KAYSUN
CORPORATION
INJECTION MOLDING & ENGINEERING SOLUTIONS

PLASTIC MATERIALS FOR SAFETY AND RELIABILITY

A Guide for Military & Defense Applications

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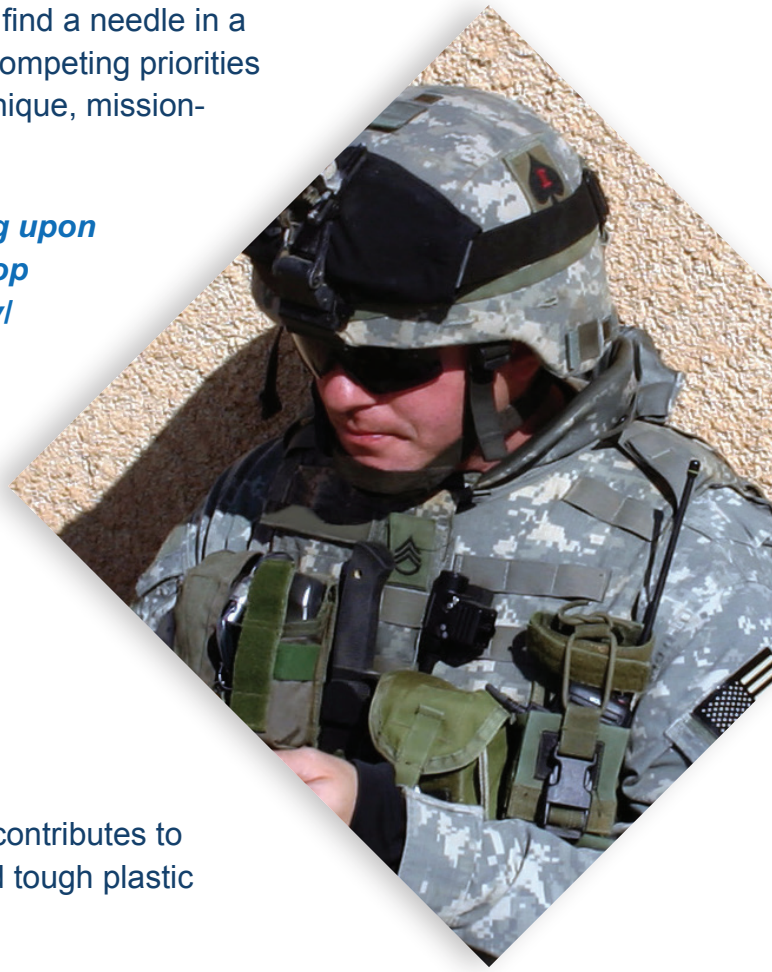
Between base polymers, additives, and fillers, there are literally tens of thousands of engineering-grade resin options available. Selecting the right one for your military/defense application can feel like trying to find a needle in a haystack — especially when you factor in potentially competing priorities of mechanical and molding properties with cost and unique, mission-critical safety needs.



Defense/safety contractors are increasingly calling upon experienced, full-service molders to devise, develop and produce plastic components that help military/defense products work smarter and safer in the field — and more economically in budgets — all without jeopardizing supply chain continuity.

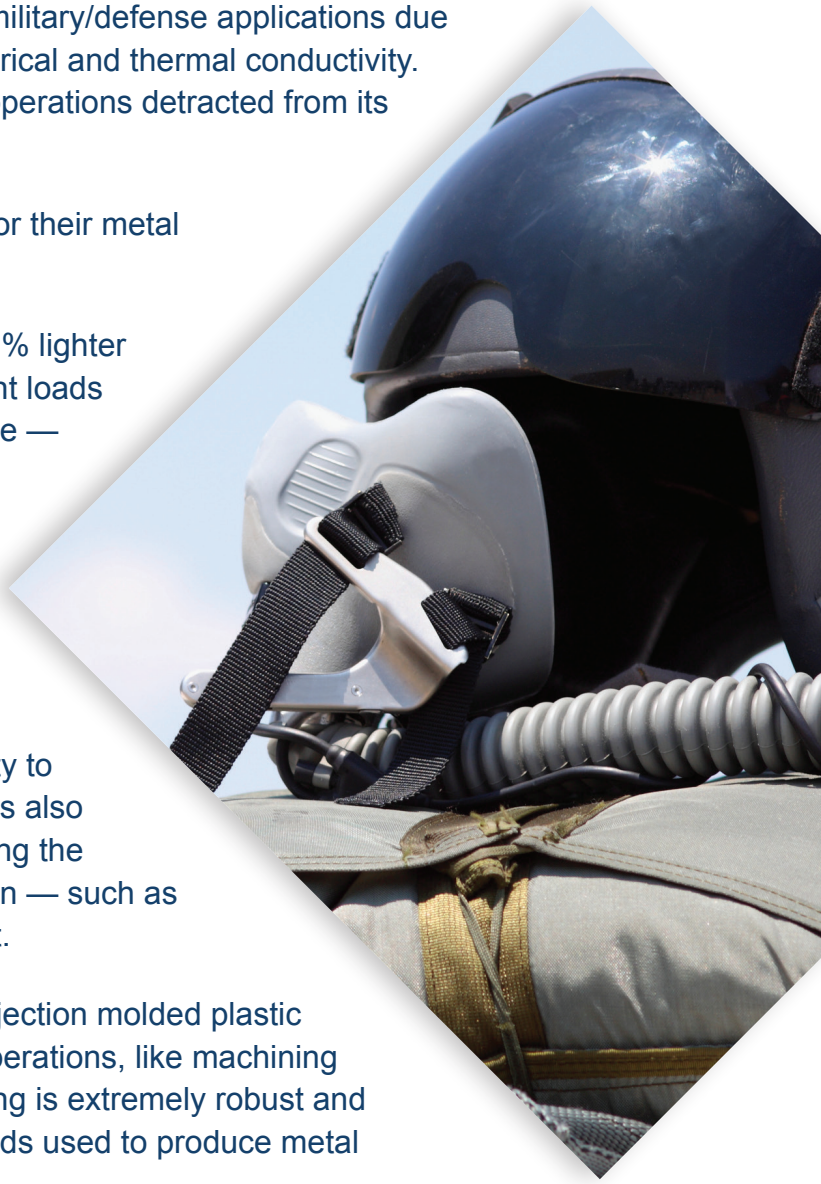
This guide will help you understand:

- The relationship between plastics characteristics and performance for injection molded components
- Which plastics align well with military/defense applications
- How an experienced, complex injection molder contributes to the design and manufacture of safe, reliable and tough plastic components.

Plastics Characteristics

Technology is driving advancements in field gear, transportation systems and navigational devices used by military and public safety personnel. Their safety depends on protective equipment and devices that are designed and manufactured with the most advanced materials and processes.

Traditionally, metal was the material of choice for military/defense applications due to its strength, tight tolerances and enhanced electrical and thermal conductivity. However, metal's weight and required secondary operations detracted from its safety and practical efficiencies.



Substituting injection molded plastic components for their metal counterparts provides three key advantages:

1. **Lower weight:** Plastics are, on average, 40% lighter than metals. Reducing per-soldier equipment loads allows service members to remain lithe, agile — and, above all, safe — when engaged in maneuvers or combat.

2. **Freedom of design and assembly:** Injection molded plastic components are subject to fewer assembly constraints, as manufacturers can consolidate multiple elements into a single plastic part. The ability to design plastic parts with complex geometries also means multiple parts can be assembled using the method best-suited to a particular application — such as welding, heat staking or mechanical snap-fit.

3. **Lower Total Cost of Ownership (TCO):** Injection molded plastic parts do not require extensive secondary operations, like machining or painting. Plus, plastic injection mold tooling is extremely robust and has a much longer life than the die-cast molds used to produce metal parts — a substantial cost savings.

Evaluating these general benefits against specific requirements critical to military/defense applications further demonstrates the practicality of injection molded plastic components:

PORTABILITY

Smaller, lighter devices make it easier for military and public safety personnel to transport, store, access and use equipment under routine and challenging conditions. Overmolding of soft-touch grips also make operation less complicated for gloved hands and offer better grasp control in dirty, smoky, oily or otherwise compromised environments.

DURABILITY

There are unique factors in the field to which devices and equipment are exposed and must endure: concussive events, extreme temperatures, frequent drops, dirt, excessive moisture, fires and hazardous chemicals. ***Unlike metal that will corrode, dent and potentially malfunction, injection molded plastic components are specifically designed to survive impact, shock and vibration*** while simultaneously withstanding corrosive environments. This becomes even more important when equipment like GPS units, other in-field communication technologies or soldier-saving medical equipment contain electronics that must be protected by a plastic housing.

ELECTRONIC DETECTION

Many military operations require personnel and equipment to remain undetected from the opposition. Metal-based machinery leaves large electromagnetic radar/sonar echo signatures and infrared heat source footprints.

A variety of non-conducting and insulating resins have been introduced to increase the stealth capabilities for military/defense applications:

- Domes constructed from polymer matrix composites shield detection equipment and deaden position-revealing vibration on military ships and aircraft
- Military helicopters outfitted with multi-spectral stealth capabilities (radar, infrared and acoustic) like polymer foam blades and Kevlar-carbon fiber structural materials
- Flexible, polymer matrix-based coatings used on a number of military vehicles to thwart “normal” and “thermal” visual detection

ELECTROSTATIC DISCHARGE

Military/defense applications often rely on technologies that cause a build-up of static electricity. Electrostatic Discharge (ESD) is the sudden flow of electricity between two electrically charged objects caused by contact, an electrical short or dielectric breakdown. ESD can interfere with communications, functionality and safety.

Plastics that qualify as electrostatic discharge materials reduce static electricity to protect devices. ESD materials are divided into four general categories:

- **Insulative:** Prevents or limits electron flow for high electrical resistance and difficulty in grounding — technically making insulative materials non-ESD
- **Anti-static:** Inhibits triboelectric charging, meaning the buildup of an electric charge caused by rubbing or contact with another material
- **Dissipative:** Charges flow to the ground slower and in a more controlled way than with conductive materials
- **Conductive:** Charges go to the ground or to another conductive object that the material touches

EASE OF USE

Handheld devices, navigational tools and other equipment are only as effective as the design. If they lack reliability in interfacing and communication, or if the training involved in getting personnel up to speed is lengthy, difficult to grasp or cumbersome — safety is compromised. ***Injection molded plastic components can often be designed and produced in reliable formats that are easy to operate and understand without undue time investment.***

How Can Injection Molders Help?

International Traffic in Arms (ITAR)-compliant injection molders work with defense contractors to develop and produce large quantities of reliable, cost-efficient military parts and products including:

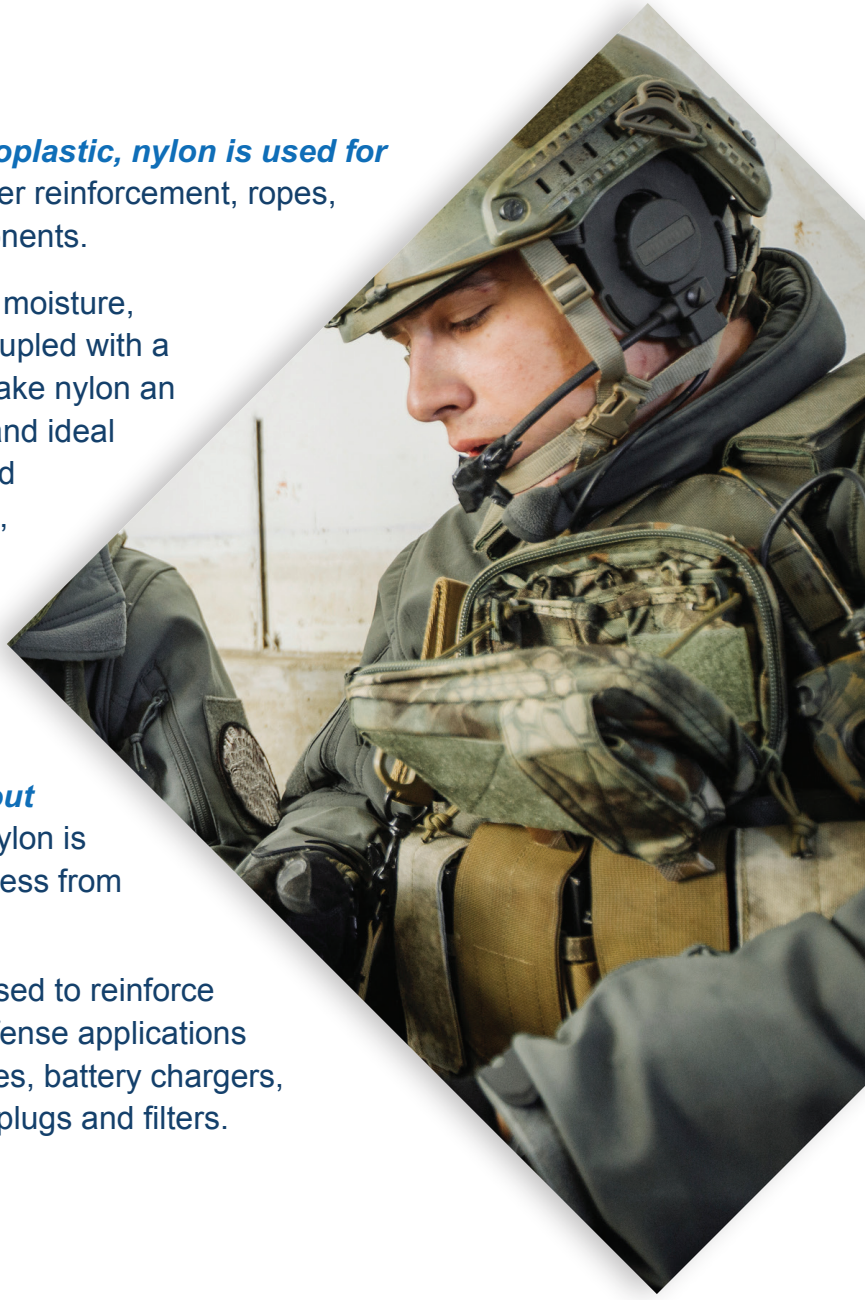
- **GPS unit housings**
- **Soldier gas masks**
- **Unmanned vehicles and drones**
- **Communication technologies**
- **Vision systems, such as night goggles or smart helmets**
- **Firefighter locator systems to route help to downed personnel**
- **Reinforced armor and vehicle components**
- **Durable medical devices for military field use**
- **Avionics instrument panels**

Plastics Types

Military/defense projects have specific, unique requirements. This narrows the breadth of resins appropriate for use, and brings several types of common thermoplastics to the forefront for consideration.

Nylon

Arguably the most widely recognized thermoplastic, nylon is used for a variety of applications from clothing to rubber reinforcement, ropes, threads and injection molded equipment components.



Nylon is very strong and resistant to abrasions, moisture, temperature and chemicals. These qualities, coupled with a relatively long life and low-friction properties, make nylon an inexpensive substitute for low-strength metals and ideal for applications that require plastic materials and high melting temperature. It is important to note, however, that high melting temperatures do not translate to flame resistance. In fact, nylon burns quickly and easily when exposed to open flame.

Nylon is often used for cost reasons, but it is not a material of sustained strength without the use of additives and fillers. On its own, nylon is susceptible to any degree of impact and brittleness from prolonged UV exposure, like direct sunlight.

For this reason, additives and fillers are often used to reinforce the material and make it suitable for military/defense applications such as wire harness connecters and assemblies, battery chargers, airbag housings and myriad switches, bearing, plugs and filters.

Particulate fillers increase modulus and electrical conductivity to improve heat and ultraviolet light resistance. Common particulate fillers include:

- Mineral
- Silica
- Ceramic
- Carbon powder/fiber
- Glass microspheres/fibers
- Powdered metal

Reinforcing fillers improve mechanical properties and include:

- Glass fibers
- Carbon
- Stainless steel
- Kevlar®

Polyether Ether Ketone (PEEK)

Polyether Ether Ketone is a high performance resin that is highly resistant to thermal degradation and attack by organic and aqueous environments. It also resists radiation and breakdown from a wide range of solvents and has outstanding electrical properties.

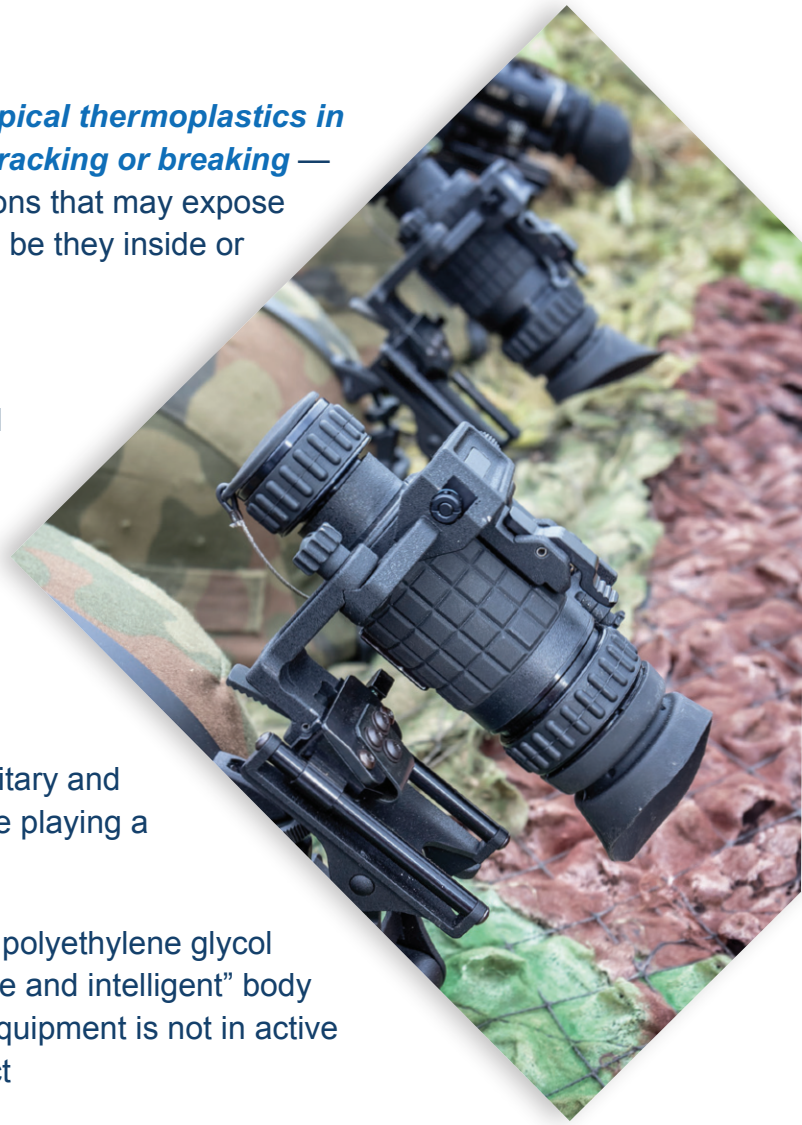
PEEK offers exceptional robustness, low smoke and gas emission in response to flame and overall environmental friendliness — a seemingly universal solution for high-temperature and/or demanding military applications like aircraft tubing systems. PEEK also presents metal-to-plastic conversion opportunities in assembly components like brackets, to speed up equipment delivery time and cut manufacturing costs.

Due to its extremely high performance characteristics, PEEK tends to be more expensive than other materials and may be unnecessary for applications such as hand-held devices that are not continuously exposed to extreme heat like that of a running piece of equipment.

When choosing a resin, it's important to not only consider the performance in final use, but also moldability and performance in the injection molding process. In working with engineers at an expert injection molder to identify the complexities of the project design, tooling and molding, you may discover design changes are needed so PEEK performs to project expectations. Why? ***PEEK is not as fluid as other resins, and its behavior during the injection molding process needs to be taken into account in the component design.***

Reinforced Polycarbonate

Reinforced polycarbonate is a departure from typical thermoplastics in that it can endure plastic deformations without cracking or breaking — an inherent advantage for military/defense applications that may expose personnel to explosions or other concussive events, be they inside or outside of vehicles:



REINFORCED VEHICLE ARMOR

Multi-layered steel/resin/fiberglass composite and matrix polymer ceramic panels have been used on tanks since the Cold War. Since then, layers of titanium, Kevlar and rubber have been added to vehicle armor to reduce weight but increase protective properties.

ADVANCED FIELD GEAR

Kevlar® has long been the standard bearer in military and public safety personnel protection, but plastics are playing a part in new approaches:

- A colloid blend of silica nanoparticles and polyethylene glycol (PEG) is being tested as a type of "passive and intelligent" body armor, meaning it is semi-viscous when equipment is not in active use, but hardens immediately upon impact
- Body suits with wireless connectivity act in tandem with explosion-resistant headgear that has advanced helmet-mounted displays, cameras and night vision to give soldiers a technological bump — they can "see" through the eyes of anything directly linked to their suits, be it a surveillance satellite or a launched drone

Reinforced polycarbonates offer clarity, heat and chemical resistance and dimensional stability. While chopped glass fiber can be added to polycarbonates to increase stiffness and improve certain mechanical properties, there is a tradeoff — particularly loss of transparency, decreased ductility and toughness, and increased melt viscosity.

Lightening the Load

Plastics are 40% lighter than metals on average, making them a better choice for a wide variety of applications, from handheld devices to armor and clothing to weapons and ammunition.

In one case cited by National Defense magazine, switching from brass to polycarbonate bullet casings enabled a machine gun manufacturer to develop a new system that reduced the overall per-soldier carry weight by nearly 50% — from 38.3 pounds to 19.9 pounds.

Plastics Performance in the Injection Molding Process

Resin selection impacts all aspects of a military/defense application, and a seemingly good fit could quickly lead to unanticipated expense, biased outcomes or completely derailed projects without input from an experienced complex injection molder, especially early in the design phase.

Only specialized plastics engineers can answer critical resins performance questions with clarity, especially those related to moldability and compatibility with secondary operations. They understand plastics' behavior in and out of the mold and can address specific events before they happen and negatively impact your project, such as:

- **Shrinkage:** Materials have different shrink rates, which has a big impact on repeatable tight tolerances and final part quality/reliability.
- **Warping:** Holding tight tolerances despite temperature swings, or when plastic parts are combined with other material types such as metals, can be a challenge because most plastics have high thermal expansion rates. Fillers can help reduce this, and experienced plastics engineers can help you find the right fillers for your application.
- **Wall thickness:** Consistent wall thickness is key to part quality and is greatly impacted by the melting points of chosen materials and mold flow pressure.
- **Compatibility with secondary operations** such as overmolding, welding, machining, drilling, cutting, or assembly. For instance, reinforced plastics can generally be welded as easily as unreinforced materials, but if the filler reduces the coefficient of friction, the weld pressure may need to be increased.

The Well-Informed Injection Molder

Proper resin selection begins with essential questions about your military/defense application from the injection molder:

- **What is the physical load?** Plastics must be impact resilient to withstand the conditions of everyday fatigue.
- **What is the mechanical function?** Plastics must be right for the rigors of the application.
- **What are the thermal conditions?** Plastics must align with fluctuating and or extreme temperatures, if necessary.
- **What is the chemical exposure?** Plastics must endure chemical hazards that vary in degree and composition.
- **Will dissimilar materials be used?** Plastics must be vetted for use of multi-shot or overmolding technologies.
- **Does the application require hot-heat resins?** These plastics are more difficult to work with mainly due to their higher melting points, necessitating careful deliberation of all aspects of the project, from safety to molding processes.

Successful military/defense applications start with proper material selection, and proper material selection starts with an experienced injection molder like Kaysun. Our team of specialized plastics engineers can identify plastics that align with your needs and budget, perform in molding and manufacture, and help military and public safety personnel work smarter and more safely in the field.

Contact us today to discuss your next project.

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