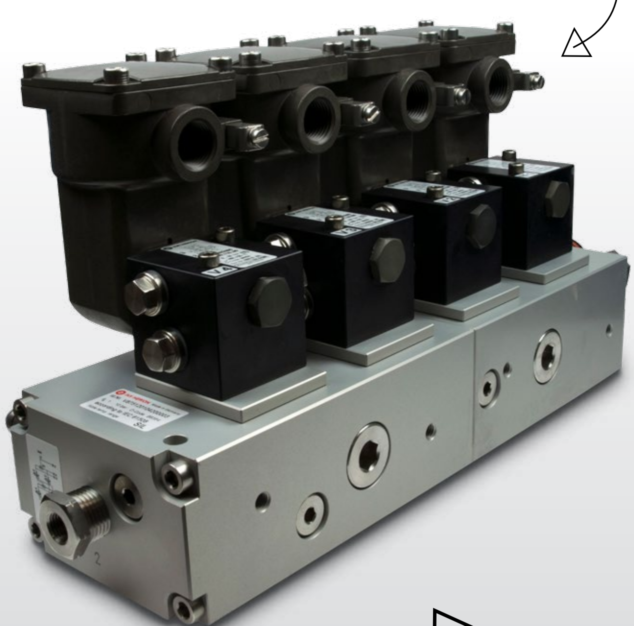
IMI NORGREN

WHITE PAPER

Manifold Assemblies
Simplifying valve installations

Cost effectiveness

Easy of assembly



Engineering GREAT Solutions

IMI Precision Engineering

Executive Summary

Assembling valves and other components on manifolds for integrated fluidic control systems helps oems design and build more compact, reliable equipment, often at lower cost and in less time. Today's laminated acrylic manifolds add light weight, optical clarity and increased design complexity to this list of advantages.

This white paper describes different types of manifolds, their advantages and applications illustrated with examples of assemblies designed using norgren's own engineering advantage capabilities.

Why Manifolds?

Machine reliability, ease of assembly, smaller footprint and cost-effectiviness are all advantages of using manifolds.

Manifolds provide a platform for integrating solenoid valves, pressure switches, check valves, regulators, gauges and other components into one fluidic assembly. An integrated assembly gives OEM designers and end users several advantages.

Reliability

Mounting components in a single assembly minimizes potential leak points by eliminating tubing and fittings. Reducing leaks makes the machine more reliable and reduces downtime as well as the cost of trouble-shooting and repairing individual components and connections.

Ease of assembly

A fluid control system can comprise several dozen valves and components. Each of these has to be mounted and connected.

In contrast a manifold sub-assembly with components already mounted is ready to be plugged into a machine with just a few connections. This significantly reduces assembly time and labor costs while also reducing the possibility of connection errors.

Smaller footprint

A manifold allows designers to increase the density of components and also eliminates tubing and mounting brackets that consume space. The resulting smaller footprint gives machine builders greater design flexibility and is particularly desirable for applications like portable medical equipment where compact size is a competitive advantage.

Cost effectiveness

Manifold assemblies help OEMs reduce acquisition costs and end users reduce operating costs. For OEMs, buying a manifold and components from a single source reduces time spent on finding, specifying and qualifying multiple products from multiple vendors. They save even more time and money working with a supplier who can assemble and test the system.

Many analytical applications, in life sciences for example, routinely require the use of very expensive reagents and even modest reductions can result in big savings. A well-designed manifold assembly can deliver these savings by eliminating fittings and tubing, which reduces the overall wet volume of the fluidic system.

Manifold Materials

Manifolds can be made from a variety of materials.
The application usually determines material selection.

The criteria for specifying a manifold material are:

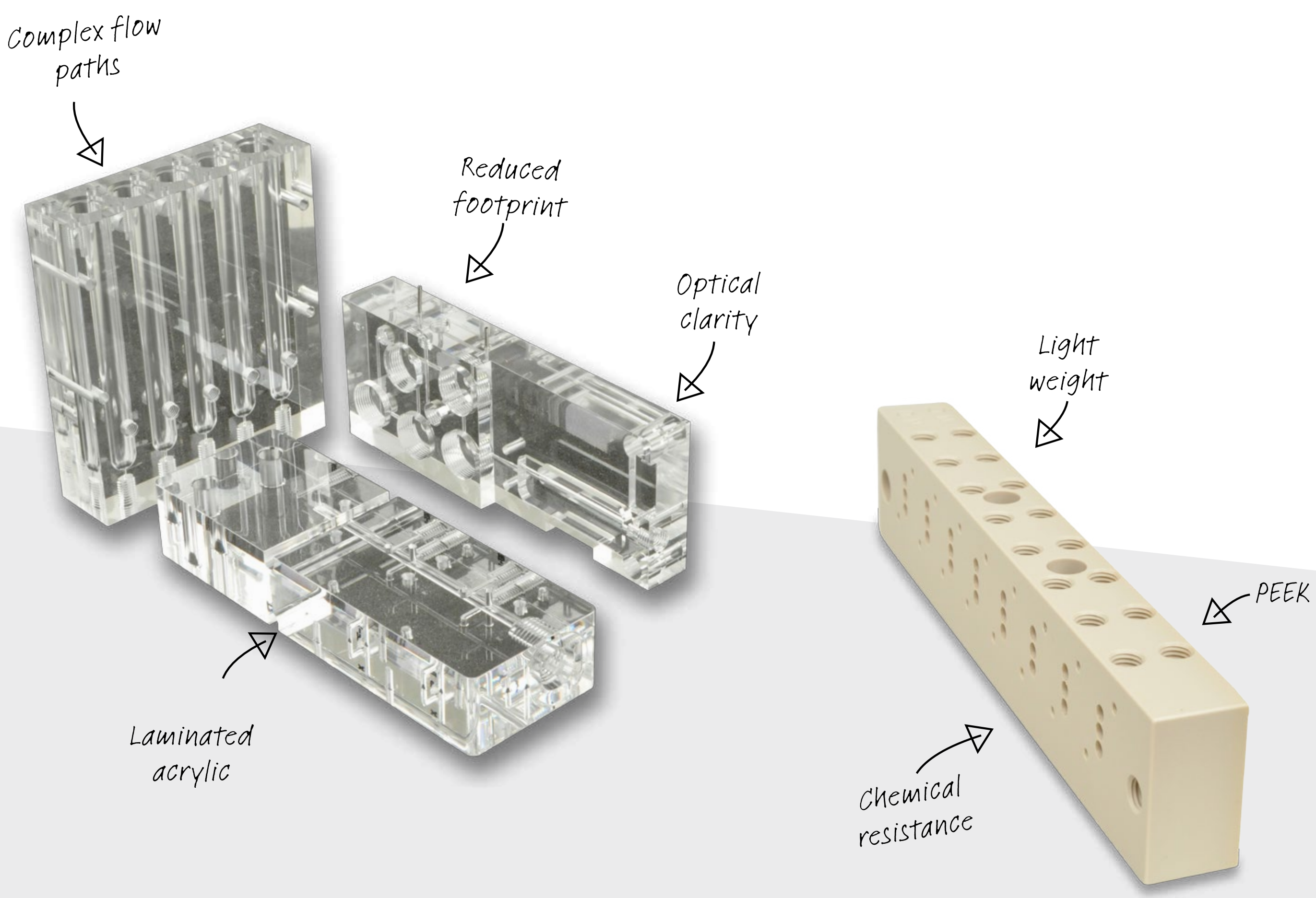
> **Media**
> Is the material compatible with the chemicals such as reagents that it will be handling?

> **Environment**
> Will the assembly be subjected to extreme temperatures? Caustics? Humidity?

> **Pressure**
> Will gases or liquids be moving at high pressure?

> **Weight**
> Does the application require a lightweight assembly?

> **Cost**
> If an application is particularly cost sensitive, which is the lowest cost material that still meets performance requirements?



Manifolds are made of materials in two broad categories: metal and plastic. Metals are typically selected for harsh environments. Common metals are aluminum and brass, though stainless steel can be used if the assembly will be exposed to environments like salt water spray or caustic chemicals.

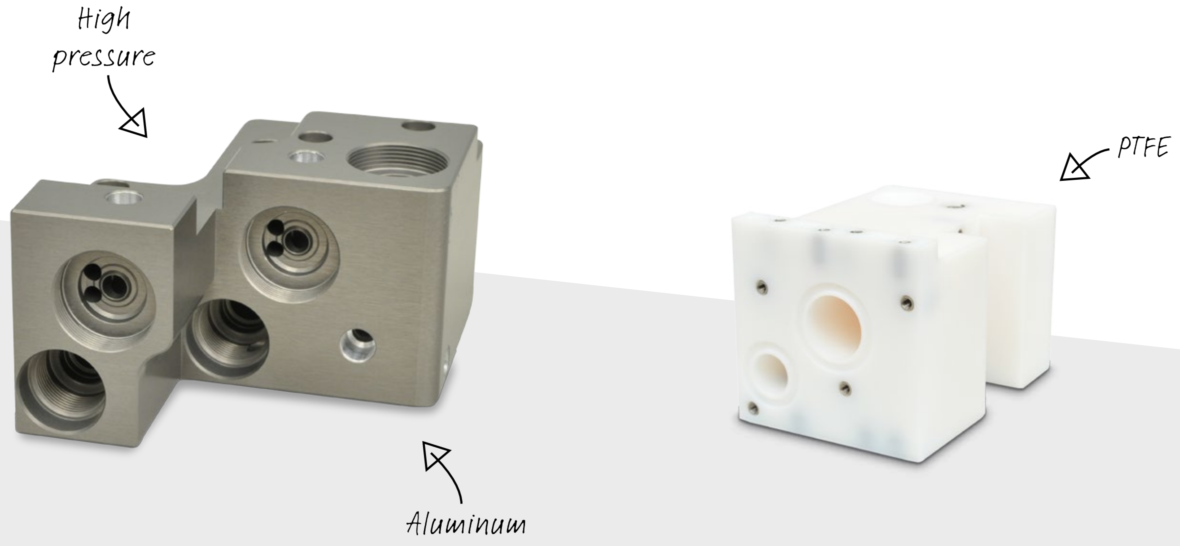
Flow paths in metal manifolds can only be drilled in straight lines, so designs tend to be fairly simple. Metal manifolds can be designed and produced more quickly and at lower cost than plastic ones. They are highly durable, making them desirable for high pressure applications and other harsh environments. Metal manifolds are sometimes preferred by users simply because they are accustomed to working with metal.

Plastics are viewed as more sanitary than metals, and so are commonly used in food and beverage, medical and pharmaceutical applications. Plastics typically deliver better chemical resistance and thermal conductivity. They have the capacity to be lighter than metal and to act as an electrical insulator. Popular extruded plastics used for manifolds include polyoxymethylene, polyvinyl chloride (PVC), chlorinated polyvinyl chloride (CPVC), acrylic, polycarbonate, polyethermide and polyether ether ketone (PEEK), among others. Several application-specific factors must be considered when selecting a plastic manifold material. Contact Norgren for design and material selection assistance.

Unlike metal, plastic manifolds can be laminated in layers. This allows the creation of multiple flow paths that can curve or turn corners. Laminate manifold materials include acrylic, polycarbonate and polyetherimide (PEI).

Acrylic is the least expensive of the three, but also has the most limited temperature range and chemical resistance. One advantage of acrylic is optical clarity, making it useful for applications where operators need to see the media moving through the assembly.

Polycarbonate tolerates a broader temperature range and has better chemical compatibility than acrylic, but it is less clear, having a blue cast. PEI is the most expensive, but has the highest heat and chemical resistance of the three, making it the plastic of choice for certain challenging applications.



Manifold Construction

Manifolds allow for the internal connection of flow paths through straight or complex three-dimensional channels

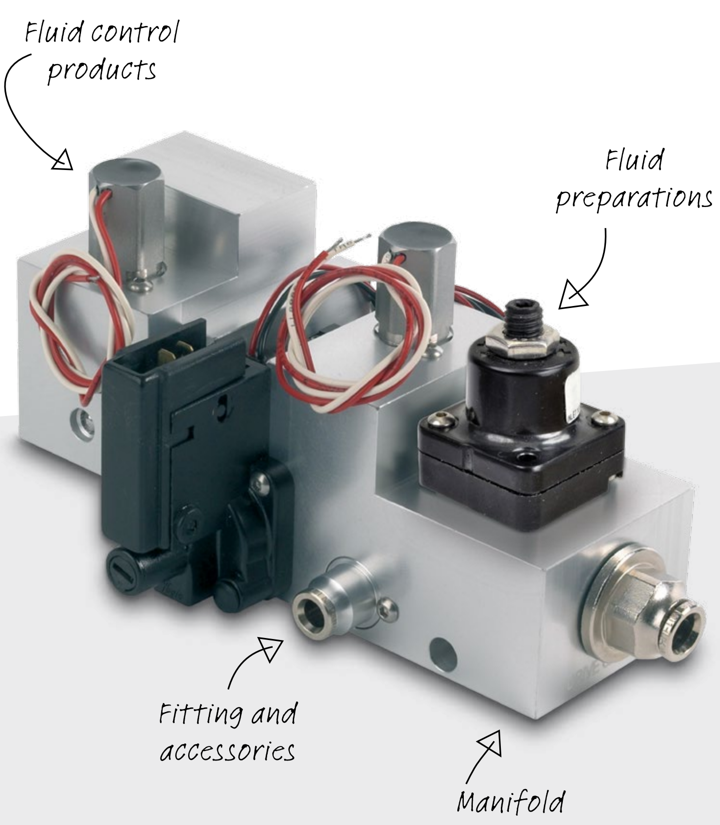
One of the benefits of manifolds is reducing the number of connections compared to mounting individual components. One way to visualize this is to think of an ice cream bar with a selection of five toppings. While each could have its own dispense nozzle, it is more efficient for the ice cream eater if the five feed into one dispenser.

In a valve manifold, the same effect is achieved by cross drilling – drilling holes that intersect so multiple channels lead to or from a single opening. One challenge in cross drilling is to keep the intersections free of debris or burrs caused when the drill passes through the manifold material into empty space. Just this little bit of material can get caught in a valve and cause a failure. The reliability of two identical assemblies can vary widely depending on the quality of the machining, and this impacts the overall reliability of the finished machine or instrument. A designer sourcing a manifold assembly should investigate the supplier’s techniques and track record for reliability.

Cross drilling is a straightforward and cost effective way to integrate multiple channels and connections into block of metal or plastic, but it has some limitations. Holes can only be drilled in straight lines and with a single diameter, so there is a limit to the complexity and dimensionality of the design. If a more complicated (or more densely populated) manifold is required, then a multi-layer laminated plastic manifold is called for.

A laminated manifold is constructed by machining the desired flow paths in layers of plastic and then bonding the layers together for the finished manifold. This process is much more flexible than drilling. It is possible to make curved channels, to change the diameter of the channel or even add contoured features like mixing or accumulation chambers right in the manifold. Increasing the number of layers accommodates more complex designs.

A supplier experienced in manifold technology can help the OEM design team select the best system based on their application requirements. For example, if they can divide functions into subsets like one assembly for pneumatic motion control and another one for liquid dispensing, perhaps two cross-drilled manifolds will be adequate (and less costly). On the other hand, if they are building a portable machine where space is at a premium, they may need a single, more sophisticated laminated manifold.



Bonding Methods

The multiple layers of laminated manifolds need to be bonded securely to create a single integrated unit. To some extent, the method used will depend on the end use of the manifold.

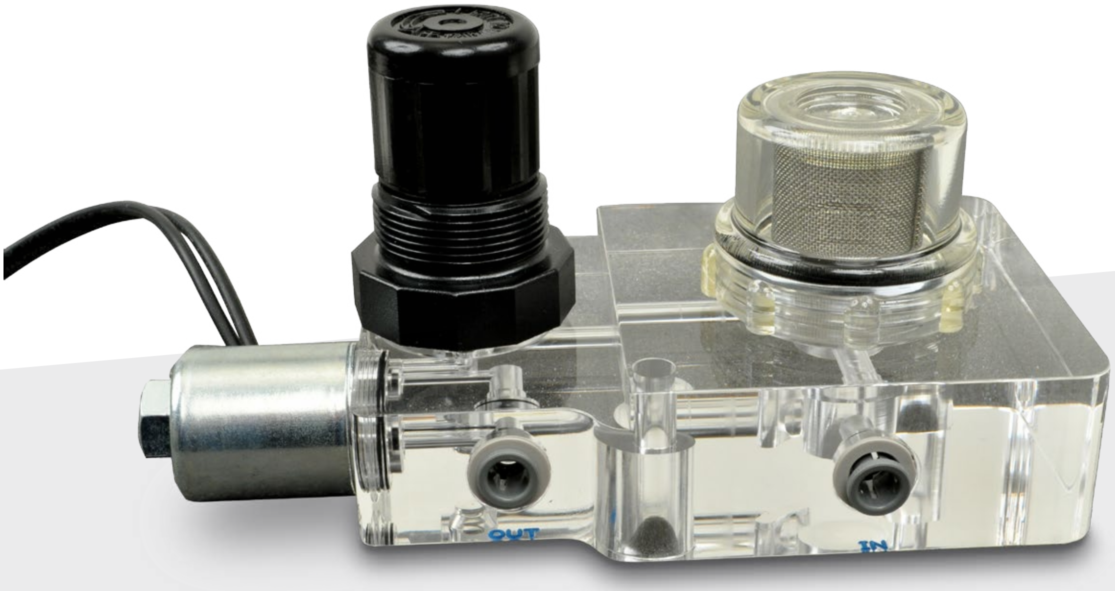
There are four methods commonly used to bond the layers of laminated plastic manifolds.

Solvent bonding

In this method, the material is immersed in solvent to soften it and then the layers are pressed together. The solvent essentially puts the material into suspension, so when the two layers are pressed together and the solvent dissipates, what is left is a single solid piece of plastic. While this protects the integrity of the material, it is quite difficult to control the manifold's dimensional stability in this process. While the two parts to be bonded are in the suspension phase, they can slip against each other, moving the flow paths and other internal features out of alignment. Imprecise bonding can contribute to the carryover and retention of contaminants and debris. Finally, air trapped between layers reduces the visual clarity of the manifold, eliminating one of the key advantages to using plastic.

Adhesive bonding

Here an adhesive interacts with the material of both layers. As it cures, it bonds the layers together. This introduces another material into the unit, which can raise compatibility issues. For example, if the adhesive has a different coefficient of thermal expansion or if it is stronger or more elastic than the plastic substrate, it can put stress on the surface. It is also difficult to control dimensional stability when adhesive bonding, as the thickness of the glue joint can vary or even leave voids. And as the parts being bonded are compressed there is a risk the adhesive will be pressed into the channels, changing their shape and size.



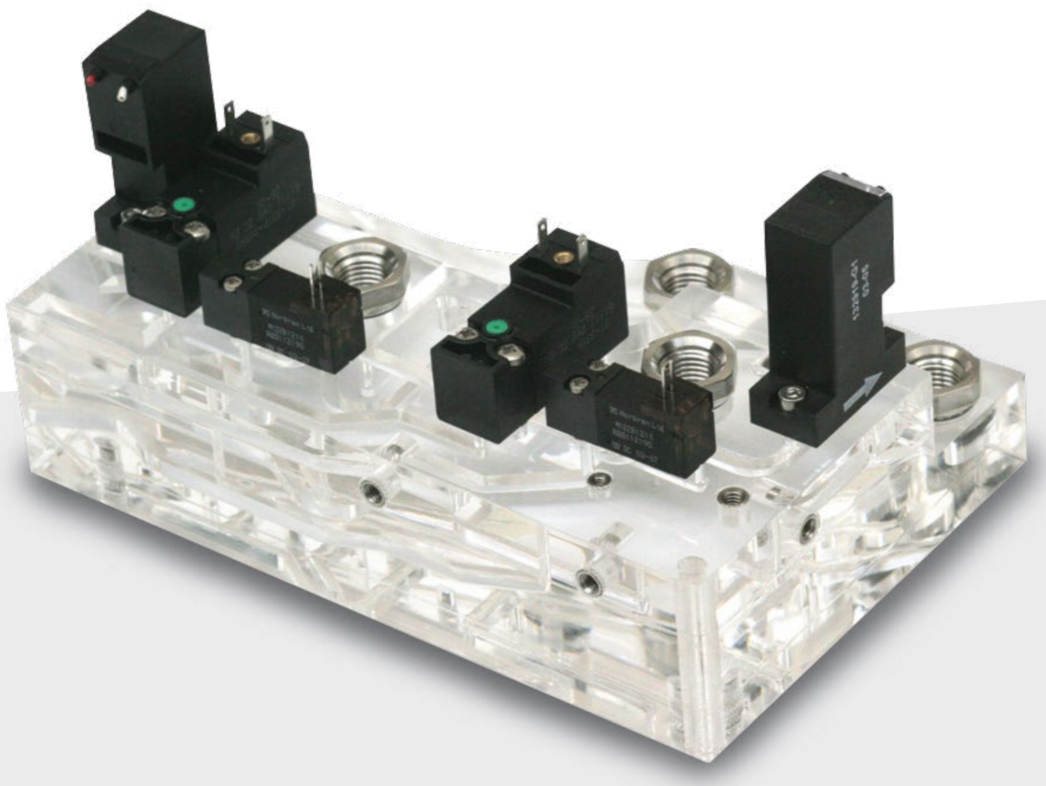
Thermal diffusion bonding

The science behind this method is that pressing two things together with enough pressure, heat and time will eventually cause the molecules of each to fuse into one. This results in a solid block of plastic with no weak spots. Pressure and heat over time can distort the shape of the channels, so it important that the pieces are machined precisely to compensate for this. The labor required to accomplish this and the time the piece must be under pressure combine to make this a fairly time consuming and costly process.

Laser bonding

The method Norgren prefers to use when building its acrylic manifolds is laser bonding. Once the pieces of the manifold are machined and cleaned, a laser absorber is applied. A laser is passed over the part for a few seconds and the light wave interacts with the absorber to generate heat in a very focused area. This acts as a "flash weld," bonding the pieces together. The absorber discolors the plastic slightly, leaving a visible clue as to where the joint was, but the material itself is burnt out by the laser, leaving no residue in the manifold channels.

Since with laser bonding the manifold is exposed to heat over a very small area for a very short time, the features machined into the plastic retain their original shape. Laser bonding results in very stable dimensional accuracy and integrity.



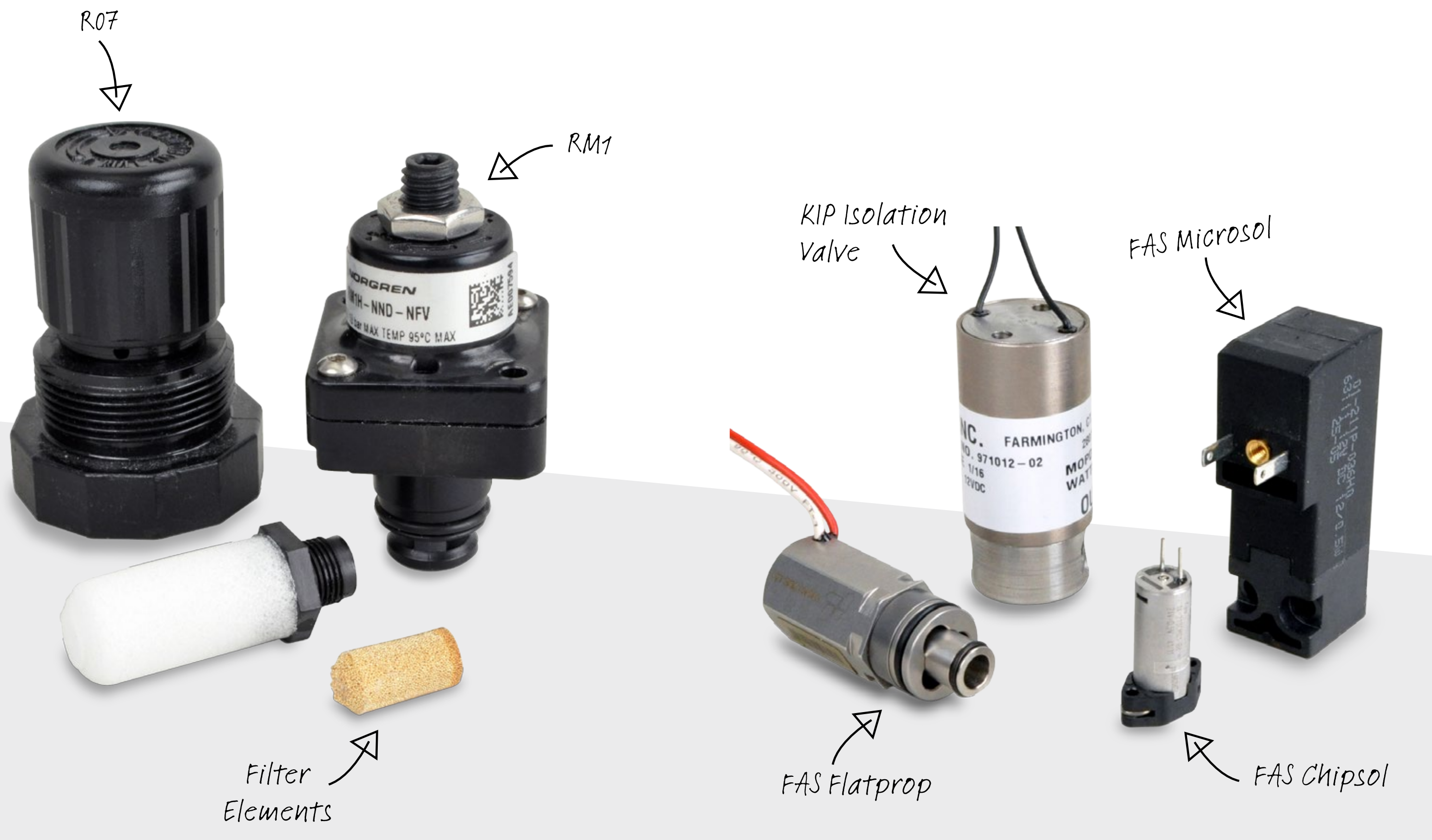
Manifold Components

Machine designers can mount the valves and accessories of their choice themselves, but there are measurable benefits to working with a supplier offering both manifold capabilities and a comprehensive line of components.

While the simplest manifold assemblies are essentially valve islands, more complicated assemblies can be comprised of dozens of components and perform multiple tasks. Besides solenoid valves, these might include regulators, pressure relief valves, proportional valves, check valves to control flow direction, and filters. The manifold itself may also include integrated tube connections that protrude from the manifold so a plastic tube can be attached without an additional fitting. One of the benefits of using a manifold is that components can be changed or replaced without disturbing any plumbing.

Some components are designed specifically for manifold mounting, saving time and increasing reliability. Typically manifold components have all the fluid connections on one face. Valves with a plug-in sub-base, such as Norgren's VS manifolding valves, make it easy to add or switch valves in the field. Other examples of Norgren components commonly used in manifolds include standard digital and solenoid valves, media separated valves, FAS Flatprop valves, the RM1 regulator and the R07 regulator.

OEMs maximize the advantages of manifolds when they work with a supplier that understands both manifold and components well enough to design and build a sub-assembly that does the job the OEM needs it to do. Relying on a supplier for an assembled and validated unit for pneumatic or fluidic control frees OEM resources to focus on their own core competencies.



Manifolds At Work Some Examples

Following Are Three Examples Of Machines Where Manifold Assemblies Designed By Norgren Solved Specific Problems.

Leveling valve manifold

A transportation application required valves that could inflate or exhaust bags in an air suspension system to raise and lower a vehicle quickly and smoothly. Norgren designed an assembly using an aluminum block manifold with three Nugget 200 spool valves operated by Webber solenoid valves. The Nugget 200 has a proven track record in commercial vehicles and rail applications over several years and the Weber solenoids were chosen for their reliability in challenging operating environments.

A design change added the requirement to stabilize the vehicle when cornering. Norgren was able to expand the existing aluminum block manifold slightly to increase the number of valves from three to five to meet this new demand. By using a manifold instead of individual valves, Norgren eliminated the need for individual piping, simplifying installation and maintenance while improving reliability

Portable ventilator/respiratory therapy device

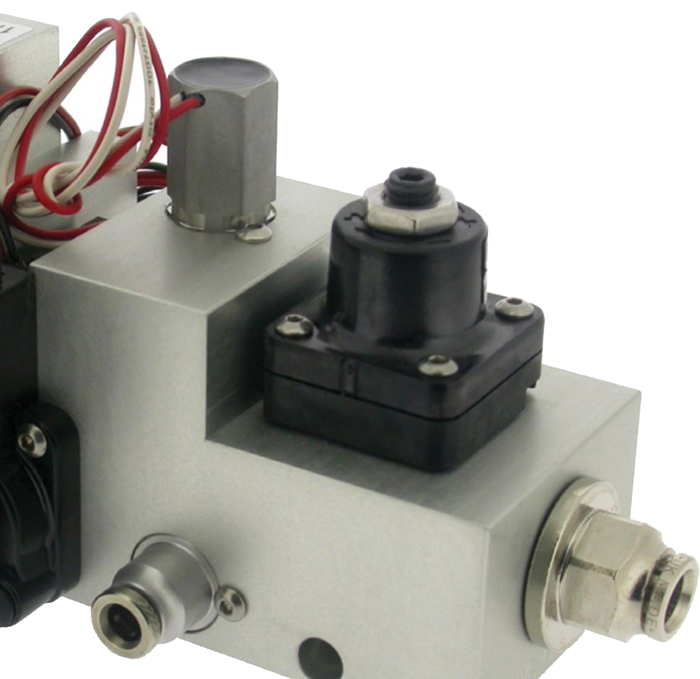
The Norgren assembly integrated an accumulator, valves, pressure transducers, a custom outlet block and a built-in filter assembly. This manifold assembly was created to fit into an unusually slim housing. Integrating the accumulator and filter allowed the assembly to fit the small footprint and also reduced weight – a key requirement in portable equipment.

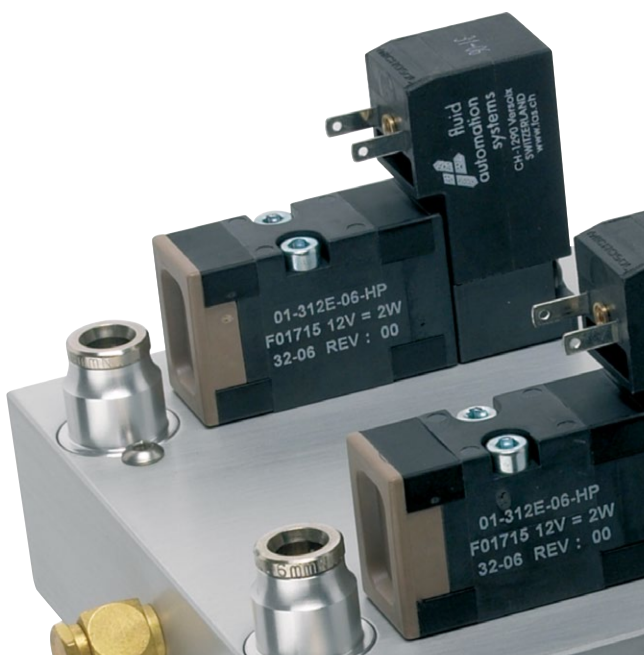
All the valves were designed by Norgren FAS for manifold mounting, so combining them with a Norgren KIP manifold delivered a single-source turnkey assembly, simplifying acquisition for the customer.

DNA analysis system

In this lab-on-chip application, the OEM needed to move small samples and multiple reagents at high speeds with high reliability. Norgren recommended an acrylic manifold because of the complexity of air channels routed to multiple locations. An acrylic laminated manifold allowed Norgren to deliver a complicated but compact structure at a reasonable cost.

The four-layer laser-bonded manifold holds nearly 60 valves, each meeting different requirements for speed, longevity and salt and moisture resistance depending on their function. The manifold had to be designed to mate with a chip, so dimensional stability was critical.





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