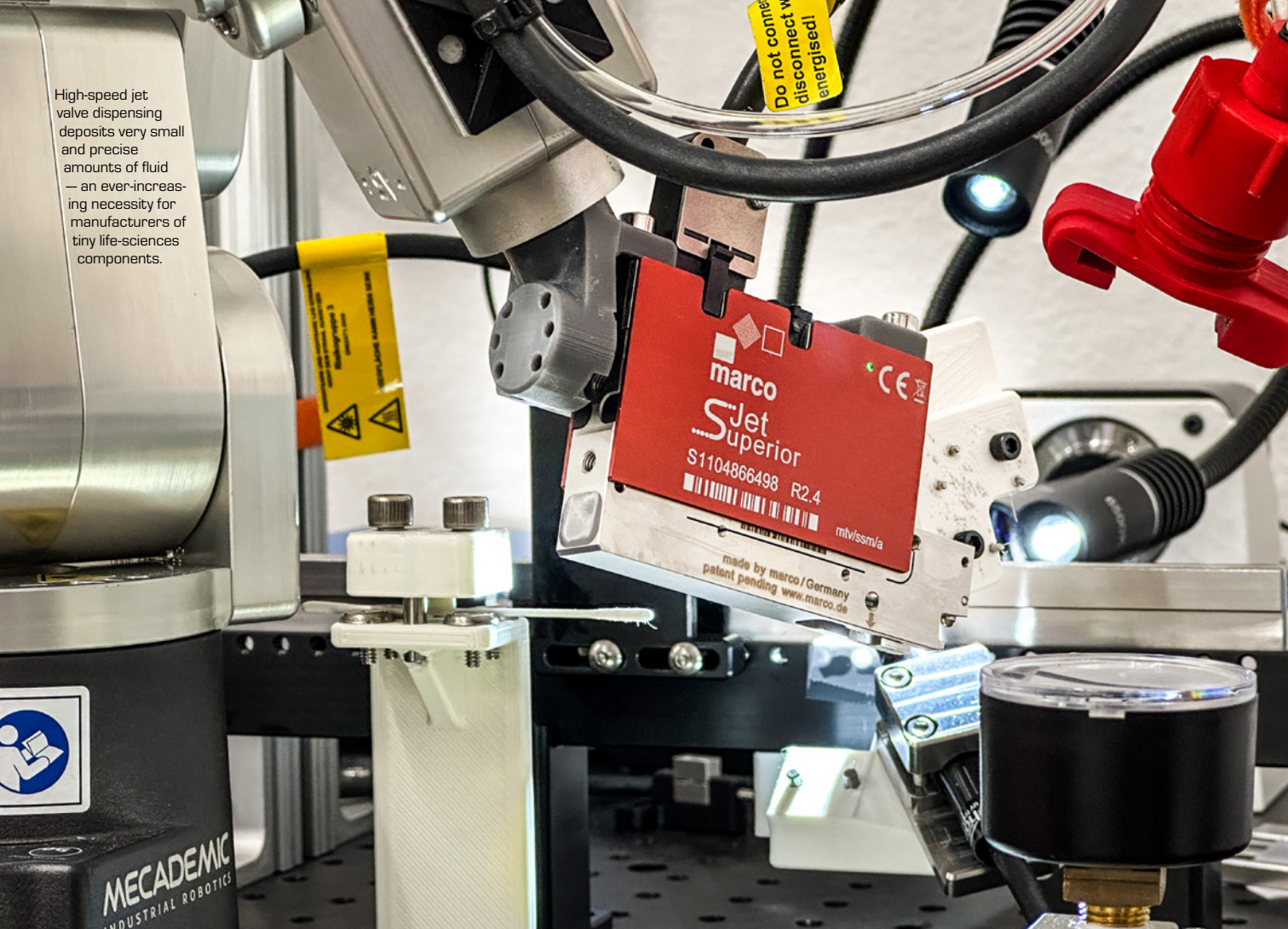


High-speed jet valve dispensing deposits very small and precise amounts of fluid — an ever-increasing necessity for manufacturers of tiny life-sciences components.



## Optimizing Fluid Micro-Dispensing for Assembly of Life-Critical Medical Components

**M**edical component manufacturing must meet stringent regulations for quality and product consistency, making process control a critical issue with materials, machining, assembly and packaging. This is vitally important with fluid dispensing applications used in the assembly of medical devices, point-of-care testing and near-patient testing products, medical wearables and other life sciences applications, which require accurate and consistent deposition of fluid amounts of UV-cure adhesives, silicones and other fluids in their manufacture.

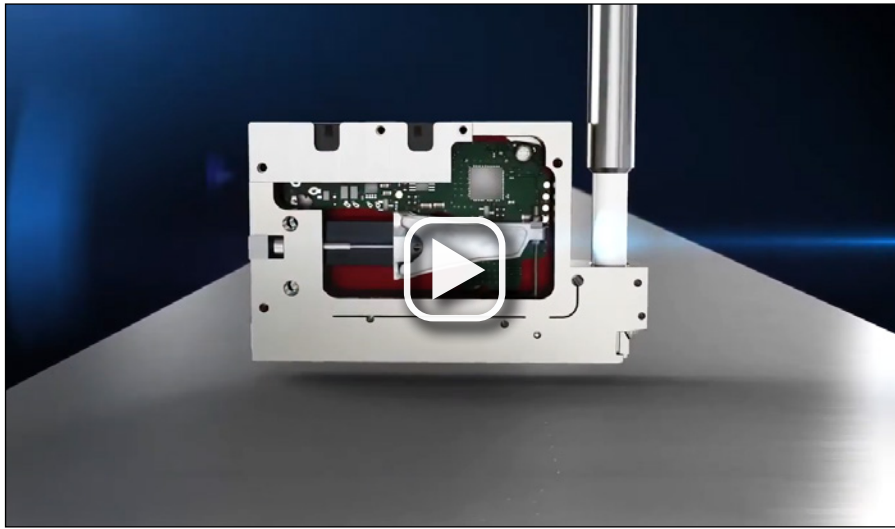
This article examines how one medical manufacturer upgraded its assembly process of life-critical components from manual fluid dispensing to more efficient automated dispensing. Marco Precision Dispensing Systems teamed up with Pipeline Design & Engineering to develop a custom micro-dispensing solution for UV-cure adhesives.

Regardless of the application, the fluids being dispensed and the dispensing technique, the dispensing method must also

meet requirements for volume throughput and cost efficiency. Increases in production volume requirements and higher yields are often the key drivers that necessitate the move to a more efficient dispensing system. It is the nature of medical components that warrant a more personalized and manual fluid dispensing approach in their assembly. The geometry of the part is often too complex to make automation a viable option. Or the production volume is too low to warrant the investment.

In most high-volume manufacturing environments, both automated and semi-automated fluid dispensing applications may be in use, dependent on the manufacturing capacity and quality standards required at any stage in the assembly process.

Many medical device manufacturers likely started out with manual squeeze bottles, toothpicks, and medical syringes for dispensing. Then, as production volumes increase, manufacturers employ more controlled approaches with precision fluid dispensers fulfilling at least part of their fluid dispensing applications.



Watch the video to see how the jetting valve process works. (Credit: marco Precision Dispensing Systems)

Following is a profile of one such medical component manufacturer that is upgrading from manual dispensing approaches to a highly automated fluid dispensing capability.

### Making the Switch

This medical device manufacturer was looking for a solution to a manufacturing assembly issue. For years the company had been manually assembling a medical component which involved gluing a very small diameter medical wire (0.014 in. or 14,000 of an inch) within a larger diameter metal tube (0.008 in. or 8,000 of an inch).

The assembly process was performed manually with technicians looking through microscopes while applying a small amount of UV-cure adhesive, drop by drop, with a crude hand-held tool. A very tedious and slow process which produced inconsistent results from operator to operator.

The manufacturer wanted to double its production. Instead of increasing the number of assembly technicians and expanding its floor space, the company was looking to automate the process, but did not have a solution identified for increasing precision and production volume. So, the medical device manufacturer elicited the help of an engineering firm to design and implement an automated production solution.

That firm was Pipeline Design & Engineering, LLC (Pipeline), which partners with engineering and manufacturing teams to translate their needs into engineering requirements, develop advanced manufacturing processes and custom manufacturing equipment to meet specifications.

“Our core strength is R&D, which is effectively developing these manufacturing processes,” says Aaron Moncur, founder of Pipeline. “We excel in developing the process and then building the automated machine around this assembly process.”

And this is indeed what Pipeline has been engaged in delivering for this medical component manufacturer — advanced manufacturing process development through automated machine building including robotics and process controls.

“Our customer engaged us in this process development phase because their internal efforts hadn’t produced the re-

sults they were hoping for, and they needed a team to focus on finding a solution,” explains Moncur. “The challenge is that everything was so small — trying to automate the precise application of glue with an industrial robot onto the tip of something that is 0.014 in. in diameter.”

“Consequently, the initial process development aspect of this project addressed the automation of fluid dispensing,” says Moncur. “To support this initial phase, we selected marco Precision Dispensing Systems.”

### Engineering a Micro-Dispense Solution

Marco Precision Dispensing Systems (marco) is a world leader in the engineering and manufacturing of products and systems used for micro-dispensing of adhesives, coatings, sealants, biomaterials and other fluids for the assembly of critical components in medical devices, electronics and other industries.

“The project involved, essentially, integrating valves, fluid systems and controls for a micro-dispense station,” says Tom Schafer, general manager, North America, for marco. “We have developed many dispense systems with UV-cure adhesives, particularly for bonding plastics in medical device assemblies. This application was similar to what we have done for other companies. We used an off-the-shelf product but have customized it for their specific application.”

The dispense parameters did involve some complex maneuvers. Each wire required several drops of UV-cure in different locations to adhere the wire to the metal tubing. A unique conical-shaped bonding between the end of the metal tubing and the wire needed to be dispensed with the UV-cure adhesive. It required some experimentation to create the desired shape correctly. Also, a UV-cure deposit in a specific geometry needed to be dispensed onto the tip of the wire, which was equivalent to building this geometry on the end of a staple.

“We were trying to find an appropriate nozzle for the size of the dispensing,” says Michael Gorman, senior applications engineer at marco. “One of the difficulties was dispensing material onto the metal tube, and then relying on the fluid to flow into precise locations. In initial trials, it would not flow into the correct locations.



Watch the video to see how to improve production through the development of advanced manufacturing processes.  
(Credit: Pipeline Design & Engineering)

Our recommendation was to rotate the metal tube and perform a second operation to create the desired geometry. To achieve that goal, we needed an extended nozzle for part clearance reasons. But we did not make an extended nozzle with a 40  $\mu\text{m}$  orifice, so we custom-developed one for the Pipeline application.”

For this project, marco specified high-speed jet valve dispensing. The ability to deposit very small and precise amounts of fluid is an ever-increasing necessity for manufacturers of tiny life-sciences components. Jet micro-dispensing meets these requirements with the capability to deposit extremely accurate and very small amounts of fluid.

High-speed jetting is made possible by piezoelectric technology, which enables this style of jet valve to dispense fluids at frequencies up to 1,200 Hz. Modular piezoelectric jet valves can be configured for multiple uses combining the benefits of high-speed jetting, piezoelectric technology, and incredible application flexibility.

### Sjet Valve

Meeting these requirements is marco’s patented Superior Jet Dispensing Valve (Sjet Valve) which permits high-precision and fast dispensing of a large variety of media from low viscosity fluids through to high viscosity or paste-like media.

“With its unique piezo drive, the valve performs fast and reliably for both non-contact and contact dispensing, with dispensing frequencies achievable up to 1,200 Hz in continuous operation,” says Gorman. “The Sjet Valve can dispense volumes as small as 0.5nl and reach drop diameters less than 150 $\mu\text{m}$  in size. It can dispense adhesives in narrow spaces as small as 100 $\mu\text{m}$ , an important feature for many applications in medical component manufacturing.”

The valve’s modular design incorporates an easy to install fluid channel (fluid body) and an easy to replace valve seat module. The media supply and dispensing channel are hermetically separated from the valve drive to eliminate contamination and ensure long life. The valve communicates via RS485 bus technology with auxiliary devices such as heaters, pressure regulators, level sensors, and real-time inspection equipment.

Wetted parts can be easily exchanged for maintenance or re-configuration of the valve hardware. The modular valve drive itself is largely maintenance and wear-free, and marco guarantees a failure-free service life of one billion cycles.

### Dispense Controls for Micro-Dispensing

For the precise application of UV-cure adhesives and other assembly fluids, precision dispensing systems must deliver consistent results. Shot-to-shot repeatability and dosing accuracy are critical factors in fluid dispensing, and of particular importance in the manufacture of medical devices. If too much fluid is applied, the longer it can take to cure, which will delay production downstream, or fluid wets into “keep out” areas resulting in contamination. Conversely, if too little fluid is applied, the part will not properly bond, again interrupting downstream assembly or causing a failure in the product and reducing yield.

“The dispensing system put in place with this medical device manufacturer is controlled via marco’s Dispensing Control Unit (DCU) which provides communication in real-time with all aspects of the dispense system,” notes Gorman. “The powerful DCU serves as a coordinating element between the graphical user interface, robot controller, and dispensing tools. The DCU adapts the recorded dispensing processes to the robot movement and the jetting valves in real time to ensure exact dispensing times and parameters. Synchronizing the valve triggering to the robot position and motion state are critical to obtaining desired results and applying the right amount of adhesive in the right position on the part.”

The dispense control software delivers a clear overview of all components and their current status. Special menus displayed on the user interface provide comfortable and intuitive control for all systems. Ten different systems can be controlled in parallel via one single terminal.

### End-to-End Fluid Management

“Part of marco’s ability to address these difficult applications is that it has developed end-to-end fluid management systems



by taking control of the fluid from storage to dispensing,” says Schafer. “It allows us to maintain and control key parameters used in the dispensing process while ensuring an optimized fluid path for properly degassed fluids.”

The fluid goes through a degassing procedure using a vacuum tank system that controls vacuum level, temperature, stirring speed, and frequency. Once air is removed from the fluid, an integrated mechanical piston pump delivers fluid to a push membrane and dispensing valve(s). This system uses mechanical force to move material through the fluid system and the fluid is never in direct contact with compressed air. This eliminates issues, such as bubbles, inconsistent dosing, stringing, and nozzle clogging that are a result of air, moisture, and contaminants being absorbed into the fluid during fluid preparation and delivery process.

For critical applications that require hermetic sealing of medicines (drug-delivery devices), fluid in an optical path (electronic displays and lighting), and high reliability electronics encapsulation (aviation, aerospace, automotive controls), proper degassing and fluid handling is necessary. For dosing applications in the nano-liter and sub-nanoliter range, the sources of variance need to be minimized to achieve the desired dosing repeatability and production results.

#### Dispense Process Verification Complete

The dispense process verification was initiated by marco in late 2022 and completed in early 2023.

“The big advantage marco was able to bring to Pipeline is our capability for dispensing very small amounts with excellent repeatability,” says Schafer. “Part, after part, after part, we can provide the same amount of material, whether that is measured by volume, mass or shape, at high speeds. This dosing capability, along with marco’s ability to custom-design solutions and process controls, creates high performance systems.”

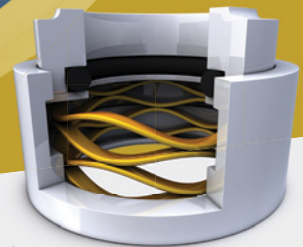
“The entirety of marco’s fluid dispense production on this project is now technically complete,” says Moncur. “Next step, Pipeline will take this dispensing process and build a production machine around it. We will use marco’s same dispenser in the production machine when it is built.”

“Working with marco was a positive experience, and the product worked exactly how we needed it to,” says Moncur. “It allowed us to design this project to meet our customer’s specific requirements. It was definitely a win for Pipeline and our medical component manufacturer.”

**This article was written by Patrick Roberts, a freelancer who writes on in-**

**dustrial, manufacturing, and technology issues. For more information on Pipeline Design & Engineering, LLC, contact Aaron Moncur, [amoncur@teampipeline.us](mailto:amoncur@teampipeline.us) or visit [www.teampipeline.us](http://www.teampipeline.us). For more information on marco Precision Dispensing Systems, contact Tom Schafer, [tom.schafer@marco-systems.com](mailto:tom.schafer@marco-systems.com) or visit [www.marco-systems.com](http://www.marco-systems.com).**

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