TECHNOLOGY FOCUS
टैक्नोलॉजी फोकस
An In-house S&T Bulletin of DRDO
www.drdo.gov.in
Vol 29 | Issue 5 | October 2021 | ISSN No. 0971 - 4413

SMALL ARMS & AMMUNITION

Technology Focus focuses on the technological achievements in the organization covering the products, processes and technologies.

October 2021
Vol. 29 | Issue 5 | ISSN No. 0971-4413

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INSAS in Action during Operation Vijay

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From the Desk of Guest Editor

Armament Research & Development Establishment (ARDE) is a premier establishment of Department of DRDO in Ministry of Defence. The establishment is mandated to design and develop conventional and advanced Armament Systems for the Services and Paramilitary Forces. ARDE has established its competency in design, skills in Testing and Evaluations and acquired technologies, infrastructure and other resources to carry out the complex Armament development work with panache.

Future wars will involve multi-domain operations but the primacy of the man on ground that is Infantry will be a decisive factor in winning the war. Small arms still hold a key position in armory of any nation in times of nuclear capabilities, artificial intelligence, automation, remote controlled or SMART network centric warfare. The basic weapon of Infantry is a Rifle and even today in the era of advancement in Armament the war carried out by Infantry has not gone out of fashion.

The armed forces of the nation need to be equipped with reliable small arms. The reliability of weapon nearing to 100 per cent was seen as a tall order for the designer and manufacturer in yesteryear. Today the designer and manufacturer is aufait in achieving 100 % reliability consistently...!

The art of designing the small arms is changing with the advent of development in technologies in every sphere. The need of the small arms world over is ever in demand though, any small arms once inducted into services holds the ground for next 10 to 15 years. The urge to command the territory is driving force for this demand. The mission specific weapons are also explored which also drives the demand !

With its experience gained from inception of the establishment , and in response to the needs of the armed forces, ARDE has designed and developed small arms such as 7.62 x 42 mm Ishapur Self-Loading Rifle (SLR), 5.56 x 45 mm Indian Small Arms System (INSAS) consisting of Rifle, LMG and five types of ammunition, 40 mm Under Barrel Grenade Launcher (UBGL) for INSAS and AK-47 Rifles, 5.56 x 30 mm Joint Venture Protective Carbine (JVPC), Lethal Ammunition 5.56 x 45mm for INSAS Rifle, Multi-Calibre Rifle capable of firing 5.56 x 45 mm, 7.62 x 39 mm and 6.8 x 43 mm ammunition and Corner Shot Weapon System.

The process of small arms designing is an evolutionary process, similar to military operations where 'Observe, Orient, Decide and Act' (OODA) loop is followed, small arms take the same OODA loop for design and development. The overall effect on our armed forces is that the Combat Competitive Index (CCI) of armed forces has been enhanced with these developments.

Small arms development is a complex and multi-disciplinary field. Specialised testing and evaluation facilities are required to prove and visualise the events. ARDE has constantly undertaken technology development activities for small arms. These are aimed at enhancing the performance of small arms to meet the armed forces requirements.

This issue of *Technology Focus* presents a comprehensive overview of the technologies related to small arms weapons and ammunition and ARDE's pioneering contributions towards their development.

Dr V Venkateswara Rao
Outstanding Scientist & Director
ARDE

SMALL ARMS & AMMUNITION

When the Infantry is near the enemy, the conclusive strike is done with small arms. When a recruit joins the army, the first weapon he touches is a small arms, and endless hours of soldiers' service are spent in association with small arms, whether during operations, guard duty, training, on the parade ground or while cleaning, or securing them in the stores. A soldier's morale depends significantly on his confidence and pride in his weapon.

Small arms are broadly categorised into personal weapons and supporting weapons. The International Tracing Instrument (ITI), adopted by the United Nations General Assembly on 8 December 2005, defines Small arms as:

"Small arms" are weapons designed for individual use. They include revolvers and self-loading pistols, rifles, carbines, Sub machine Guns (SMG), and Light Machine Guns (LMG). However, in gneral the calibre of small arms are less than 0.5" (12.7 mm)

To cut the size of the family of weapons and to clarify terminology, new categories of Small arms were agreed upon by NATO in 1972. These are:

- ⌘ Individual Weapon
- ⌘ Light Support Weapon
- ⌘ Medium Support Weapon

Factors to be considered in Designing Small Arms

Following requirements are taken care of while designing Small Arms ammunition & weapon:

- ⌘ Effective Range
- ⌘ Wounding Effect
- ⌘ Weight
- ⌘ Automaticity
- ⌘ Accuracy
- ⌘ Consistency
- ⌘ Rate of Fire andmode of fire
- ⌘ Reliability
- ⌘ Length

Small Arms Ammunition

Small arms ammunition carries the kill mechanism and the target kill is decided by the lethality of the Bullet against the target. It provides basic source of energy for operating mechanism of automatic weapons. The service life of a weapon is decided by the number of rounds it can fire. A weapon without ammunition is only an expensive article.

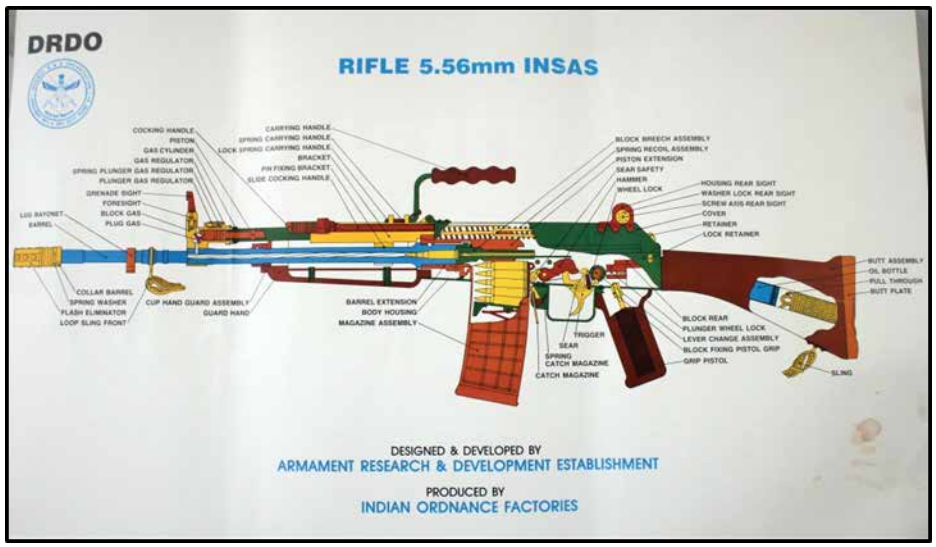
Typical energy distribution in ammunition is as:

- ⌘ KE of the bullet : 20 - 30 %
- ⌘ Rotational energy of bullet : 0.2 %
- ⌘ Frictional losses : 3 %
- ⌘ Work done on gases : 3 %
- ⌘ Recoil energy : 1 %
- ⌘ Muzzle blast : 40 %
- ⌘ Heat transfer to barrel : 30 %

Note: Efficiencyof a typical Small Arms is in the range of 20-30 %.

When ARDE was formed, the work of development of small arms and their ammunition was assigned to it. Such work was undertaken by Technical Development Establishment (weapons) and Technical Development Establishment (ammunition), working under the Department of Defence Production and Supply in MOD.

The indigenous development of small arms commenced in a real sense after the formation of ARDE in 1958. Hence the story of the development



Schematic Diagram with indication of major parts of 5.56 mm INSAS

of small arms at ARDE mirrors the development of 'small arms in India'. At the very beginning of 1962, when assistance to OFB was required for the production of 7.62 L1A1 Ishapore rifle, 9 mm SMC and 7.62 Bren LMG gun, a small group of scientists and engineers from ARDE brought out essential changes in the design of weapons suitable for Indian conditions.

Weapons and Ammunition Designed & Developed at ARDE

Peter's Pistol

The first attempt for the development of any small arms started with the Self-Loading Pistol. Lt Col Peter was the Officer-in-Charge of this weapon; hence the pistol was referred to as 'Peter's Pistol' in honor of the developer. The experience gained and the infrastructure acquired during this project paved the way for the successful development of the SLR and the INSAS family of weapons, which strongly positioned ARDE in the field of small arms.

7.62 x 51 mm Ishapore Rifle

In April 1958, the Defence Production Board decided to manufacture automatic rifles in 7.62 x 51 mm NATO calibre. TDE (Weapons) was entrusted with the task of design and developing this weapon.

When ARDE was formed in September 1958, the work was assigned to ARDE. The first lot of six Rifles was manufactured by Rifle Factory, Ishapore, hence the name, 'Ishapore Rifle'. The semi-automatic SLR was a boon to the infantry, hitherto equipped with bolt action .303 inch Rifle. The manufacture of rifles was taken up at Rifle Factory, Ishapore and OF, Trichy and manufacture of indigenous ammunition at Ordnance Factory, Varangaon. So far more than one million rifles have been produced. This rugged and reliable weapon gave an excellent account of itself and proved its mettle in the 1971 Bangladesh war.

7.62 x 42 mm Pashan Light Rifle

As technology advanced, the war scenario and tactics changed. Hence a need was felt to develop a lightweight and easily maneuverable rifle to give more mobility to soldiers. The User trials were carried out with success. The 7.62 x 42 mm PLR was effective, lightweight, had a controlled burst mechanism and was equipped with engineering plastic furniture.

Though the rifle could not be introduced in the Indian Army's inventory, it generated the confidence for developing a system required by the Users.

5.56 x 45 mm Indian Small Arms System and Ammunition

Taking a clue from the world wide developments, ARDE undertook a project to develop a family of small arms in 5.56 x 45 mm caliber and christened it 'INSAS' (Indian Small arms System). The family of weapons included rifle, Light Machine Gun (LMG), carbine, its ammunitions and accessories. INSAS underwent the most stringent tests in a variety of harsh environments to prove its robustness. In 1994, the decision to induct the weapon system was taken. The OFB established a new plant and machinery specifically for INSAS production, and implemented new production techniques such as cold swaging and chrome plating for barrel. Automated plants for manufacture of cartridge cases and bullets were also set up. The rifle and LMG with fixed and foldable butt versions and their ammunition were inducted into the Services.

5.56 x 45 mm INSAS

5.56 X 45 mm INSAS: Key Performance & Size Parameters.

Parameter	Value
Round length	60 mm
Case length	45 mm
Rim diameter	9.86 mm
Bullet diameter	5.56 mm
Cartridge weight	12.85 g (brass case)
Bullet weight	4.16 g - 4.24 g
Muzzle velocity (MV)	890 ± 10 m/s

The indigenous 5.56 x 45 mm ammunition is a modified version of NATO SS109 ammunition currently used by armed forces. Initially the ammunition was developed by ARDE during INSAS programme and production established at AFK and OFV.

Field use is the real test of a weapon, and INSAS saw action during Op Vijay in 1999, where it was extensively used. This rifle is also holding its ground in Services today. To date, approximately 20 Lakh Rifles, 600 Cr Ammunition and 1 Lakh LMGs have been produced and supplied to security forces.

5.56 x 45 mm Lethal Ammunition for INSAS

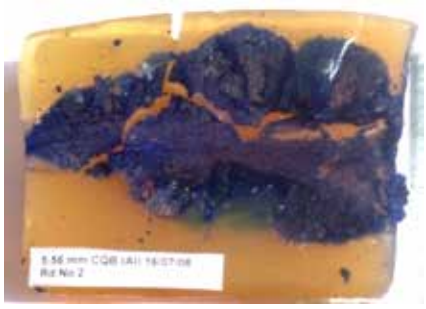
The laboratory enhanced lethality of 5.56 mm ball ammunition being used with INSAS Rifle for close Qtr ranges (200 m - 300 m). New Ammunition (by change of profile and internal construction) designed by ARDE and developed by AFK, Pune and extensive lethality assessment trials were conducted by the User.

The new lethal ammunition meets all technical parameters of INSAS ammunition and can be fired with an INSAS weapon. The effect of lethality

5.56 x 45 mm Lethal ammunition

5.56 x 45 mm INSAS ammunition

5.56 x 45 mm INSAS ammunition



5.56 x 45 mm Lethal ammunition

can be seen on 10 per cent ordnance grade gelatin of both the ammunition. This ammunition was tested by the User and considered as a product improvement of INSAS ammunition.

40 mm x 46 mm UBGL

Under Barrel Grenade Launcher (UBGL) was developed to enhance the firepower and effectiveness of INSAS rifle and provide grenade firing capability up to 400 m range. UBGL fires 40 mm x 46 mm HE, HEDP and RP smoke rounds common with multiple grenade launcher. It can also be attached to an AK-47 rifle owing to its modular design. The production of the UBGL is at OF Trichy and

approximately 20,000 UBGLs are in service. Salient features of the UBGL are as follows:

- Modular design: Can be fitted on INSAS rifle as well as AK-47 rifles
- 3-point attachment to rifle gives rigidity for fitment
- In-built safety to avoid accidental firing
- Breech-loading enables easy loading and unloading of ammunition
- Pump action along with conventional extractor makes extraction and ejection of cartridge case easier
- Location of trigger allows firing of both rifle and UBGL without change of posture
- High specific strength aircraft-grade aluminum body and barrel
- Fires common ammunition with MGL available with Indian Army
- Low recoil enables shoulder firing
- Wide choice of ammunition for different roles
- Provision of beta light source for firing in low light conditions

INSAS with UBGL

5.56 x 30 mm JVPC

AK-47 with UBGL

JVPC: Single Hand Firing

5.56 x 30 mm Joint Venture Protective Carbine

The laboratory undertook the development of Joint Venture Protective Carbine (JVPC) in 5.56 x 30 mm caliber to replace the aging 9 mm carbine in service. The weapon was developed with the latest technologies such as metal injection molding and engineering plastics. Its reliability in all-terrain is more than 99.7 per cent. Since DRDO and OFB jointly develop the protective carbine, it has been named the Joint Venture Protective Carbine.The OFB is associated with the manufacture of critical components and the integration of the weapon. It has been tested and has proven its reliability in extreme conditions, a prime requirement of the User. After successful User trials, clearance for its induction has been given by the army. Key features of the carbine are:

- Low recoil
- Single hand firing capability
- Retractable butt for a compact and balanced weapon, suitable for concealed area operations
- Capable of defeating 3.5 mm thick M S plate & level III SBA up to 150 m range
- Silencer can be attached for low noise attack
- Ambidextrous design
- Multiple picatinny rails

5.56 x 30 mm Ammunition for Joint Venture Protective Carbine

5.56 x 30 mm JVPC ammunition is unique calibre ammunition developed for CQB operation. It is meant to replace the in-service 9 mm x 19mm Parabellum ammunition. It can defeat soft body armour (24 layers of Kevlar) & 3.5 mm MS plate at 100 m range.

5.56 x 30 mm JVPC Ammunition

Ammunition is highly accurate up to the range of 200 m both in SS & SB mode. Compared to contemporary ammunitions worldwide, i.e, 5.7 mm x 28 mm P90 or the 4.6 mm x 30 mm MP7 ammunition, JVPC ammunition is comparable and superior in performance.

5.56 mm x 30 mm ammunition is under development at Ammunition Factory Khadki (AFK), Pune. More than 2 Lakh ball ammunition are manufactured by AFK and supplied for various trials. Four different variants of ammunition are under development. These are Ball Ammunition, Proof Ammunition, Drill Ammunition, and Blank Ammunition. Ball, Proof and Drill ammunition already developed and Blank ammunition are under development.Indian Armed Forces, including CAPFs are using this ammunition.

Technical Specification of 5.56 x 30 mm JVPC.	
Caliber	5.56 x 30 mm
Weight(without accessories)	<3.0 kg
Length	• 745 mm (butt extend) • 552 mm (butt folded)
Barrel length	300 mm
Operation	Gas operation
Locking system	Rotating bolt
Magazine capacity	30 rds
Rate of fire	700-800 rpm
Mode of fire	Single & auto
Sights	Iron, Reflex, Laser, IR
Muzzle velocity	650 m/s
Safety	Mechanical & applied
Accessories	Magazine, Silencer, Bayonet, Muzzle cap, Sling

Key performance and Size Parameters of 5.56 x 30 mm JVPC Ammunition	
Parameters	**Details**
Caliber	5.56 x 30 mm
Bullet mass	3.0 g
Ammunition types	Ball, Drill, Proof, Blank
Muzzle velocity	655 m/s ± 15 m/s
Effective range	200 m
Consistency	Figure of Merit < 5 cm

Multi-calibre Rifle

Army uses 5.56x45 and 7.62 x 39 mm calibre weapons under different areas to meet operational requirements. It was felt that a platform could be developed, allowing the User to fire other caliber ammunitions without completely changing the weapon. Accordingly, a Multi-calibre Rifle capable of firing three types of ammunition, viz., 5.56 mm x 45 mm, 7.62 mm x 39 mm and 6.8 mm x 43 mm has been developed. The rifle can be configured as permission requirements by quickly changing the barrel group, magazine and breech block.

Multi-calibre Rifle

Key features and the technical specifications are:

- Capable of firing different caliber ammunition by changing three components
- 92 per cent commonality between components
- Provision for mounting 40 mm UBGL
- Lightweight and modular design
- Multiple picatinny rails 6, 9,12 and 3 o'clock positions
- Push-type magazine release mechanism
- Hard anodised machined Al-alloy body

Technical Specification of Multi-calibre Rifle.	
Calibre	• 5.56 x 45 mm • 7.62 x 39 mm • 6.8 x 43 mm
Automation	Gas operated
Rate of fire	600 rpm - 650 rpm
Wt with empty magazine	< 3.5 kg
Weapon length	< 910 mm
Effective Range	• 5.56 x 45 mm: 400 m • 7.62 x 39 mm: 300 m • 6.8 x 43 mm : 500m
Muzzle velocity	• 5.56 x 45 mm: 890 m/s • 7.62 x 39 mm: 710 m/s • 6.8 x 43 mm : 760 m/s
Mode of fire	• Single and auto
Magazine capacity	• 30 rds
Mechanical Sights	• Iron
Safety	Applied & Mechanical
Sighting system	• CCD-based Day sight • TI-based Night sight • UBGL Sights • LRF, DMC, FCS

- Foldable butt with adjustable lengths
- Picatinny mounted universal iron sights
- Ambidextrous operating controls: cocking, change lever, magazine release

CSWS : Pistol Version

Corner Shot Weapon System (CSWS: Trikaal)

The corner shot weapon system is a special-purpose weapon system, developed for security forces operating in hostile situations and counter-insurgency operations. It allows the soldier to see and attack the targets located around corners

CSWS : UBGL Version

CSWS Firing at ARDE

Technical Specifications:CSWS	
Weapons	• 9 mm Pistol • 40 mm UBGL
Range	• 25 m with Pistol • 100 m with UBGL
Platform length	• 860 mm (unfold butt) • 700 mm (folded butt)
Mass	• 3.84 kg (exclWpn)
locking	• + 65° , 0° & - 65°
Trigger pull	• 2.5 kg – 4.0 kg
Sighting system	• Day & Night Camera • Tactical Torch • IR Illuminator • Laser Aiming Device
Display	• 3.5 inch Colour monitor with visible fixed cross
Battery	• Li-ion type 6800 mAh • (Re chargeable) • Min 4 hrs life
Compliance	• JSS: 5855-11:2009

without exposing himself for a counterattack. The CSWS is developed in two versions; one to accommodate in-service 9 mm pistol and the other for 40 mm UBGL and ToT has been transferred to two agencies. Successful trials with CAPFs have been conducted and the weapon is under procurement by various agencies.

Salient features:

- Ergonomic design for easy maneuverability
- Trigger system with a safety mechanism
- Foldable butt stock
- Day and night firing capability
- Adjustable LED monitor
- High power re-chargeable battery
- Compliance with JSS 5855-11:2009

5.56 x 45 mm CQB Carbine

5.56 x 45 mm Close Quarter battle (CQB) Carbine is a lightweight, compact, effective weapon used in close combat CI/CT operations. It is developed to meet the requirements of the army operating in close-quarter conflicts. Its features are:

- Machined lower and upper bodies
- Rivets free design
- Non-detachable connecting pins
- Telescopic (Rear) opening design
- Cocking on the body to avoid heating
- Multiple Picatinny rails at 3, 6, 9, & 12 'o clock position
- Improved polymer magazine with metallic Inserts
- Foldable butt
- Simple shot and auto mode
- Applied and mechanical safeties
- Mechanical sights

5.56 x 45 mm CQB Carbine

Technical Specifications of 5.56 x 45 mm CQB Carbine	
Calibre	5.56 X 45mm
Ammunition	In- service 5.56 mm INSAS and NATO
Weight	3.2 kg
Length	<800 mm
Accuracy at 100 m	• SS mode: 9/10 hits in 15 cm X 15 cm • SB Mode: 18/30 hits in 24 cm X 24 cm
Effective range	Penetration of 3.5 mm MS plate at 200 m
Magazine capacity	30 rds made with engg plastic with metallic inserts
Sight	Iron
Accessories	3 Point sling, bayonet, vertical fore grip

7.62 X 51 mm Light Machine Gun

Light Machine Gun (LMG) is an automatic, bipod mounted or portable firearm, generally for a range of about 800 m. To date, the Indian Army is using 5.56 x 45 mm INSAS LMG. However, due to a change in operational requirement, the Indian Army initiated a case for procurement of 7.62 x 51 mm LMGs, which are widely used across the globe and have different configurations based upon

7.62 mm x 51 mm LMG

the country of origin. Detailed studies were carried out on the 7.62 LMGs available globally and their capabilities and features. This area weapon aimed at suppressing the enemy at longer ranges is being developed to meet the Users' requirements as per JSQR.

Salient features of the weapon are as follows:

- Single piece machined receiver
- Chromium-plated barrel for longer life
- Quick barrel change through interrupted threads
- Equipped with three position gas regulator & MIL std 1913 Picatinny rail
- Buttstock with hydraulic shock absorber
- Fire capability on bipod or tripod
- Can be mounted on ground vehicles, naval vessels and aircrafts

9 x 19 mm Machine Pistol

The 9 x 19 mm calibre pistols and Sub machine Carbines are battle-proven weapons used by almost all the security forces worldwide for personal and VIP protection. This newly developed machine pistol is a blowback operated, automatic weapon with a rate of fire of more than 700 rpm, having an effective range of 100 m and weighs approx 1.9 kg.

The machine pistol is developed keeping the operational ergonomics, reflexive actions in mind. It can fire 9 x 19 mm Indian and NATO ammunition, replacing the vintage 9 mm pistols and the imported SMGs currently used by our security forces. Key features of the weapon are as follows:

- Machined (aircraft grade Al alloy) and Carbon Fibre bodies

Technical Specifications of 7.62 x 51 mm (LMG)	
Calibre	7.62 x 51mm
Effective range	800 m
Max length	< 1200 mm
Overall weight (with bipod)	9.78 kg
Automation	Gas operated
Locking	Tilted bolt
Mode of fire	Single (SS), Auto (SB)
Belt capacity	250 Rounds in one belt
Muzzle velocity	➢ 800 m/s
Rate of Fire	650 Rds/min
Safety	Applied, Mechanical
Sights	Iron sight with luminous tip, PNS
Picatinny rail	12 o' Clock
Accessories	Bipod, Fore grip

9 x 19 mm Machine Pistol Specifications.	
Calibre	9 x 19 mm
Ammunition	9 x 19 mm in-service and NATO
Operation	Blowback
Effective range	100 m
Weapon mass	<2.0 kg
Barrel length	7.2 inch and 6.5 inch
Length	• Butt Folded - 382mm • Butt Extended - 612mm
Butt	Side folding
Picatinny rail	At 6o'Clock and 12o'Clock (Full length)
Construction	• Aircraft grade Aluminium alloy with hard coating • Carbon fibre polymer pistol grip and butt
Accessories	• 3-point Sling • Silencer • Reflex sight • Magazine (32 rounds)

- Rivets free design
- Non-detachable connecting pins
- Cocking on the body to avoid heating
- Multiple picatinny rails
- Foldable butt
- Ergonomically designed pistol grip & Butt Stock & table

9 x 19 mm Machine Pistol

Air Burst Grenade for 40 mm UBGL

Grenades are one of the most effective munitions for the infantry. These are fired from stand-alone weapons like Automatic Grenade Launcher (AGL) or shoulder-fired weapons like UBGL mounted on rifles. They enhance the firepower of the soldier substantially by providing multiple effects at the target end. In principle, high explosive anti-personnel grenades create a terminal effect using chemical energy projectiles. Their lethality is governed by the number of fragments, impact velocities, and mass of the splinters. After initiation, the explosive provides energy to the splinters/fragments for being projected towards the target. Conventional grenades are generally integrated with Impact or Point Detonating (PD) Fuze and burst after hitting the target. Due to this, a substantial amount of splinters goes into the ground, thus limiting the lethal radius. They are also less effective for the enemy hiding inside bunkers, rooms and defilade. Such limitations can be overcome by incorporating the capability of air bursting. It can be achieved by utilising either Proximity Fuze or Electronic Time (ET) Fuze-based solutions.

The laboratory has developed all the technologies for realising Air Burst Grenade (ABG) for 40 mm UBGL. Unlike the conventional grenades that detonate on impact, this grenade has a significant edge in terms of terminal performance due to airburst capability.

A time-programmable electronic fuze achieves this capability. It can be programmed using a Firing Control System (FCS), which can be integrated with a weapon by incorporating minor modifications. The fuze has been designed to provide multiple layers of safety during storage, transportation and handling. The grenade is provided with Impact. Delay and Self Destruction (SD) modes. The grenade body is designed to possess internal notches for providing the desired lethality through a controlled fragmentation effect. HEMRL has

Air Burst Grenade for 40 mm UGBL

Fuze Setter

developed all the explosive and allied components related to the grenade. The technologies so developed have been demonstrated successfully to Central Armed Police Forces (CAPF). Further development of Impact and SD feature-based family of grenades, which includes High Explosive Dual Purpose, Red Phosphorous (RP) and Target Marker (TM) grenades to be used with in-service UBGL and MGL are taken up by the laboratory.

• Caliber	:	40mm
• Kill mechanism	:	Pre-notched High Explosive
• Lethality	:	More than 5m (Anti-personnel)
• Fuze	:	Electronic Time (Programmable)
• Mode of operation	:	Time /Impact /Self-destruction
• Range	:	More than 400 m
• Setter	:	Wireless fuze Setter

Infrastructure Facility for Test and Evaluation

ARDE has test infrastructure required for the evaluation of small arms and ammunition. Followings setups are available in ARDE:

- Small arms test and evaluation equipment
  - 50 m firing range
  - Sand test setup
  - Mud test setup
  - Water immersion test setup
  - Rain test setup
  - Drop test setup
  - Ballistic pendulum for recoil measurement
- Environmental test Facility
  - Hot and cold test setup
  - Thermal shock setup
  - Salt spray test setup
  - Humidity test chamber
  - Other setups
- Bump test setup
- Vibration test setup
- Instrumented setups
  - High-speed videography
  - Doppler radar for measurement of rate of fire and muzzle velocity
  - Acoustic test setup to measure the sound levels of firing
- Open range 1000 m
- Velocity tunnel of 100 m
- EPVAT test setup for ammunition
- Universal ballistic setup
- Optical screen for accuracy measurement
- Acoustic test setup for measuring accuracy

Small Arms Test & Evaluation Centre, ARDE

User Trial : JVPC 5.56 x 30 mm



Technology Established for Small Arms

Various technologies have been established at ARDE for the design and development of small arms and to meet the Users' requirements of reliability, weight reduction, aesthetics and lethality. These technologies are:

Lightweight/High Strength Materials

A world over the trend in the development of small arms is making lightweight small arms. It gives the soldier the advantage of carrying more ammunition for the operation. Further, present weapons are equipped with various modules like reflex sight, thermal imager, foregrip, flashlight, etc., based on nature of operation resulting in an overweight weapon that may not be easily handled by the fire. The use of lightweight, high-strength engineering plastics, composites and alloys is, therefore, necessary to further reduce the weight and optimise the weight of the total weapon. To achieve this goal, composites are extensively used in the small arms components. In INSAS and JVPC, long glass fiber-filled high strength polymers were used in the furniture items like handguard, stock, pistol grip, trigger guard, etc. In UBGL, high-strength aircraft aluminum was used for the barrel and body. It has reduced the weight tremendously. In the recent project, ARDE explores the carbon fiber-filled composites for the weapons parts replacing even the steel in some cases.

Metal Injection Molding

Small arms are required in huge numbers with very high reliability. The majority of components are small and intricate in shape and require very accurate dimensions. Manufacture of components to the required sizes is essential to achieve desired reliability in all-terrain and environmental conditions. Advanced manufacturing techniques which gives uniformity in dimension, material properties and thus ensures complete interchangeability, is now widely used in the development of Small arms developed in ARDE. Metal Injection Moulding (MIM) is a manufacturing process in which fine metal powder is mixed with a special binder and injected into a die to form the required shape. The binder is then removed and the part is finally sintered, to produce a high-strength metal component. MIM manufacturing method is the most suitable way for mass manufacturing of small and intricate components with extremely high accuracy; hence the acceptance percentage is very high. The MIM process reduces or eliminates machining operations. Fully automatic injection molding machines that enable tools with several cavities make large-scale series production possible. The technology was first introduced in INSAS where two components, namely Extractor and Ejector, were made through MIM manufacturing. Later in the JVPC project, 26 components out of 108 were made through MIM and it resulted in getting 100 percent reliability in the User trial. In a current project, ARDE aims to introduce almost 50 percent of the components through the MIM route.

Development of Surface Coatings (EN-PTFE/BN, EN-Boron and Molycoat)

Many research in the area of multifunctional coatings to enhance the tribological properties is being pursued in the world. Until a few years back, an established process in India was heat treatments followed by phosphating on small arms components. In the case of the barrel, the inner surface was chrome plated to enhance the life of the barrel.

With phosphating, the weapon aesthetics are also not up to the mark other systems available globally. In recent years, ARDE is venturing in multifunctional coatings and has developed/ exploited coatings like Nickel- Boron, Nickel-Boron Nitride, Nickel PTFE, Molycoat, etc., for the small arms components to enhance the performance of Small Arms. These coatings are tough (similar to chromium coating), have good adhesion, have a very low coefficient of friction and can withstand almost 1000 hrs of Salt spray test. In the case of Barrel, ARDE is evaluating ways to avoid Chromium plating as it is an environmental hazard. A special nitriding process was recently evolved for the gun barrel of 9 x 19 mm machine pistol under development at ARDE. The same is under the evaluation stage.

Availability of Technologies in India

These coatings are already adopted by various global small arms successfully. A suitable technology will be evaluated for trigger mechanism and weapon body breeching. Apart from UCT's EXO, Nickel Boron Nitride/PTFE and Molycoat technologies are the other technologies that will also be seen for feasibility and evaluated for JVPC in the new project. All three technologies are already available in India and are being used for certain commercial applications and some limited civil small arms. After evaluation, suitable technology will be adopted for JVPC from the mass production point of view for better functioning, surface protection, maintainability and aesthetics of weapon.

Simulations and Life Assessment of Small Arms

ARDE extensively uses simulation software like MSC ADAMS, Simulia ABAQUS, FE SAFE, TOSCA, I-sight, etc., in the design and development of small arms. The multi-body dynamic simulations on ADAMS help in understanding and improving the kinematic behavior of the mechanism. This is essential to develop a highly reliable mechanical system that is now an essential requirement from the user. FEA Software like ABAQUS, FE SAFE, helps in estimating the fatigue life of critical components. TOSCA is mainly used for shape and geometry optimization of the small arms components. The use of these software has helped in designing optimum small arms systems. In the coming years, ARDE will be further exploring co-simulations and acoustic simulation for the development of small arms.

Barrel Manufacturing Technology for Small Arms

Barrels manufacturing is the key for any small arms development, which requires investment and expertise. Other subsystems can be realized through a well-established technology base available with the industry. ARDE has undertaken an infrastructure project to establish the barrel manufacturing facility so that the barrels can be manufactured in-house and the total development time of the weapon can be reduced.

The barrel is a critical part of small arms required to impart velocity, direction and spin to the bullet when fired. As such, it must withstand the high pressures and temperatures that are developed each time the weapon is fired.

Barrel manufacturing is the most challenging and critical process in the complete manufacturing process of small arms, considering the dimensional accuracy and precision involved. Barrel straightness, surface finish and concentricity of the land and grooves of the rifling are of utmost importance.

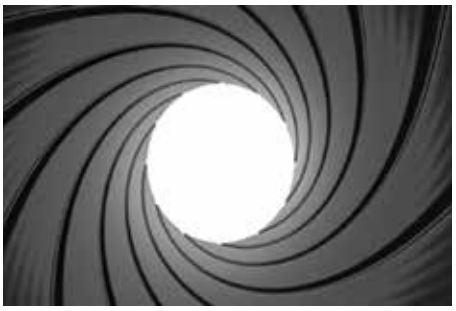
Initially, these barrels were produced by broaching process on the pre-deep hole drilled blanks. The broaching operation was carried out to make the rifled grooves. Over a while, the cold hammer forging process has evolved to manufacture these barrels wherein blanks are beaten into shape with the hydraulic hammer that applies even compression to all sides of the barrel blank. Using this process, the precondition to achieve a high degree of straightness and surface finish in the barrel is to use blanks having the same quality as desired in the final product. The better the quality of the blank bore, the better will be the quality in the groove/ land range of the forged barrel.

The internal dimension of the blank bore is achieved by gun drilling followed by honing. Therefore, the feature control in these machining stages is very critical. The blank length is kept more minor than the finished barrel, while the diameter is kept more prominent to accommodate

the mandrel. It is then progressively hammered around the mandrel during forging resulting in an increase in length of about 30 per cent than the blank length. The barrel thus obtained has excellent mechanical properties.

Another critical technological requirement in barrel manufacturing is surface protection by plating, considering the operational conditions and working environment. The plate has to withstand the mechanical, thermal and chemical stresses encountered during firing and prevent premature wear and erosion of the gun barrel, which would otherwise reduce its service life.

The most important property of the coating is the elastic modulus. It should be comparable to the substrate such that the firing loads can be effectively transferred to the substrate.



Rifling in gun barrel

Trends in Small Arms

The present small arms systems are designed to suit most conventional warfare. However, there is a continuous change in the operational requirement in the last few decades. The infantry has to face various tactical scenarios, including conventional, mountain, jungle, and asymmetric warfare like military operations in Urban terrain, counter-insurgency warfare, etc. No single type of small Arms can fulfill all the requirements.The design of any weapon system revolves around its ammunition. There is a specific contradictory requirement that exists for a different role of weapons. Since operational demands cannot be compromised, many calibers found their place in the army inventory. At present, most countries use 9 mm X 19 mm caliber weapons as personal defence weapons. However, due to the lack of penetrating capacity, specific new caliber low power systems like 5.56 X 30 mm, 4.7 X 30 mm and 5.7 X 28 mm are competing to occupy this space. For roles other than PDW class, most countries use 5.56 X 45 mm, 7.62 X 39 mm or 7.62 X 51/54 mm calibre weapons. Presently, studies are in progress to provide a long-term solution with a new caliber of 6.8 X 43 mm calibre systems to give lethality at par with 7.62 X 39/51mm and accuracy at par with 5.56 X 45 mm calibre systems. However, the lethality and hit probability need to be balanced carefully.

Future Development Projects in ARDE

Lack of private solid participation resulted in a lack of innovations and technology gaps. Tough competition from the international markets and rapid change of user expectations aggravated the problem. Private participation could not take off because of the highly regulated environment. However, there is a drastic change in the policies in recent years, which enabled granting licenses and categorising the procurement process in favor of Indian industries, i.e., buy Indian, buy and make Indian. Despite such relaxations, private companies are not able to commit investments because of uncertainty in user requirements.

Following future developments have been planned in ARDE in small arms:

- 6.8 X 43 mm family of weapons
- Case-telescopic ammunition & weapon system
- Green bullets
- Laser ignition of small arms ammunition

DESIDOC thanks Shri R P Pandey, Sc 'G' and his team of Armament Research & Development Establishment (ARDE) for bringing out this issue of *Technology Focus*.

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Published by DESIDOC

RNI No. 55787/93