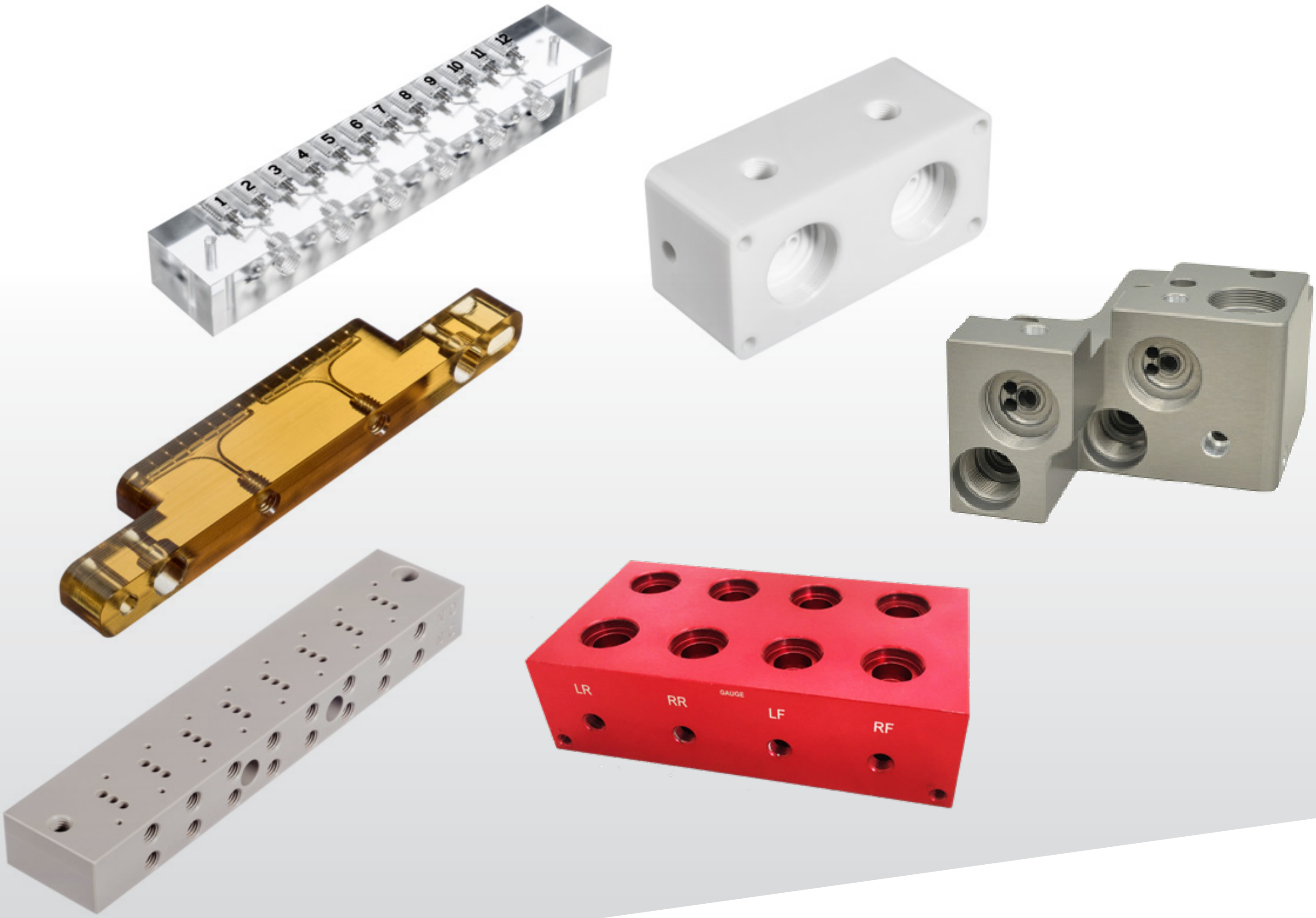
Life Science

IMI Precision Engineering

WHITE PAPER

Selecting the Right Manifold Body Material for Your Fluidic Application



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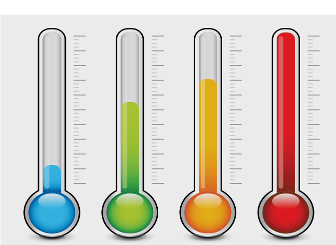
Manifolds used in life science fluidics can offer significant value beyond discrete tubing approaches to system design. Manifolds provide a more compact solution with fewer leak points, easier equipment assembly and service, and lower carryover of sample. While a manifold approach to design can offer greater flow path flexibility, careful consideration is necessary in selecting the optimal manifold body materials to address functional requirements, cost, and aesthetics.

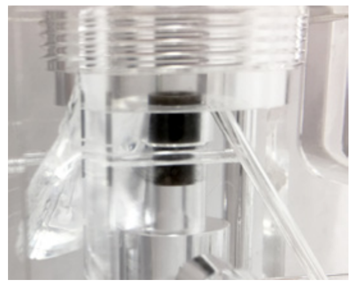
Performance: Functional requirements

When selecting manifold body materials, designers must be confident that materials will hold up the fluidic system's environmental conditions and specified tolerances. One of the most important considerations in manifold material selection is chemical compatibility.

Engineers must be familiar with all medias that may contact the manifold wetted path. If only mild aqueous solutions or inert gases enter the flow paths, engineers have a broad range of choices in manifold body materials. If aggressive solvents or corrosives will enter the system, more chemically inert materials are required to ensure long term functional performance. Engineers must also be familiar with the sensitivity of the application as it pertains to outgassing or leeching of manifold body materials into the sample flow path. In some applications, this may be of little concern, however, many analytical devices are sensitive enough to detect these contaminants and thus will corrupt instrument readouts.

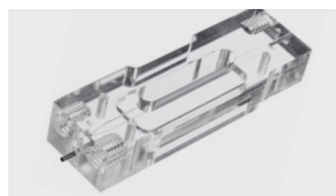


Media and surrounding temperature is another important consideration when deciding what materials are suitable for manifold body assembly. Hot gases or liquids used in an application will drive design constraints towards more thermally suitable materials to avoid heat-induced distortions or weakening of the manifold fluidic channels. Thermal conductivity of the manifold material may also be a consideration to either insulate or conduct media temperature from outside environment. Pressure requirements also influence material selection to ensure that channel distortions or critical failures do not occur. Thin wall conditions, flow channel spacing, and plenum volumes are all factors that will impact the maximum operating pressure of the manifold.



Stress fracture from excessive force of a press fit

Other mechanical forces also need to be considered even if not directly related to the fluidic path. Forces endured from components such as fasteners or if the manifold is also a structural component of the broader system, require designers to investigate the mechanical properties of the body material to ensure it will not crack or bend under these forces.

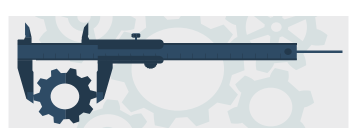


Flow cells require optical clarity for instrument functionality

Optical clarity is another constraint that may be part of the manifold material selection process. Certain applications in life science require this for visual analyses or laser interrogation of sample as with flow cytometry.

This window of interrogation must be optically clear for the system to generate an accurate signal.

While this can be achieved using a quartz insert, target, and a coverslip overlay at the interrogation site of the manifold, this insert must be adhered to the larger manifold body. Often this is done with UV cured adhesives. These adhesives must be miscible with the manifold body to ensure a strong, reliable bond.

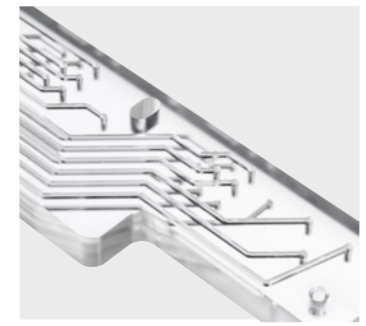


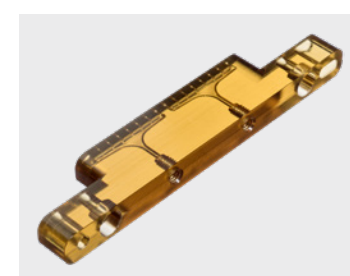
The ability of the manifold to hold tolerances specified in the design will also drive material selection. Softer materials tend to be more difficult to hold to tighter tolerances in microfluidic system design. PEEK, CPVC, PMMA and PP are favorable for holding tighter tolerance and dimensional stability, holding tolerance gets more difficult with POM, and becomes very difficult with PTFE and PVDF. Small hole drilling in SS is difficult due to tool wear and machine time, where Aluminum or Brass are much easier. The more ductile the material, the more difficult it is to maintain tight tolerance. Overall size of the manifold is also a design constraint.

A simple machined manifold may satisfy all the functional requirements of the fluidic system however, with size constraints, a layered manifold approach enables a smaller footprint through more compact channels. A layered manifold brings with it additional decisions in material selection including bonding methods of layers.

Cost: Material, and fabrication, and volume

After functional requirements are met, engineers must review the remaining material options to decide what will make the most economic sense considering not only direct raw material cost, but also costs of fabrication, post-processing, and production forecasts.





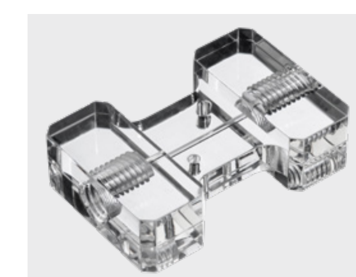
Raw material selection will of course, have a direct impact on cost. The more exotic and versatile the material, the more expensive these materials tend to be. If the volume of material used is low and the unit production of the manifold is also low, this may have a limited impact on the overall system cost. However, larger manifolds with higher unit volumes demand more cost scrutiny of materials. While there are well-known chemically inert materials used in manifold design such as Polyether ether ketone (PEEK) and Polytetrafluoroethylene (PTFE), other materials such as Cyclic olefin copolymer (COC) can be less expensive and still offer good chemical resistance to a wide array of medias used in life science applications such as mild acids and alcohols. Further investigation into mid-level chemical compatible materials may reveal that chemical compatibility requirements are addressed at a lower price point.

Labor costs associated with materials also greatly impact the overall cost of the design. The materials used may require post processing in manifold fabrication to ensure quality and thus drive up cost. Take for example the comparison between two thermoplastics, PEEK and Polyetherimide (PEI). Both materials exhibit good chemical compatibility across a wide range of medias, and both can withstand high temperatures making them both suitable for a wide range of applications. PEEK can pose challenges in post processing with manual deburring over PEI which requires only minimal hands-on efforts in annealing.

If high volumes are forecasted, injection molded production of the manifold can make sense to reduce labor associated with machining parts. Some materials are more suitable than others for this process. For example, a high-volume project that requires an extremely chemically inert flow path may compare production using PTFE vs. PEEK. PTFE cannot be injection molded whereas PEEK can. Therefore, high volume production for chemically inert systems may favor PEEK as the manifold body material of choice.

Aesthetics: Achieving the right look and feel

Fluidic systems are often behind the scenes to end users, and thus the aesthetics may be overlooked. However, component appearances may be important enough to warrant additional post processing efforts for a more finished look. Flame polishing of acrylic bodies create a more transparent glass-like appearance, anodizing of aluminum parts displays a more decorative durable appearance, and passivation or plating of stainless steel parts provide corrosion resistance. With these additional efforts, end-users who service their own equipment see a finished product free of blemishes or corrosion. Even tucked away under the equipment's hood, looks matter.



Manifold body material selection is driven by functional requirements. From there, it is a series of cost trade-offs based on material, labor, and production scale up forecasts. Finally, it's question of aesthetics. When well executed, this approach to manifold body selection delivers functional, reliable manifold body materials at the right price that look great.

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