

LEADERSHIP IN AMMUNITION EFFECTIVENESS

TAKING RESPONSIBILITY IN A CHANGING WORLD



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CHALLENGES IN AMMUNITION SELECTION

Armed forces worldwide face challenges in selecting the appropriate medium-calibre ammunition. Military planners have to consider more and more aspects when selecting an asset mix:

- The armed forces have to prepare for a broad range of missions including asymmetric conflicts and must adapt to changing requirements quickly. A huge ammunition portfolio helps to cover a broad set of missions but severely limits flexibility. A small but optimized selection of ammunition types fulfils both objectives.
- Adversaries, especially in asymmetric conflicts, are getting increasingly creative in using new weapons that are difficult to counter with traditional weapons and ammunition. The ammunition must have a high degree of flexibility and multiple effects on targets to be usable against such new threats.
- The cost of the ammunition has to meet ever-constrained budgets. Decisive is not the cost per round but the cost to reliably defeat a target under real-life conditions.
- The need for flexibility to cope with a broad set of missions and the often necessary fast reaction demand for uncomplicated logistics and multifunctional ammunition. Ammunition coming with logistics burdens reduces the capability to intervene quickly and efficiently.

AMMUNITION TYPES

In medium-calibre ammunition you can find a broad range of different technologies. Some have been available for decades; newer technologies take advantage of new advances in material science or physics. These technologies can be clustered in several ways, two are detailed below:

Full-calibre and sub-calibre rounds:

- Full-calibre rounds do not have separating parts so one can use them on-board aircraft and for shooting over own troops.
- Sub-calibre rounds have a higher muzzle velocity and kinetic energy. The shorter flight time reduces the lead distance for moving targets and the effect of side wind; the flatter the trajectory the higher the hit probability.

Mode of action:

- Armoured and other hard targets are penetrated using a long and dense penetrator with high kinetic energy. Penetrator and target material fragments destroy assets and ignite combustible substances inside the target.
- Soft to medium armoured targets are engaged using fragmenting payloads. These can destroy assets inside a target and create a forward directed fragment cone inside the target; ideally the fragments spread widely inside the target.
- There are targets like multiple, spatially-distributed targets or small and moving targets that with normal ammunition could be destroyed. Realistically seen this would require too many rounds to have a decent hit probability. Such special targets are engaged with sub-projectiles being released close to the target. Other applications for this ammunition include targets where a sufficient number of fragments or sub-projectiles are required in a bigger area to have a decent kill probability.
- The engagement of lightly-protected targets and suppression can be done using explosive ammunition. The use of fuzes results in the danger of duds, the presence of explosives creates unfavourable handling requirements and increases the hazard classification. Ammunition with explosive payloads stored inside a weapon platform increases the damages to the weapon platform and the risk to the crew.
- Target practice ammunition is used for every day training purposes and matches the flight trajectories of the respective full- or sub-calibre ammunition.



AMMUNITION TECHNOLOGY

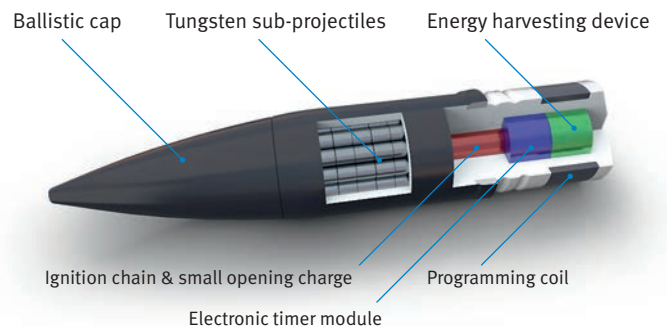
The following paragraphs address the most important ammunition technologies and their performance against relevant targets. All statements are generic and valid for all calibres – the performance of a particular ammunition type depends on several factors. Please contact us or refer to the respective product documentation.

ABM

The Rheinmetall Air Burst Munition (ABM) bases on kinetic energy fragments instead of high explosives and is called Kinetic Energy Time Fuze (KETF) munition.

The rounds are built around a programmable time fuze and a high number of dense tungsten sub-projectiles. The programmable fuze contains an energy-harvesting device (no batteries), a programming coil, an electronic timer module, ignition chain and a small opening charge. The energy-harvesting device creates electrical energy when the projectile is fired. The electronic timer module then is programmed via the programming coil while leaving the barrel.

The ignition chain and opening charge release the spin-stabilized sub projectiles from the round into a standard distribution pattern at a selected point in front of the target. The round will self-destruct if it is not programmed properly or become inert, therefore no duds.



The cannon is equipped with a programming base as part of the muzzle brake and an ABM electronics unit interfacing with the fire control unit (FCU). All three units are connected via harnesses.

Despite a velocity of more than 1000 m/s the programming base measures the speed of each individual round. The FCU (fire control unit) defines the optimal distance, the ABM electronics compensates for the deviation of the measured speed from the nominal speed and defines the time setting. The programming base then programs this optimal time into the round's timer electronics so that each round releases the sub-projectiles at the optimal expulsion distance from the target.

Our individually-programmed rounds are accurate and flexible enough to engage targets in breadth and depth. The lethal spread pattern of this ammunition enables gunners to engage and disperse. The huge number of sub-projectiles makes ABM rounds ideal for engaging small or fast moving and spatially distributed targets on land, sea or in air defence.

In programmed mode, the crew can select the appropriate target category for a single shot or salvo from a few customer defined preprogrammed ones. Per target category the sub-projectile density (defining the hit probability per round), the kill probability of the individual sub-projectiles (releasing the sub-projectiles closer to the target resulting in higher

density of sub-projectiles per sqm and higher energy) and the number of rounds are balanced to achieve the required kill probability of a salvo. So, for example, the crew can effectively engage small and multiple, distributed targets with fewer rounds than with other ammunition.

In un-programmed mode the projectile is capable of penetrating urban targets (e.g. double reinforced-concrete walls) and lightly armored vehicles spreading sub-projectiles inside the target area with a devastating effect.

As part of the system integration, Rheinmetall assists you to achieve the highest kill probability for each target set. Rheinmetall offers ABM ammunition with different sub-projectile sizes but can also customize the size to meet your special mission requirements.

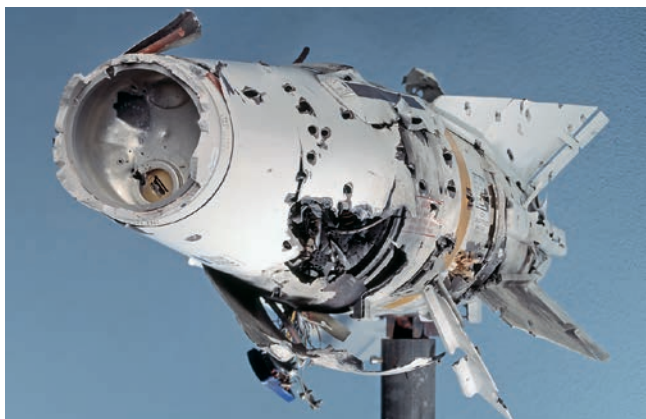
Only Rheinmetall offers an ABM solution that measures the muzzle velocity of each round and corrects (via programming) each round individually to minimize the dispersion of the release distance. This ensures effective and efficient target destruction.



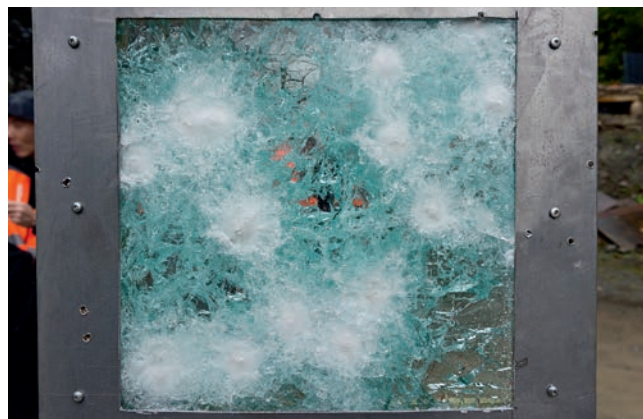
10 rounds of Air Burst Munition – precise release of tungsten carbide sub-projectiles



30 mm x 173 KETF against 20 cm double reinforced concrete – engagement in depth



Engagement of small and fast targets



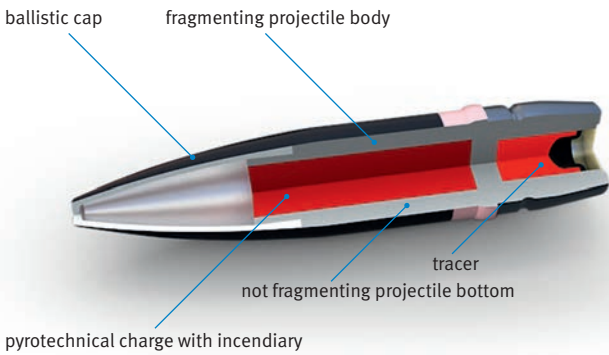
Air Burst Munition against armoured glass

(S)APPIE

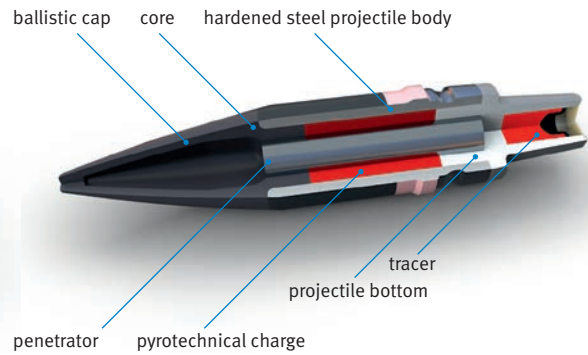
The Semi Armor Piercing with Pyrotechnically-Induced Effect (SAPPIE) projectile is composed of a hardened steel projectile body and low-density, inner filler. On impact, the inner filler is compressed inside the hard projectile body as this penetrates the outer target plate. High pressure builds up in the filler. This pressure is directed to the hard projectile body making it deconstruct into a forward directed fragment cone once inside the target. The SAPPIE-T ammunition uses a pyrotechnical

material as the low-density, inner filling. The pyrotechnical charge deflagrates on impact increasing the speed of the fragments significantly. The opening angle of the fragments remains nearly constant over the firing distance. When replacing part of the inner filler with a tungsten carbide penetrator, the round gets additional armour-piercing capability and is called APPIE. The body fragmentation characteristics remain largely unchanged.

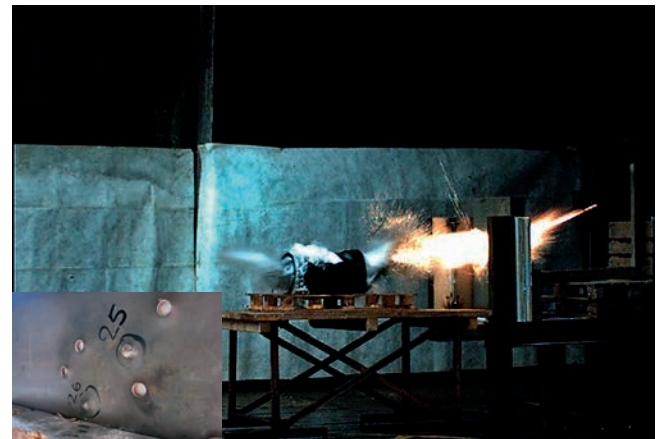
SAPPIE-T



APPIE-T



(S)APPIE matches the explosive effect of HE/HEI on the target surface. Additionally it has significantly higher penetration capabilities and delivers fragments into the target effectively destroying it. Unlike HEI, these rounds are able to penetrate rolled, homogenous steel and semi-armoured targets. For some requirements APPIE is a viable alternative to AP rounds. Besides the penetration capability SAPPIE and APPIE both offer suppressive effects (flash, bang & blast) and an additional incendiary effect. Duds are not possible because there is no fuze. The lack of explosive material and fuzes results in a lower hazard classification which is similar to TP rounds. The more favourable hazard classification greatly reduces transport and handling requirements compared to HEI.



HEI & SAPHEI

The High Explosive Incendiary (HEI) ammunition is a full-calibre ammunition and features an explosive substance (normally complemented with incendiary material) and a fuze. The fuze can be in the nose (HEI) or base (SAPHEI) depending on the target of choice. On impact the explosive substance will detonate – the steel body of the round creates a spherical

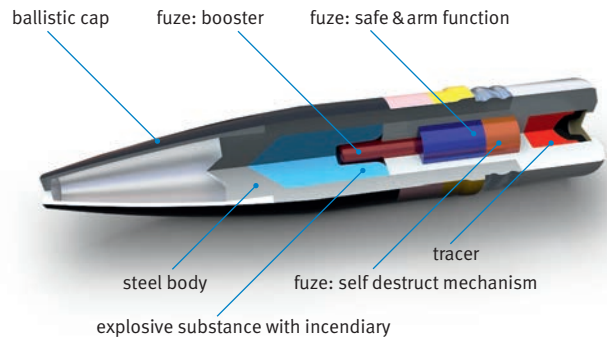
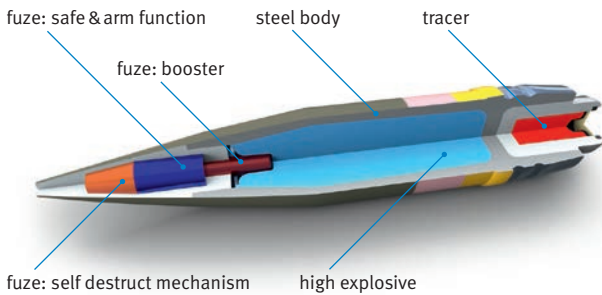
fragment cone. In addition it offers very good suppression (flash, bang & blast), target marking and an incendiary effect. HE ammunition due to the fuze has duds. Ammunition with explosives requires careful storage and handling and has a higher hazard classification.

HEI-T

While HEI ammunition can be used to destroy soft targets such as helicopters, pick-up trucks and small boats, performance against armoured targets is poor. The round will not penetrate the target and the fragmentation and blast occur outside the target.

SAPHEI

Semi Armour Piercing High Explosive Incendiary (SAPHEI) ammunition has a strong nose that can penetrate steel. The body of the round has a base fuze that after an ignition delay will cause fragmentation once it passes through surface. There is less explosive material and fewer fragments than with HE or HEI but greater penetration capability.



FRANGIBLE AMMUNITION

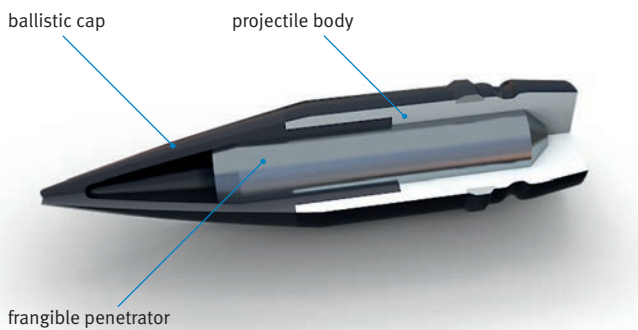
Frangible ammunition is a very versatile technology with good performance on a wide range of soft and hard targets.

The core element of the ammunition is a penetrator made from a high-density tungsten alloy material. We carefully design the material properties for optimal fragmentation versus penetration performance. The penetrator passes through armour or other hard and light targets and fragments

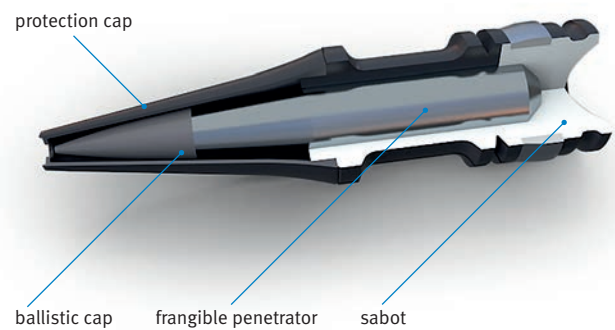
once inside. This process cascades as the fragments strike other objects inside the target resulting in a deep and radial damage pattern. If they hit something combustible there will be a secondary incendiary effect.

Variants include use of several tungsten pellets instead of a single penetrator and the use of an additional pyrotechnic pellet to create a flash at impact.

FAP



FAPDS



The penetration capability of frangible ammunition lies well above that of HEI but below that of APFSDS. Its versatility makes it an ideal general purpose round destroying all targets except for the latest generation of armored vehicles using spaced armor.

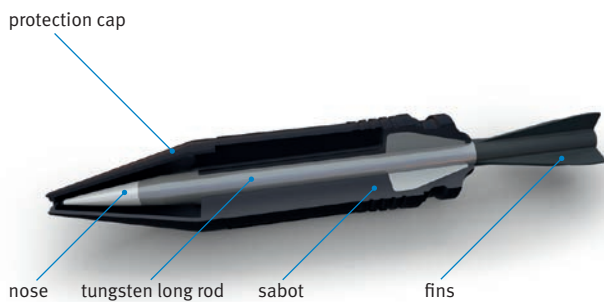
Frangible ammunition is available both as full- and sub-calibre ammunition. The full-calibre Frangible Armour Piercing (FAP) is only used on aircraft and is especially well suited for airborne platforms as it contains no explosives and no separating parts.



FAP fragments cause massive structural damages deep inside the target

APFSDS

The sub-calibre ammunition “Armour-Piercing Fin-Stabilized Discarding-Sabot” (APFSDS) uses a kinetic-energy penetrator in the shape of a long, thin rod. The long rod has four fins for aerodynamic stability and is made from tungsten. The tungsten alloy is optimized to defeat high hardness and/or spaced armour. The tip of the rod is made from a softer material and the interface between rod and tip is specially shaped for optimum grip against angled armour.



Our APFSDS allows for a full-spin launch for instantaneous sabot separation, the result is excellent ammunition accuracy largely unaffected by barrel wear.

APFSDS has excellent armour-piercing capabilities and causes spalling. The remaining penetrator, the spall and the high pressure built-up have a devastating effect inside the target. On softer targets, the effect is limited.



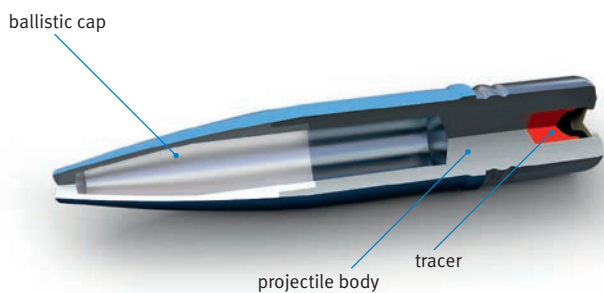
35 mm x 228 APFSDS-T against single RHA-plate at a distance of 2 km

TRAINING AMMUNITION

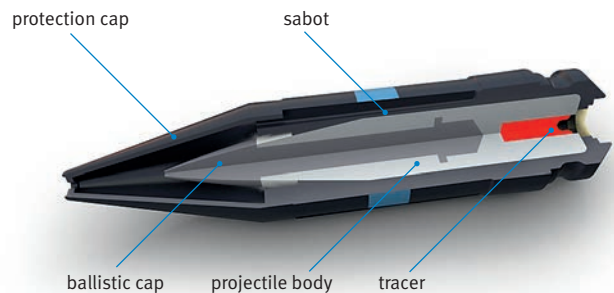
Training ammunition (Target Practice – TP and Target Practice Discarding Sabot – TPDS) complements tactical ammunition and are ballistically matched to our full- and sub-calibre war

shots. Special short-range variants cater to space-constrained firing ranges. Tracers are an option. Training ammunition is less expensive than combat ammunition.

TP-T




































































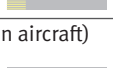













TPFDS-T




AMMUNITION TYPES VERSUS TARGETS

As detailed above the different ammunition types have their specific strengths and capabilities. The chart below depicts this graphically.

Assume the calibre and the engagement range are appropriate and that the weapon systems are comparable.

Effective against \ Type	 Combatants	 Covered Combatants	 Pick-up	 Urban Area	 Truck	 APC	 IFV	 MBT	 Utility Helicopter/Light Aircraft	 Armoured Attack Helicopter	 Aircraft	 Bigger UAV	 Jetski	 Boat
HEI 														
SAPHEI 														
SAPPIE 														
APPIE 														
ABM 														
FAP (on aircraft) 														
FAPDS (land) 														
APFSDS 														

 – Suppression

 – Blind the crew by destroying optical sights and electro-optical sensors

Using the ammunition effectiveness chart above and weapon system specifications one can identify the appropriate ammunition mix. One should consider the hit-kill ratio, the

cost to defeat a target and the impact on logistics for a well-balanced ammunition portfolio. Rheinmetall stands ready to support you in this evaluation process.

MEDIUM-CALIBRE PRODUCTION AND TESTING CAPABILITIES

Rheinmetall has both breadth and depth in manufacturing and testing medium-calibre ammunition.

Full production capabilities:

- Cartridge-case production, mechanical component production & plastics injection moulding
- Heavy metal production and working (tungsten alloy penetrators and similar)
- Production and working of propellant, pyrotechnical and explosive substances
- Pyrotechnical charges production
- Fuze production
- Loading, Assembly & Packaging (LAP)



Rigorous quality management for product development and customer lot production.

Own Proving Grounds in Switzerland and Germany:

- Full testing and measuring setup, extensive selection of cannons, target preparation facility
- Maximum firing ranges of 5500m and 13000m
- NATO-accredited Test Centre at our Swiss proving ground



MEDIUM-CALIBRE AMMUNITION SERVICES

Besides medium-calibre ammunition, Rheinmetall provides services to help customers efficiently handle all aspects of ammunition usage:

- We will work closely together with your system integrator to supply our ammunition data for the fire control system and to integrate our ABM Kit (programming base and ABM electronics) into your cannon of choice.

- Our facilities are prepared to refurbish or convert ammunition into training ammunition and to prolong shelf life.
- We can set up and equip your test centre.

And of course, Rheinmetall is also your partner for very reliable and high-performance cannons in various calibres and various applications.

RHEINMETALL CANNON PORTFOLIO

Rheinmetall provides a modern portfolio of medium-calibre cannons. Building on a long tradition of design and production of cannons in the 20 mm to 35 mm calibre range today's products have exceptional firepower, precision and reliability.

Combined with an excellent mass-to-performance ratio and long service lives our cannons are ideally suited for any current or future ground, naval or air application.

TECHNICAL DATA						
Name	Calibre	Rate of fire (rounds/min)	Rate of fire rapid single shot	Barrel length (cal.)	Recoil force (kN)	Recoil travel max. (mm)
KAE	20 mm x 128	1,000	100–300	85	14	10
KBA	25 mm x 137	600	175	80	24	34
BK27	27 mm x 145	1,700	Single shot	63	28	1
KCA	30 mm x 173	1,350	100–300	75	50	21
MK30/2-ABM	30 mm x 173	600	Single shot	90	18	45
WOTAN 30	30 mm x 173	200	Single shot	87	45	55
WOTAN 35	35 mm x 228	200	Single shot	*	*	*
KDC	35 mm x 228	550	Single shot	90	25	55
KDG	35 mm x 228	1,000	200	90	22	40



YOUR PARTNER FOR MEDIUM-CALIBRE AMMUNITION AND WEAPONS

Decades of experience in the design, development and production of medium-calibre ammunition and automatic cannons for Rheinmetall have resulted in a leading position in ammunition and weapon systems.

Numerous armed forces around the globe depend on Rheinmetall's products. It is also a leading systems house for research, development and production of ammunition

and automatic cannons. Rheinmetall offers a customer-oriented service portfolio that, among other services, includes consulting, system Integration support, prolongation of shelf life and demilitarisation of ammunition.

When it comes to medium-calibre weapons and ammunition you can rely on Rheinmetall.

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