse shape: half sine, saw tooth	Shock tests on various systems/ subsystems as per required specifications
Accelerometer calibration system	Low frequency calibration: 5-10 Hz High frequency calibration: 10-10 kHz Sensitivity measurement: @ 100 Hz Linearity search function: Available	Calibration of piezo-resistive gauges, velocity sensors, geophones, force type sensors and ICP/charge accelerometers

EMI-EMC Test Facility

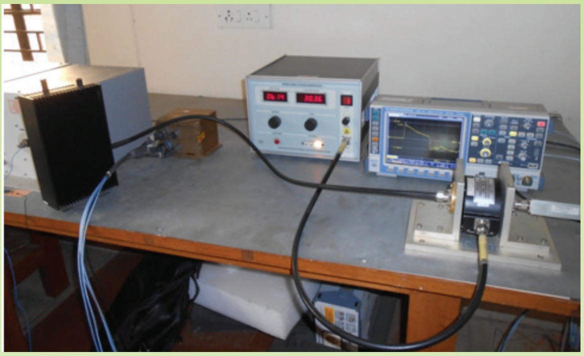
EMI-EMC test facility	Conducted Susceptibility Test (CS101, CS114, CS115, CS116) Human Electrostatic Discharge Test (HESD) Conducted Emission Test (CE102) Radiated Emission Test (RE102) Radiated Emission Test (RE102)	To ascertain reliable performance of electronic equipment in the EM environments. The facility meets the requirements of Mil-Std-461E and is being upgraded to Mil-Std-461F

CS-116 System

CS-101 Test Set-up



CS-114 Test Set-up



CS-115 Test Set-up

Calibration Facility

Calibration facility has been set-up in TBRL for calibration of electrical, electronics, and mechanical instruments used in various groups of TBRL.

The laboratory is equipped with various advanced calibration masters like multi-product calibrator, DMM, counter system, function generator, capacitance and inductance standards of various capacities, resistance standards including decade and mega ohm boxes.

The calibration facility for calibration of various instruments used in TBRL like digital multimeter, clamp meter, oscilloscope, function generator, power supply, LCR meter, milli/micro ohm meter, insulation tester, HV probe, timer/counter, etc.

Clean Room Based Calibration Lab

Calibration in Progress

Split Hopkinson Pressure Bar Facility

Split Hopkinson Pressure Bar (SHPB) facility is the most commonly used method for determining material properties at high strain rates. The performance of materials at high strain rates is of interest for various applications such as design of military structures, design of turbine blade, protective armour, and other components subjected to dynamic loading.

Salient Features

- Strain rates of the order of 104/sec
- Suitable for compressive and tensile tests
- Impactors of length varying between 50-450 and 100-900 mm
- Striker velocity between 5-35 m/s

Applications

- Characterisation of deformation, fracture, and local load carrying capacity of materials subjected to high strain rates (e.g, Armour plates subjected to projectile impact)
- Material data generation for explosive welding, forming, and other high velocity fabrication processes
- Characterisation of impact absorbing structures like car bumpers, bulletproof jackets, shock absorbers, helmets, air bags, industrial conveyors, actuators, power tools, packaging materials, etc.

Fragment Launching Guns

The laboratory is the nodal agency in the country for generating useful design data for entire spectrum of terminal ballistics from low velocity to high velocity impact of fragments including long rod and plate projectiles. Small caliber (0.5”/20 mm) and medium caliber (30/40 mm) fragment launching guns are available for launching projectiles to velocities from few hundred meters to 2 km/s.

Salient Features

- Bore diameters: 12.7, 20, 30, and 40 mm
- Indoor set-up for testing inert materials and outdoor set-up for testing high energy materials

Split Hopkinson Pressure Bar

Outdoor Experimental Set-up of 40 mm Gun for Testing High Energy Materials

- Any irregular shaped fragment upto size 35 mm can be launched using customised sabots
- Computer controlled remote firing
- Non-contact optical velocity measurement system and target
- Safety features like motion sensors and CCTV cameras

Applications

- V-50 ballistic limit evaluation of bomb suppression blankets against Fragment Simulating Projectiles (FSP) as per international standards
- Impact sensitivity evaluation of newly developed high energy materials (propellants/explosives) as per international standards
- Lethality evaluation of various missile warhead fragments developed by DRDO
- Evaluation of aerodynamic stability and penetration capability of scaled down FSAPDS ammunition using long rod projectiles
- Evaluation of sensitive electronic components (armament fuzes and circuits, etc.) against high 'g' accelerations

Indoor Experimental Set-up of Propellant Guns at Ballistic Test Facility

Impact Sensitivity Test on Explosives (Fragment Impact Test)

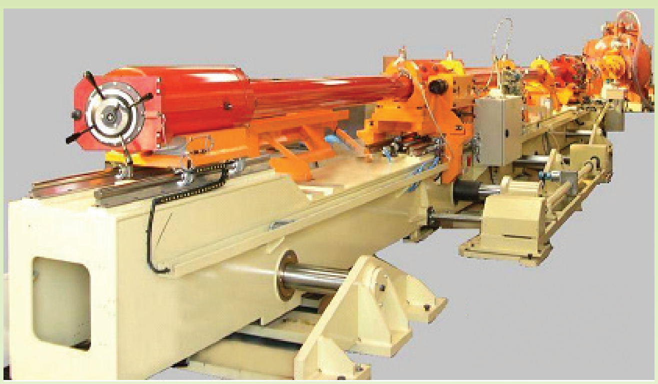
Recovered Cubes

Two Stage Light Gas Gun Facility

TBRL has recently acquired a two stage light gas gun for launching the projectiles of various shapes to velocities from 2-8 km/s depending on the mass of projectile. This gun is being used to carry out ball impact, plate impact, and other hypervelocity impact applications.

Research Activities/Applications

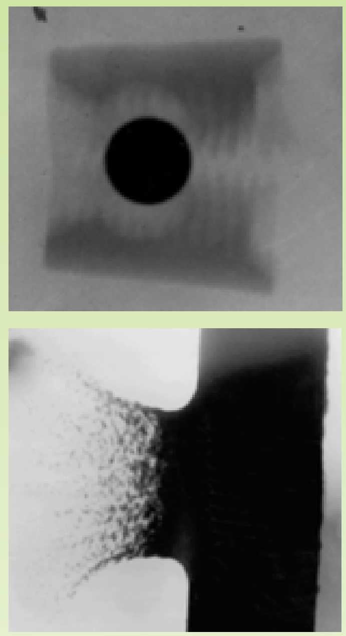
- Plate impact tests for Shock Hugoniot
- Studies on long rod projectile impact on targets
- Shock-to-detonation Transition (SDT) and DDT studies
- Re-entry simulation for aerospace applications
- Validation of space shields against meteorites impact
- Hypervelocity impact of projectiles on different targets



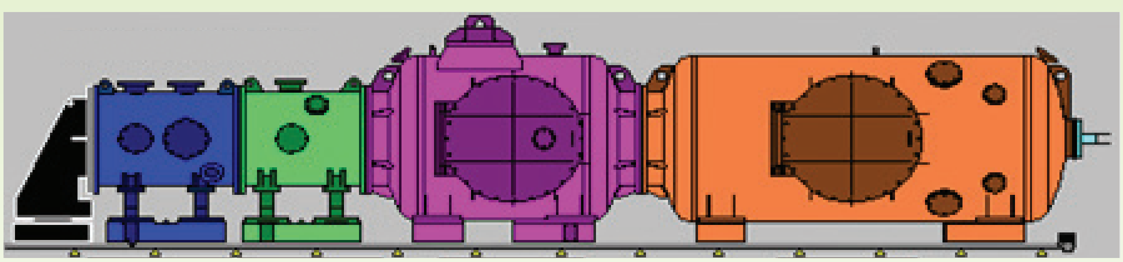
Two Stage Light Gas Gun

Diagnostic Techniques/Equipments

- 2 Channels 450 kV flash x-ray system
- 6 Channels 150 kV flash x-ray system
- Laser beam trigger and velocity measurement system
- Multi-chronometer with 10 channels
- 12 channel multi-shadows camera
- Shock arrival pins, Manganin gauges, and recorders for shock dynamic studies
- Electrical shock arrival pins



Flash Radiograph of Ball Impact on Steel Target at Velocity 3.8 km/s



Chamber 4 Chamber 3 Chamber 2 Chamber 1

Target Chambers

Drop Test Facility

Instrumented and mechanised drop test facility is established at TBRL to study the impact of dropping the munition/warhead of weight upto 1500 kg from 12-15 m height on the test surface. The facility has following features:

- Test Surface (FRC Bed): (Plan/Elevation)

Bed is sufficiently large to receive the dropped munitions and can accommodate any secondary impact too, i.e., from the munitions toppling. Sufficiently strong to take care of any detonation.

- Drop Tower

For reasons of standardisation, the minimum drop height for the logistic drop tests is 12 m. This height can be increased up to 15 m appropriately if required to suit the Russian standards of dropping. Sufficiently strong to hold the entire mass of 2000 kg and absorb any impulse because of drop. Clear height between hook and bed is 16.5 m.

- Safety Blocks

- Safety block of height 2.5 m is stacked to tackle rebound height of dropping munitions and to arrest/contain the fragments in case of any detonation.

- Release Mechanism

The test facility is equipped with pneumatic based release mechanism such that the test item can be reliably dropped from a given height onto a impact surface.

- Video Surveillance

The facility has video surveillance system so that it can be safely operated from zone 6 control room. (700 m from Trial site)

Drop Tower

Drop Test Trial of RGB-12 Bomb

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दूरभाषः 011-23902403, 23902472

फैक्सः 011-23819151; 011-23813465

ई–मेलः director@desidoc.drdo.in; techfocus@desidoc.drdo.in; technologyfocus@desidoc.deldom

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Readers may send their suggestions to the Editor, *Technology Focus*
DESIDOC, Metcalfe House
Delhi - 110 054

Telephone: 011-23902403, 23902472

Fax: 011-23819151; 011-23813465

E-mail: director@desidoc.drdo.in; techfocus@desidoc.drdo.in; technologyfocus@desidoc.deldom

Internet: www.drdo.gov.in/drdo/English/index.jsp?pg=techfocus.jsp

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