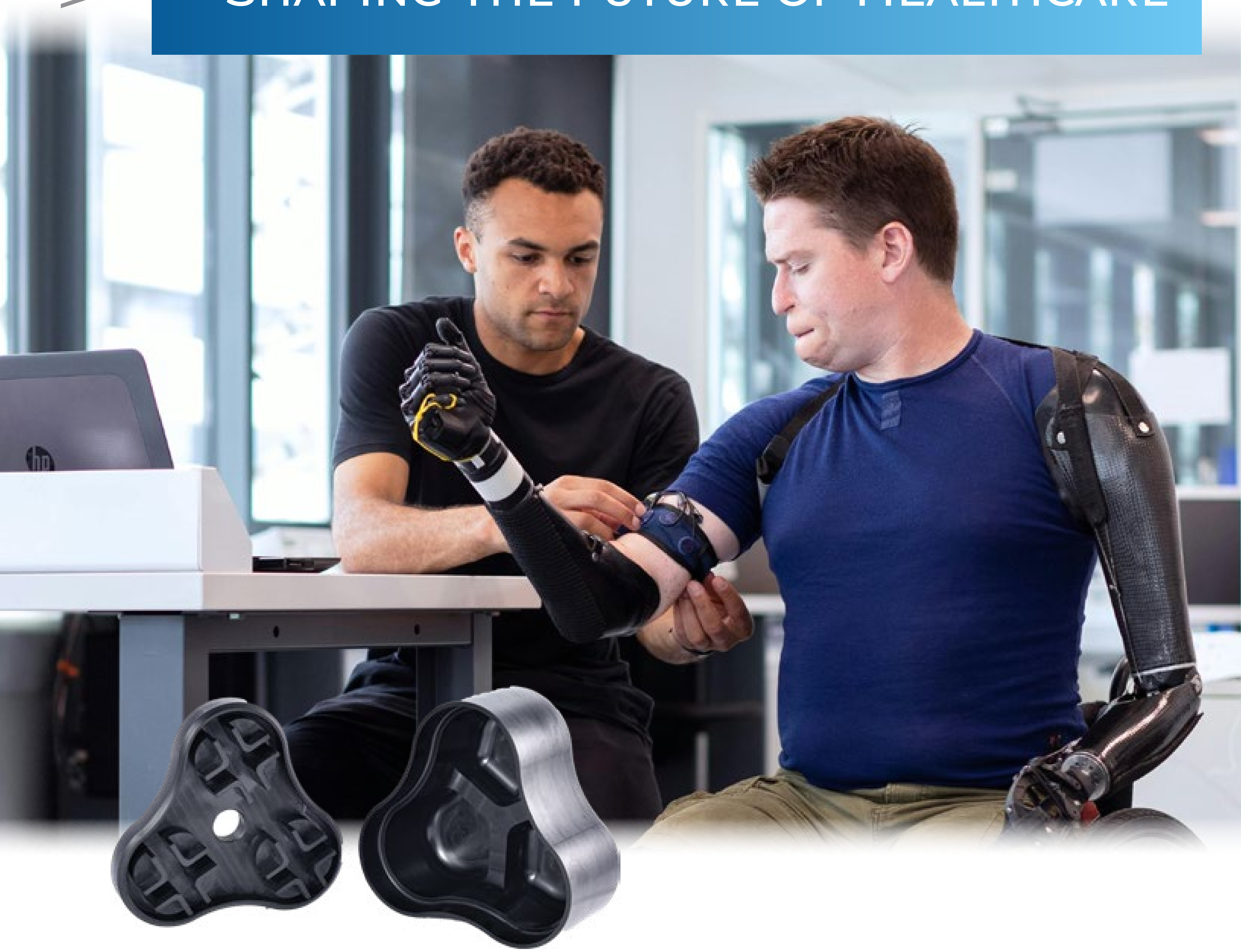
Controlled Fluidics

White Paper

ADVANCED MEDICAL PLASTICS:

Shaping The Future of Healthcare



Plastics offer undeniable convenience, shaping our routines with practical solutions from insulated coffee cups to lightweight luggage. This convenience, however, takes on a different dimension in healthcare. They protect sterile environments with packaging and gloves, ensure accurate medicine delivery with syringes, and sustain lives with heart valves and dialysis machines. Devices and components such as these often tip the scales in life-threatening situations and can directly save lives.

The Rise of Plastics in Medicine

The evolution of plastics in the healthcare industry represents a remarkable journey. Initially, plastics entered the medical scene as alternatives to more traditional materials like glass, which was prone to breakage, and metals, which were heavy and sometimes corrosive. These early plastics offered cost savings and versatility. Yet they soon revealed benefits that went far beyond those of their predecessors.

Today, advanced medical plastics are integral to the healthcare landscape. Their adaptability has led to innovations such as lightweight prosthetic limbs that mimic the strength and resilience of bone and heart valves that can endure the demands of the human circulatory system. The capacity of these advanced plastics to undergo highly precise machining enables the creation of smaller and more specialized medical devices. This then enhances patient comfort and surgical precision among several other benefits.

The Versatility of Plastics

Plastics offer an unmatched combination of safety, strength, and lightness. As we explore the defining properties of medical plastics, we uncover the many ways these materials enhance patient care and drive medical innovation. These also are qualities teams need to seek for their medical projects.

Biocompatibility

Biocompatibility is essential for medical plastics that contact bodily tissues and fluids, ensuring **they do not provoke adverse reactions or release toxins.** This property is vital for the safety and effectiveness of medical devices, from implants that must integrate with the body to surgical tools that interact with human tissues.

Durability

Durability in medical plastics ensures **they can endure wear, impacts, and sterilization (if needed) without losing integrity,** which is crucial for the reliability of both single-use and reusable medical devices.

Strength-to-Weight Ratio

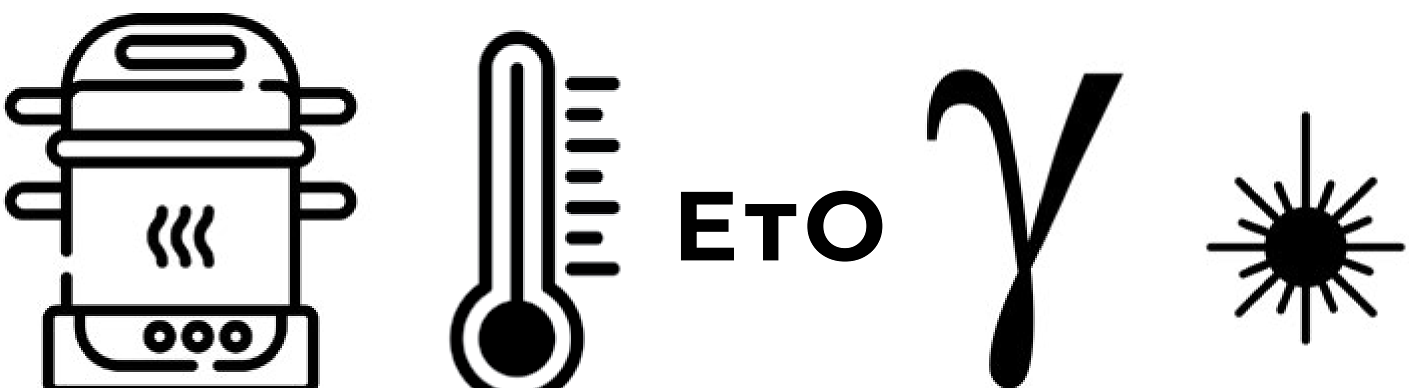
A high strength-to-weight ratio in medical plastics is key for creating devices that are **both durable and easy to handle, supporting their resilience and usability in healthcare settings.**

Sterilizability

Sterilizability ensures medical plastics can be **disinfected without damage and maintain safety by preventing infections from pathogens on devices** that come in contact with patients. This is critical for devices that require frequent cleaning to uphold rigorous healthcare standards.

It is important to note that not all sterilization methods are compatible with every type of advanced medical plastic material. Various sterilization methods exist, and some advanced medical plastics are more likely to retain functionality and resist degradation than others when subjected to them. For example, acetal is compatible with autoclave, dry heat, and ethylene oxide (EtO) sterilization methods, yet it has poor compatibility with gamma irradiation. This means that acetal, if subjected to gamma irradiation for sterilization, is unlikely to maintain functionality over an extended period. Such exposure would lead to faster degradation of the device, increasing risks for patients and medical staff.

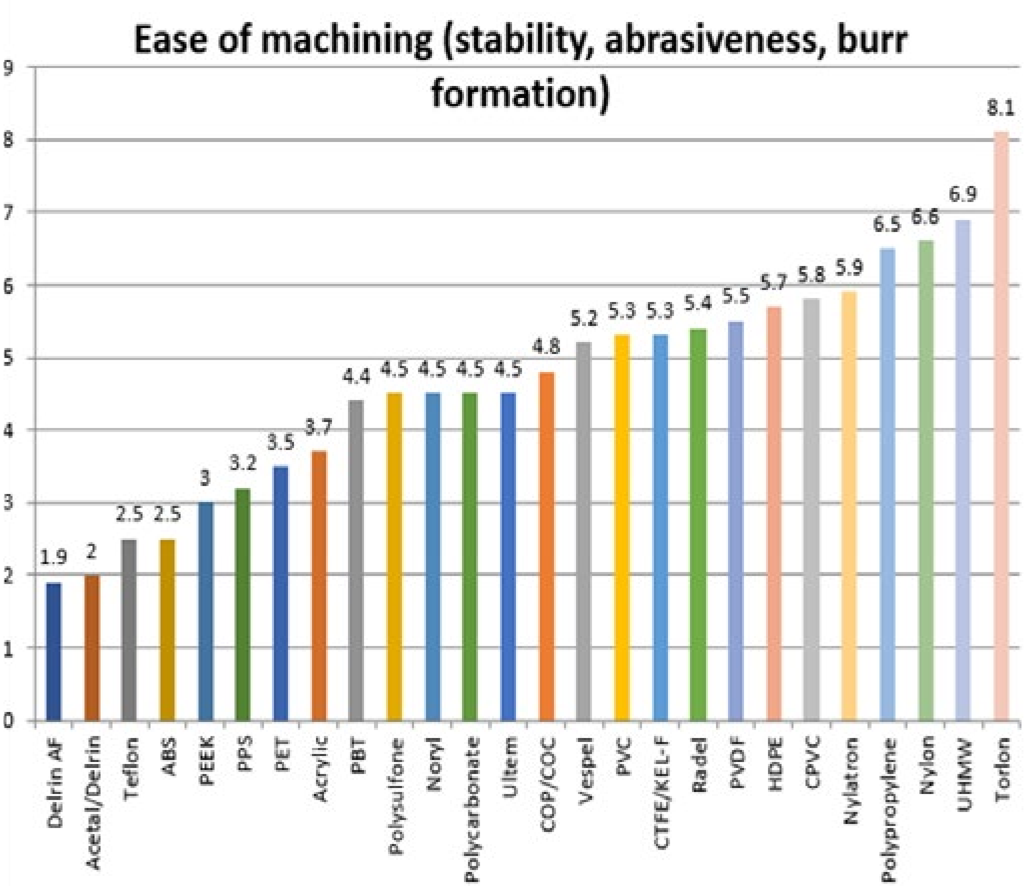
Know which sterilization method the product will face regularly. They typically fall in one or more processes:



AUTOCLAVE | DRY HEAT | ETHYLENE OXIDE | GAMMA IRRADIATION | ELECTRON BEAM

For a full chart of plastic materials and their sterilization capabilities, visit our Design Guide online at www.controlledfluidics.com/en-us/plastic-manifold-design-guide/chemical-resistance.

Ease of Machining



Graph courtesy of Omnexus

Ease of machining refers to **how easily a medical plastic can be cut, shaped, or formed into a finished product with the desired dimensions and surface finish.** Expressed as a number, this property encapsulates three important factors: stability, abrasiveness, and tendency for burr formation.

Higher numbers mean more difficult machining. Knowing this number can help in the manufacture of complex and custom medical plastic devices and components with tight tolerances, enabling efficient production while reducing waste and costs.

Radiolucency

Radiolucency allows some plastic materials used within medical situations to be essentially invisible in X-ray images. This characteristic is indeed crucial for the accurate placement and monitoring of internal medical devices such as catheters and implants. It ensures that these devices do not obstruct the view of a patient's anatomy during diagnostic imaging.

Which Plastics Are Best For Medical Use?

The table below showcases the most common types of medical-grade plastics, their defining characteristics, and the medical applications they are best suited for.

Plastic Type	Key Characteristics	Applications
Polyethylene (PE)	Easily machined, flexible, tough, affordable	Fluid handling systems, blood and IV bags, catheters, syringes
High-Density Polyethylene (HDPE)	Rigid, strong, excellent chemical resistance	Containers, surgical trays, lab equipment
Ultra-High Molecular Weight Polyethylene (UHMWPE)	Extremely durable, high impact resistance, excellent strength-to-weight ratio	Joint replacements, orthopedic implants
Polypropylene (PP)	High-temperature resistance, ease of machining, economical, good chemical resistance	Syringes, medical packaging, surgical masks and gowns, urine bags
Polyvinyl Chloride (PVC)	Clear, rigid, easily sterilized, flexible with plasticizers	Blood bags, tubing, oxygen masks, dialysis equipment, catheters
Polystyrene (PS)	Optically clear, resistant to chemicals, inexpensive	Petri dishes, diagnostic instrument housings, vials, tissue culture trays
High-Impact Polystyrene (HIPS)	Greater toughness, chemical resistance, ease of machining	Surgical instrument trays, housings, emesis basins
Polycarbonate (PC)	Optical clarity, high impact resistance, sterilizability, dimensional stability	Incubators, surgical tools, orthodontic appliances, medical device housings

Plastic Type	Key Characteristics	Applications
Polymethyl Methacrylate (PMMA/Acrylic)	Transparency, UV resistance, ease of machining, low cost	Bone cement, dentures, orthopedic implants, anesthetic masks
Acrylonitrile Butadiene Styrene (ABS)	Economical, ease of machining, rigid, good dimensional stability, chemically resistant	Medical housings, handles, fittings, instrument panels
Polyetheretherketone (PEEK)	Excellent chemical resistance, thermal stability, biocompatibility	Spinal fusion cages, trauma implants, catheter bushings
Polymethylpentene (PMP)	High tensile strength, purity, transparency, exceptional sterilization resistance	Autoclavable medical trays, boxes, films, orthopedic implants

The Pitfalls of Material Selection

Selecting the right materials for medical devices involves careful consideration of specific design requirements and broader market influences.

Early in the design process, **it's essential to assess materials against engineering needs and potential market forces, such as supply chain resilience and evolving regulations**. Beyond basic performance, engineers must also evaluate sterilization compatibility and anticipate regulatory shifts that might affect material suitability.

Missteps like poor planning for sterilization or misjudging material additives can lead to expensive redesigns or device failure. By engaging with material science experts, engineers can select materials that meet the device's purpose, ensure durability, and comply with regulations. This collaboration helps align the material choice with the device's function and healthcare market demands.

MEDICAL PLASTICS APPLICATIONS

The application of plastics is as diverse as it is critical, serving as the backbone of numerous medical devices and tools. Here is an overview of some of the uses of plastics in the medical industry:

Surgical Instruments

Surgical instruments, like catheters and cannulas, require materials that are not only safe to be in contact with body tissues but can also withstand repeated sterilization without degrading. The plastics used to produce them protect instrument integrity and shape, as any deformation can lead to inaccurate results or potentially harm patients and medical staff. In these applications, plastics enable precise manufacturing to meet the strict specifications needed for complex surgical tools that glass or metal cannot offer.

Sutures

Sutures represent a unique application where the plastics need to be strong enough to hold tissues together yet flexible enough to be tied without breaking. For certain types of sutures, the plastics must also be able to be absorbed by the body over time, eliminating the need for removal and reducing the risk of infection.

Single-Use Items

For disposables like syringes, the primary concerns are hygiene and clarity. Plastics allow for clear visibility of contents and markings, are cost-effective for single-use, and maintain their properties during the sterilization process used directly after manufacturing, ensuring patient safety.

Medical Implants

Medical implants are subjected to some of the most stringent material requirements due to their direct and long-term contact with body tissues. Thanks to some medical-grade plastics, implants mimic the mechanical properties of the body parts they replace, resist bodily fluids and tissue reactions, and remain stable and functional over the lifetime of the patient.

Dental & Orthodontic Instruments

In dental and orthodontic applications, plastics withstand corrosive substances such as sterilizing agents and saliva while maintaining hygiene. They are rigid enough to avoid deformation during procedures, yet safe for long-term oral use and offer a smooth surface for patient comfort. Aesthetics also play a role, as plastics blend seamlessly with natural dentition.

Anesthetic & Imaging Equipment

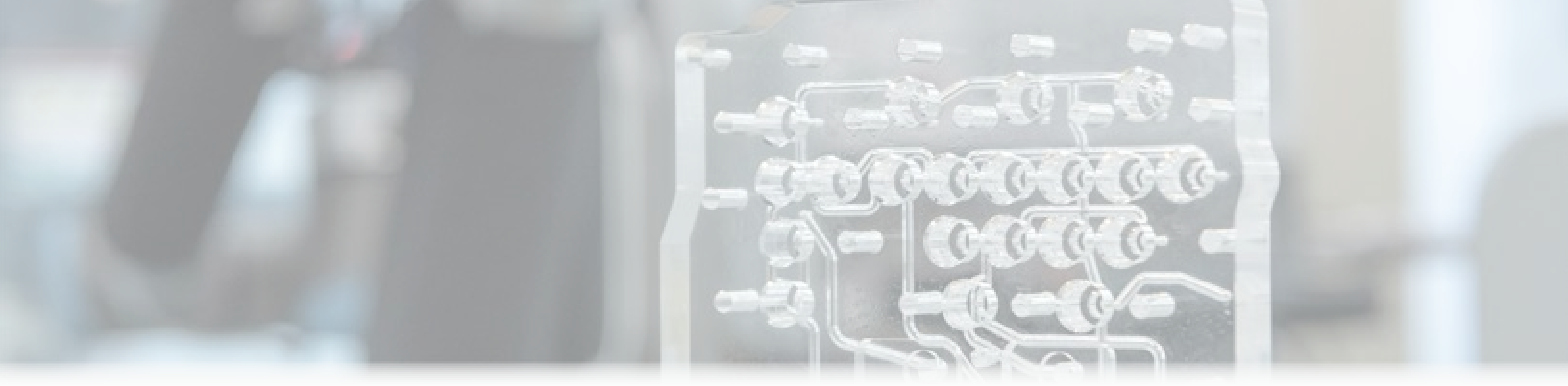
Anesthetic and imaging equipment benefit from plastics that are invisible to imaging processes, ensuring that diagnoses and monitoring are not obscured. These plastics are designed to be durable, withstanding the wear and tear from the equipment's frequent use in medical settings.

Tubing

Tubing requires materials that combine flexibility with the ability to maintain an open lumen for the passage of gases or liquids. Plastics deliver just that while also preventing interactions with the fluids the tubes carry, which could otherwise lead to complications in patient care.

Prosthetics

Prosthetics place a premium on materials that offer a high strength-to-weight ratio. Plastic prosthetics are lightweight for patient comfort but strong enough to bear the loads of daily use without failing.



HOW BONDED AND DRILLED MANIFOLDS ARE USED IN MEDICAL

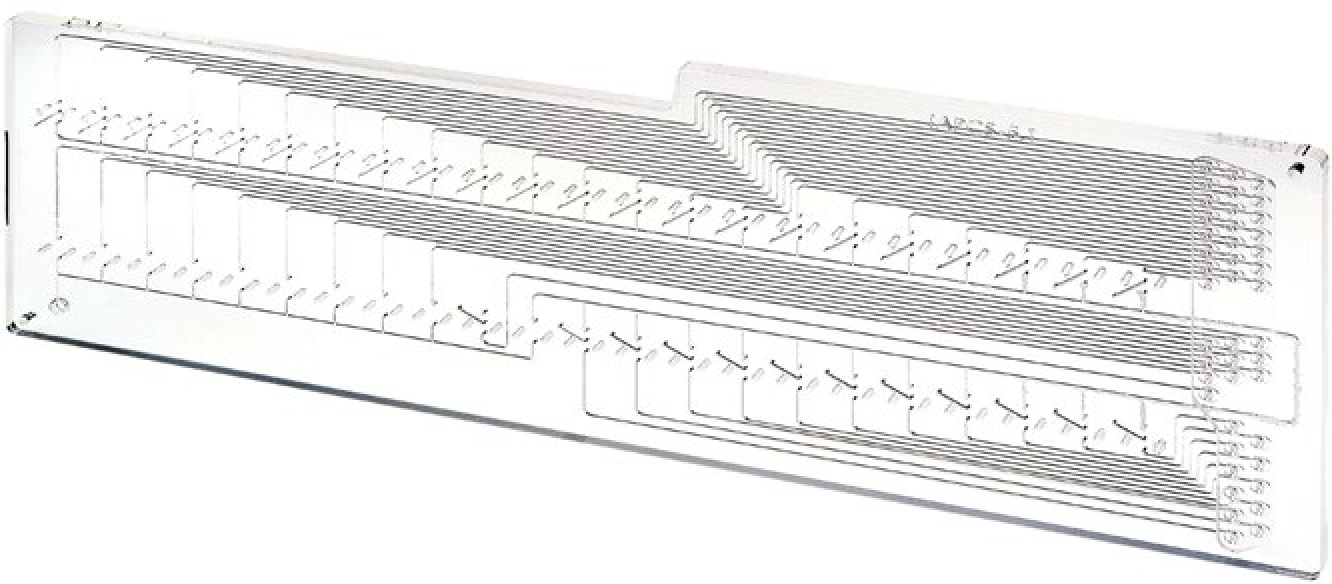
Bonded and drilled manifolds have streamlined complex medical systems and enhanced device functionality with their ability to meet highly precise and exacting measurements. Many plastic medical devices, assemblies, and components need specialized plastic manufacturing to comply with regulations and to ensure that the product fulfills its often niche purposes.

Historically, medical devices and systems that required fluid management were often cumbersome, involving a tangle of tubes, valves, and fittings. This complexity not only made the systems difficult to use and maintain but also increased the risk of failure or contamination.

Drilled manifolds, which are essentially blocks of material with precision-drilled channels and ports, began to replace these intricate assemblies. **They consolidated multiple flow paths into a single component, improving reliability and reducing the overall size of devices.** However, drilling has its limitations, especially when it comes to creating very small or complex channels.

Bonded manifolds took that simplification a step further. By layering sheets of material, each with its own pattern of channels, and then bonding them together, **manufacturers could create intricate internal pathways that were impossible to achieve** with drilling alone. This innovation has been particularly impactful in *microfluidics*, where precise control of tiny fluid volumes is crucial.

The transition to using **bonded and drilled manifolds has allowed for more compact, efficient, and reliable devices and systems in healthcare**. It has facilitated their miniaturization, leading to less invasive medical procedures and the development of point-of-care diagnostic tools.



Demonstrating Plastic Usage in Routine Medical Situations

How a New Resin Advances Diabetes Device Manufacturing

As diabetes becomes more widespread globally, the push for better management tools grows stronger. The newly introduced medical-grade resin, Valox HX325HP, is a clear example of how the medical plastics field is responding to this need.

This new resin is designed for precision in diabetes care devices, smoothly filling even the most intricate molds. It solidifies evenly, minimizing the inconsistencies often seen with other plastics. Additionally, it's resistant to chemicals, reducing the risk of cracks over time. The resin also meets sterilization standards with methods such as ethylene oxide, gamma, and steam, ensuring safe and hygienic use.

A Story of Lifesaving Medical 3D Printing

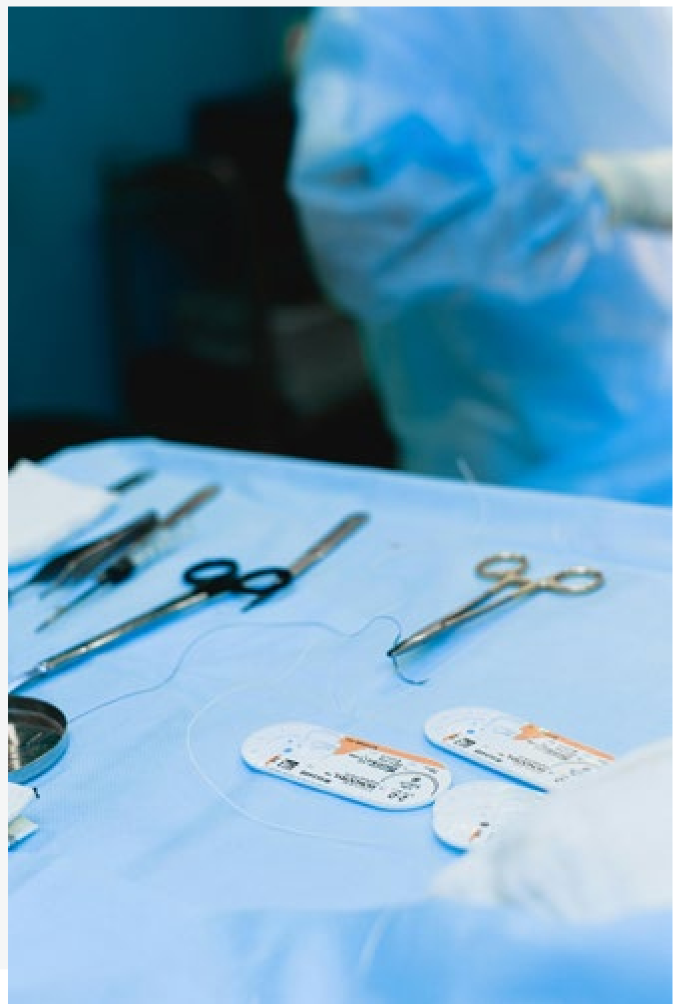
The Revolutionary Leap in Medical Plastics

The lifesaving role of plastic in medicine was vividly demonstrated in the case of Kaiba Gionfriddo, a toddler with a rare and life-threatening condition known as bronchial malacia. Traditional treatments were failing, and Kaiba's prospects seemed bleak.

Then, in a pioneering move, doctors turned to an innovative solution: a 3D-printed splint made from a biocompatible plastic called polycaprolactone. Designed to degrade over time, the splint provided a temporary scaffold to support Kaiba's airway as his body grew and healed around it. The use of 3D printing technology in this context highlights the incredible potential of plastics in medical applications.

The Disappearing Act of Biodegradable Plastics

Bioresorbable polymers, which the body can naturally break down over time, are one of the most innovative developments in medical science. Created to eliminate the need for a second surgery to remove implanted devices, these polymers are crafted from substances that can be metabolized by the body's own processes.

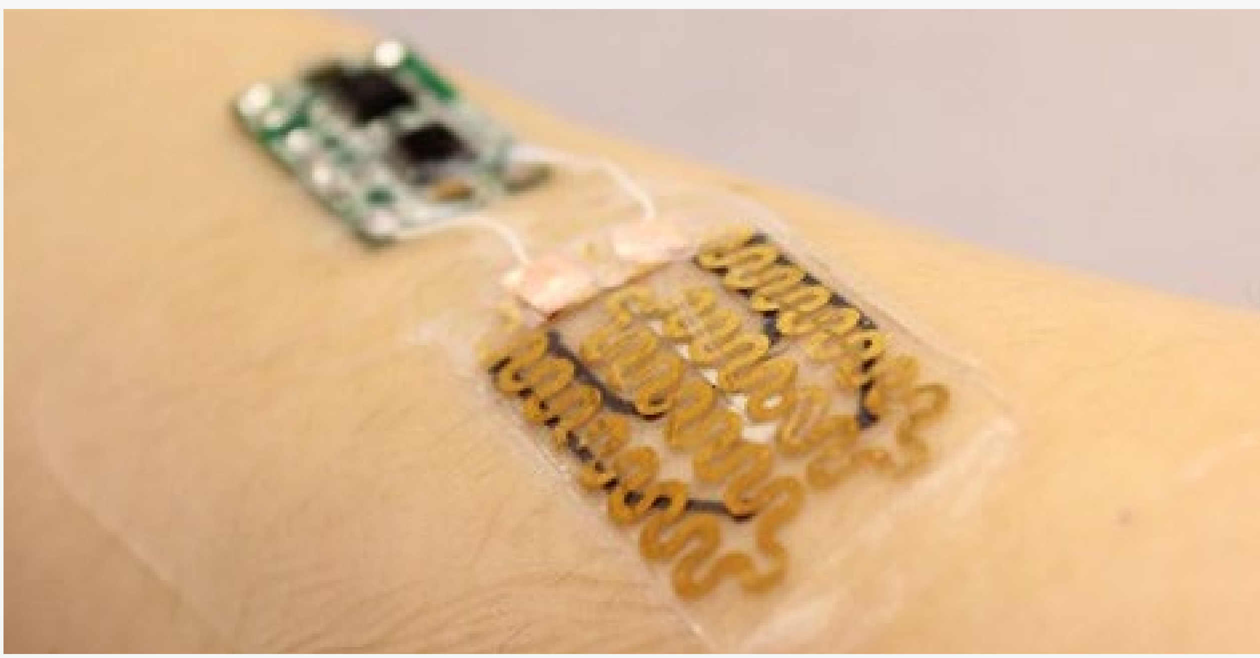


An impressive use of bioresorbable materials is found in craniofacial surgery, where they are fashioned into plates and screws to fix skeletal deformities. These devices provide temporary support as bones heal and the plastic used is gradually absorbed, leaving no trace behind. This ingenious solution simplifies the healing process, making surgeries less invasive in the long term.

Just How Smart Can Bandages Be?

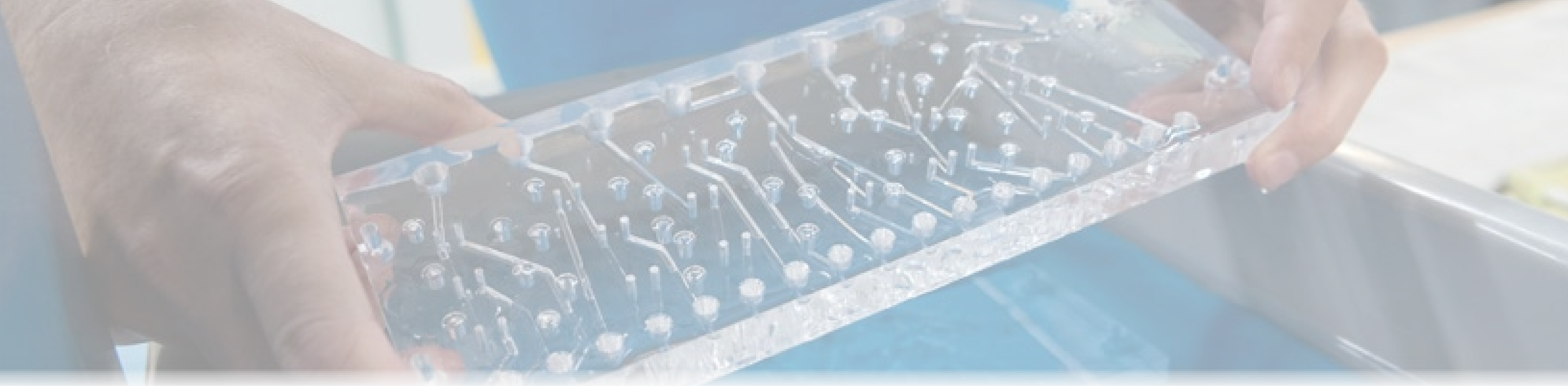
Smart bandages are transforming wound care with their ability to monitor healing, deliver targeted treatments, and even stimulate tissue growth.

Embedded with electronics within a medical-grade plastic polymer, these bandages can detect signs of infection and inflammation. They can wirelessly send this data for analysis, release medication as needed, or apply electrical stimulation—all aimed at promoting faster healing. This advanced use of medical plastics in smart bandages is a significant leap beyond traditional wound care, offering a proactive approach to treating persistent wounds.



Crafting Practice Models for Medics

3D printing has revolutionized medical training by using medical plastics to create accurate anatomical models. These models provide a hands-on experience for medics to practice procedures, from simple suturing to complex surgeries. The models can replicate patient-specific anatomy, derived from MRI or CT scan data, allowing for realistic simulation and rehearsal of surgical interventions. This technology enhances medical education, reduces the learning curve in surgical training, and ultimately leads to better patient outcomes.

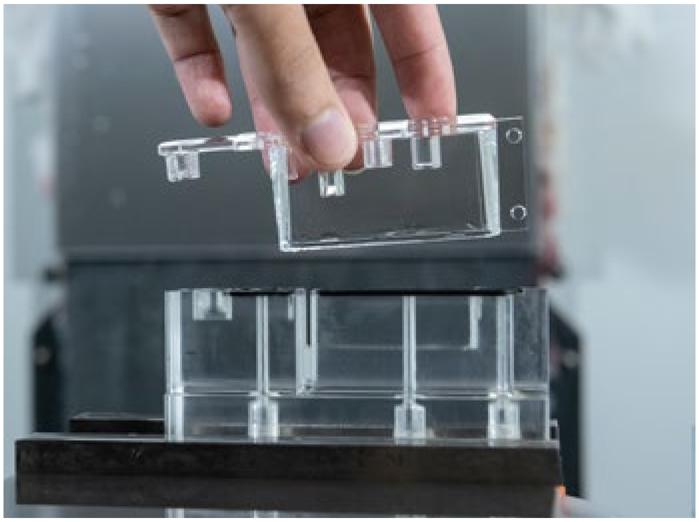


MEDICAL PLASTICS MANUFACTURING PROCESSES

Medical plastic devices, components, and assemblies are instrumental in a range of applications, providing innovative solutions from the operating room to patient recovery. These sophisticated products, however, don't just appear out of thin air—they are the result of precise and carefully honed manufacturing processes.

Injection Molding

Injection molding is prevalent due to its **efficiency in mass-producing parts with complex geometries**. Molten plastic is injected into a mold, cooled, and then ejected as a solid part. It's cost-effective for large volumes, but the initial setup and tooling can be expensive and might be prohibitive for small runs.



Advantages	Disadvantages
Cost effective for large volumes	Large initial startup cost
Great for single use products	Cost prohibitive for small volumes

CNC Machining

CNC machining involves **subtractive manufacturing** where a solid block of plastic is carved into the desired shape using computer-controlled cutting tools. This method is highly accurate and allows for customization, but it can become uneconomical depending on quantity and material used.

Advantages	Disadvantages
Wide range of materials available	Limited geometries for drilling
Consolidates complex systems	Can become costly for large volumes

Additive Manufacturing

Additive manufacturing, commonly known as 3D printing, **builds parts layer by layer from a digital model.** It's excellent for prototyping and customization, allowing for complex designs that would be difficult or impossible to achieve with traditional methods. However, it can be slower and more costly per unit than other methods, depending on quantity.

Advantages	Disadvantages
Shorter lead times	Expensive for large batches
Improves breadboarding	Cleaning is difficult

THE FUTURE OF MEDICAL PLASTICS IN AN EXPANDING INDUSTRY

As the medical device industry expands, driven by a rise in chronic diseases and an aging population, the role of plastics is set to grow steadily. **Their inherent versatility and capacity for innovation position plastics as a cornerstone for future developments in healthcare.** Staying informed about the latest advancements in medical plastics is crucial for those aiming to improve patient outcomes, build customer trust, innovate new products, and modernize outdated systems. For companies and healthcare providers alike, keeping a pulse on plastic technology trends is essential for staying ahead in an increasingly competitive and dynamic industry.

Controlled Fluidics: Your Expert Partner in Medical Plastics Manufacturing

When crafting medical devices and components, choosing a manufacturing partner with specialized expertise in medical plastics is crucial. Controlled Fluidics stands out as a leader in precision plastics machining, particularly renowned for their bonded manifolds critical in fluidic applications. With a customer-centric approach, Controlled Fluidics ensures satisfaction through responsive service, expert guidance, and adherence to tight timelines. Our commitment is echoed by our customer testimonials, praising the exceptional quality and surface finishes of their work.

Get In Touch!

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