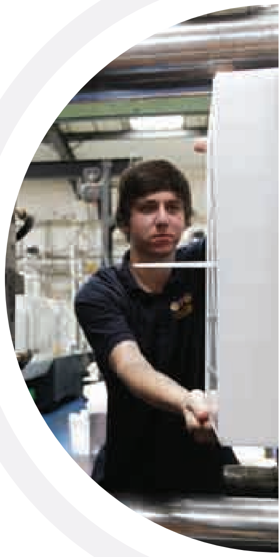

# Aerospace Services

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# Introduction

## With the advent of 'all-composite' aircraft on the horizon, plastic is the 'right stuff' for the future in aircraft design.

During the past 50 years, aeronautical technology has soared, with plastics playing a major role in the efficiency and performance of airframes, engines and structures.  In aircraft, missiles, satellites and shuttles, thermo-plastic materials have provided significant developments in civilian air travel, military air power and space exploration.

For example, when engineers look to innovate an aircraft such as Airbus's all-new A350 as well as the new 787 Dreamliner, they sought ways to enhance weight savings, improve corrosion resistance, shock and vibration dampening.  The only materials capable of beating established materials such as aluminium and titanium are polymers.

# Polymers Take-Off!

## The future for aerospace is plastic - and lots of it.

Airbus's all-new A350 as well as Boeing's all-new 787 Dreamliner provides insight into the enormous progress the aerospace industry has taken with the widespread use of composites throughout the airframe. According to James C. Seferis, a materials professor at the University of Washington, composite thermoplastic materials are "changing the paradigm of the aerospace industry, which was based on aluminum."

**So what are the key comparatives?**

## Corrosion Resistance

Polymers offer **unlimited corrosion resistance** compares to most conventional materials. Parts last longer, require less maintenance and directly reduce the overall cost of ownership.

## Vibration Dampening

Polymers are subject to **less harmonic resonance** due to their lighter weight and different attenuation properties compared to conventional materials. This is a major benefit in reducing the risk that parts will vibrate loose under the prolonged vibration common to aircraft.

## Stealth

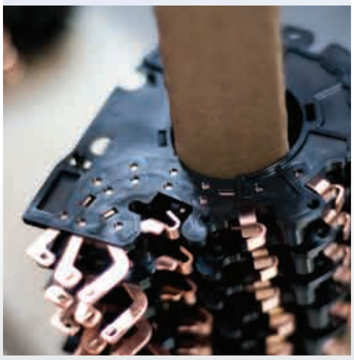
Polymers provide a **vastly reduced signature pattern**, whether magnetic, corrosion related or acoustic, compared to aluminum systems for example. The reduction in such 'signatures' can dramatically improve the survival rates of aircraft and weapons used in military environments.

## Weight Reduction

Polymers have an ability to provide **increased strength and stiffness** at lighter weights than conventional materials. The typical weight savings for thermoplastics over aluminum can be up to 40% (depending on component design). Weight savings versus other materials are even more pronounced: **60%** for titanium, **80%** for stainless steel, and **80%** for brass. For the aerospace engineer, this leads directly to smaller, lower-cost aircraft that use less fuel to perform a given mission.

# Tolerances, Temperature & Moulding

Within the **DIN 16901 standard**, there are three quality classes for moulding - general-purpose injection moulding, technical injection-moulding and high-precision injection-moulding. As one moves from general - technical - high precision, the demands on the precision of the mould increase as does the increased need for optimum production conditions and continuous quality control.



## Engineering polymers that are favoured within aerospace require precise and demanding operating conditions.

Taking **PEEK** as an example, typical melt temperatures of 382° C are required and therefore both press barrel and controls must be capable of this. A hot mould is the key to achieving crystallinity in **PEEK** parts - if the mould is too “cold” (i.e. not hot enough) the parts will have discoloration or partial translucency, and the quality of the end product will be compromised. Extensive use of thermocouples is required to verify and monitor temperature setpoints. Moulds must be specifically designed to run high-temperature materials with draft, finish, undercuts and steel types all factored in from the beginning. Insulator plates between press platen and mold clamp plates are a must.

As well as high process temperatures, thermoplastics are affected by service environment such that thermal expansion and tendency to absorb moisture need to be carefully controlled, as both play a crucial role in theoperational reliability of a part in service. With semi-crystalline materials, post-shrinkage must also be taken into account. This phenomenon, which is influenced mainly by injection moulding conditions, can lead to dimensional changes in finished parts after demoulding.

Combining extremely high temperatures with the increased precision generally required by aerospace parts means that few moulding companies have the process control capability to produce technical or high-precision components to any satisfaction.

# Polymers in Aerospace Applications

Polymers, or plastics, are created by subjecting various chemical and oil-based ingredients to pressure and heat in a sealed environment. The polymer is conditioned by specific chemical additives that control performance criteria such as flame resistance.

High-performance applications such as aerospace require strength and thermal resistance as primary characteristics. Thus many aerospace applications must use "engineering plastics" or other specialized, high temperature polymers.

Engineering plastics such as **Polyetherimide (PEI)**, **polyphthalamide (PPA),** and **polyphenylene sulfide (PPS)** are designed specifically for use in high operating temperature environments. Resins such as **polyetheretherketone (PEEK)** and various **liquid crystal polymers (LCP)** are also capable of withstanding extremely high temperatures. These later, high-performance plastics also meet stringent outgassing and flammability requirements.

Generally speaking, thermoplastic resins that can be melted within injection moulding machinery are preferred for aerospace parts. These have shorter processing times than thermosetting polymers such as epoxy and can be reheated and reformed repeatedly if required. Examples of engineering polymers are below.

## Ultem® (PEI)

**Ultem® (PEI)** is an amorphous thermoplastic available as pellets for injection molding. The material combines high performance with good processing characteristics and offers a combination of high heat resistance, high strength and broad chemical resistance. Ultem performs in operating environments up to 192° C long term and 210° C short term. Ultem meets ASTME595 (Aerospace Material Standards) outgassing requirements, UL94 flammability requirements (which is now harmonized with IEC 60707, 60695-11-10 and 60695-11-20 and ISO 9772 and 9773), as well as zero halogen outgassing requirements.

## Amodel® (PPA)

**Amodel® (PPA)** is a primarily semicrystalline thermoplastic available in pellet form for injection molding. Amodel resins have excellent mechanical properties - strength, stiffness, fatigue and creep resistance - over a broad temperature range. Amodel offers higher operating temperatures than Ultem: up to 200° C long term and 260° C short term.

## Ryton® (PPS)

**Ryton® (PPS)** is a high temperature, injection molded material. It has good mechanical properties and excellent chemical resistance at elevated temperatures. Different grades are available including glass filled and glass/mineral filled versions. As a semicrystalline material, Ryton exhibits excellent resistance to prolonged exposure to high temperatures, up to 260° C. Ryton also provides outstanding resistance to a broad spectrum of aggressive chemicals and has very stable dielectric and insulating properties. Ryton is very sensitive to moulding conditions and must be processed properly to achieve its maximum potential. Ryton meets ASTME595 outgassing requirements and UL94 flammability tests.

## Torlon® (PAI)

**Torlon® (PAI)** provides exceptional strength at high temperatures and excellent resistance to chemical solvents. Torlon is also very wear and friction resistant which makes it an ideal material for mechanical retention components such as anti-decoupling springs and contact retention springs. The injection mouldable material is nonconductive and operates at temperatures up to 260° C. Torlon is not rated for ASTME595 outgassing requirements but meets UL94 flammability tests.

## Polyetheretherketone (PEEK)

**Polyetheretherketone (PEEK)** is a semicrystalline thermoplastic which operates at extremely high temperatures, 260° C long term and 316 ° C short term. PEEK is an injection mouldable material and can be reinforced with glass, mineral, and graphite fibers. PEEK has one of the lightest strength to weight ratios and exhibits outstanding resistance to aggressive chemicals. PEEK meets ASTME595 outgassing requirements and UL94 flammability tests as well as zero halogen requirements.

## Liquid Crystal Polymer (LCP)

**Liquid Crystal Polymer (LCP)** trade name Zydar is available in pellet form for injection moulded parts. Zydar is a crystalline thermoplastic with extremely good dimensional stability at operating temperatures of up to 321° C., which makes the material ideally suited for intricate thin wall components. The base resin can be glass or mineral filled. Zydar meets ASTME595 outgassing requirements and UL94 flammability tests.

# Overmoulded Components Dedicated to Aerospace

Many components used within airframe systems need to be encapsulated for protection from the operating environment and to provide electrical and thermal dissipation.

**Advantages include: -**

- productivity and component integration
- excellent physical properties in thin sections
- wide recognition within IEC and UL systems for electrical insulation
- stability over long periods

Overmoulded thermoplastics offer a distinct cost advantage in the “finished encapsulated part ready for shipment” due to fast moulding cycles, higher product yields, and fewer secondary operations. As well as being cost effective, encapsulated thermoplastics provide excellent toughness along with high impact strength and resistance to vibration. In addition to an extensive overmoulding capability, ENL offer speciality thermoplastic compounds to protect against electrostatic discharge, dissipate static, and protect against electromagnetic interference (EMI).

## Anti-Static Properties

Compounds can be tailored to offer electrical properties spanning the surface resistivity spectrum from 100 to 1012 ohm/sq. Anti-static and conductive plastic compounds have a number of advantages over metals or surfactant coatings. Finished parts are lighter in weight, easier to handle, and less costly to ship. Their fabrication is usually easier and less expensive due to the elimination of secondary processes, and they are not subject to denting, chipping and scratching.

## Electro-Magnetic Compatibility (EMC)

EMI/RFI shielding compounds provide “immunity” for sensitive components from incoming EMI and/or prevent excessive emissions of EMI to other susceptible equipment. These specialty compounds provide significant benefits over metals, unfilled resins, or coatings.

Typical compounds use carbon fiber, stainless steel fiber, or nickel-coated carbon fiber in a thermoplastic matrix to provide the necessary shielding. These compounds can also incorporate flame retardant additives, wear additives, reinforcements, and colorants for a custom solution to meet your exact application requirements.

# Capability Through Experience

Supported by the aerospace As9100 quality standard, **ENL** have perfected over 50 years the manufacturing processes required to meet exacting requirements. And as result, **ENL** is a partner of choice to some of the world's most respected aerospace brands.

**ENL** is proud to be associated with a wide variety of aircraft programs and manufacturers, such as the Airbus A300, A319, A320, A321, A330, A340, A350, A380, A400M programs, Boeing 737, 747, 757 programs, Concorde, Eurocopter, Bombardier and the Joint Strike Fighter program.

# Aerospace Heritage

Our technical moulding service covers the complete design for manufacture process. Using modern software tools such as **SolidWorks** and **Delcam,** we optimise parts and tools to meet the exacting precision required for aerospace.

We have strong experience in manufacturing aerospace grade parts from high performance polymers such as Ultem, PEEK and Torlon. This capability is matched with in-house tool manufacturing that ensures tools are precisely matched to part design and material to maintain the highest level of precision.

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