KYNAR® BY ARKEMA

SPOTLIGHT: VOLUME 19 NUMBER 1

Kynar® PVDF for High Purity Applications

KYNAR PVDF PLANT EXPANSION USES STATE-OF-THE-ART DEIONIZED WATER-WASHING SYSTEM FOR HIGH-QUALITY END PRODUCT

As part of its $15 million expansion designed to increase production of KYNAR® PVDF resins by 35 percent, Elf Atochem North America, Inc., has installed a state-of-the-art deionized (DI) water-washing system at its Calvert City, Kentucky, facility. This marks the fourth time the plant has undergone expansion since it was built in 1964.

Other features of the facility expansion include increased drying and extrusion capacity and a more efficient distribution control system (DCS).

PVDF has gained increasing popularity recently as an ultrapure polymer used for the processing of semiconductor and pharmaceutical high-purity fluids. Because of this, the plant needed to ensure that strict quality standards were maintained throughout the process.

The DI water-washing system at Calvert City—designed to rinse the latex which harbors the polymer—is significant because both the system engineer, Apex Engineering of Calvert City, and the subcontractor, Illinois Water Treatment (IWT) of Rockford, Illinois, chose to use piping and components manufactured from KYNAR PVDF to achieve a minimum of contaminants in the final product.

According to Roger Smith, engineering project manager for Apex, "When you are building a system for washing a high-purity polymer like PVDF, it makes perfect sense to build the washing system from the same high-quality resin."

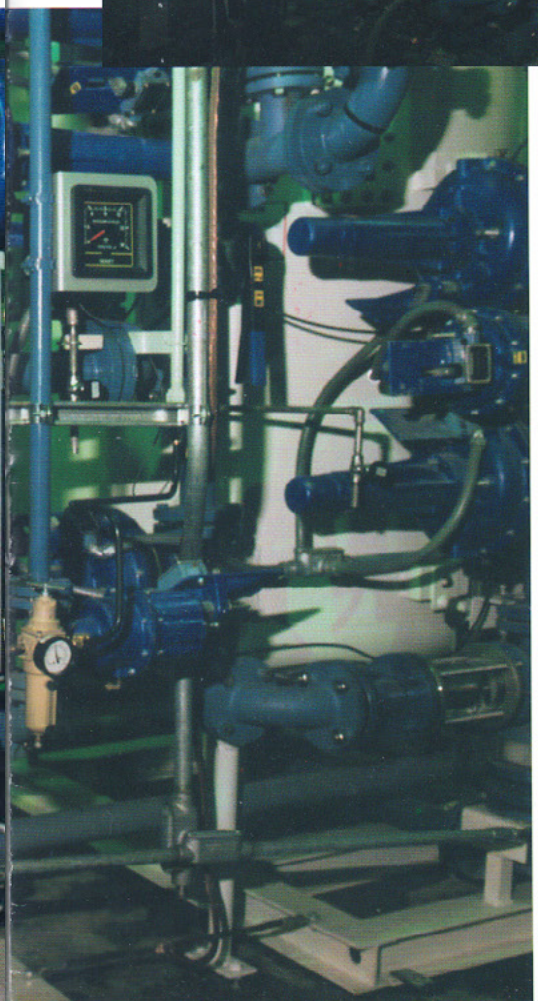
The washing system includes an ion exchange vessel lined with KYNAR FLEX® PVDF resin, which is subjected to rinses of hydrochloric acid and four percent sodium hydroxide. The vessel also uses the CSFX lining system from CIR/CO, which features a flexible polyurea-urethane adhesive that offers an added degree of toughness to the lining due to its superior impact strength at welds and its chemical resistance.

Westlake Plastics supplied its high-purity sheet made from natural KYNAR FLEX PVDF for the vessel as well as tough, fabricated spacers made from natural KYNAR homopolymer. Lined-steel piping and fittings were supplied by both Dow Chemical (natural PVDF-lined steel) and Fusibond (natural KYNAR FLEX PVDF-lined steel). The NIBCO Division of Chemtrol supplied natural KYNAR homopolymer schedule 80 solid piping for the internals of the ion exchange vessel. This allowed superior handling of the high-pressure fluids contained within the system.

For several system components, KYNAR FLEX PVDF resin was chosen over typical PVDF because of its greater impact strength at welds, ease of formation, and increased resistance to caustic wash while maintaining high-purity standards. Also, KYNAR FLEX resin offers increased pH resistance for the sodium hydroxide cleaning cycle due to the resin's inherent flexibility.

The IWT DI water-washing system is continuously monitored for trace cations

KYNAR homopolymer and KYNAR FLEX resin were each chosen due to their specific ability to provide the best product in fabricated components throughout the system.



and extractibles, utilizing a shut-off system should any measurable contamination occur.

Elf Atochem expects this new system to further enhance the performance of its line of KYNAR PVDF resins, particularly in the semiconductor, pharmaceutical, and biotechnology industries where there is a critical need to reduce all particulate contamination.

"The manufacture of PVDF lends itself to a very clean finished product, and finishing the powder separation process with a DI water wash gives the best assurance that all residual recipe ingredients and trace impurities from reaction products are removed," said Edward Bartoszek, technical manager for Elf Atochem Technical Polymers.

The DI Water-Washing System is designed to wash out impurities within the latex of the KYNAR powder. The system's piping and components made from PVDF will ensure a minimum of contaminants in the final product.

"With the DI wash of KYNAR PVDF resins, we are making an effort to obtain the highest possible purity in our PVDF resins," Bartoszek said.

The resulting DI water from the Calvert City plant has a resistivity which exceeds 18 megohms, compared to resistivity of 10 in typical pharmaceutical-grade DI water and less than one in drinking water. Eventually this value declines, and the bed must be regenerated. Normally, regeneration is required only about once a month.

Having been through many startups in the past, plant personnel experienced the usual anxiety when the new system was brought on line. The DI water system performed flawlessly from the beginning. "We came in at 5 a.m. on the day of the startup," says Jack Sturm, staff project engineer with Atochem. "We put the process on the DCS, and it took off. By 9 a.m. our batch was in spec. It was the most fantastic startup we've ever had."

KYNAR PVDF HELPS REDUCE TOCs IN THE "BLUE ZOO"

KYNAR PVDF piping is ideally suited to on-site fabrication, reducing the risk of contamination and speeding the installation process.

The Silicon Electronic Research Laboratory in Murray Hill, NJ, has become something of a legend in the semiconductor electronics industry. A major research and engineering facility of AT&T Bell Laboratories, it is known throughout the industry as the "Blue Zoo." That moniker is a reference to Bell Lab's radical move in 1972 to paint the entire lab blue to help offset the stark effect of having both white lab coats *and* an all-white lab area.

Like other laboratories involved in wafer production, the "Blue Zoo" is in the business of developing new technologies and new applications for these technologies. Because of the level of purity required in these operations, an integral part of the process is the deionized (DI) water supply system. Systems composed mostly of polyvinyl chloride (PVC) components were used beginning in 1972. Stainless steel was used occasionally for valves, tanks, and canisters. The system formed a complete Class I 18-megohm water-supply plant for rinsing chemicals from the water surfaces and returning usable water to the storage tanks for recycling back into the system.

Unfortunately, the PVC water system had one major drawback. According to Donald Raver, the "Blue Zoo's" supervisor, contamination of the water from total organic compounds (TOCs) was starting to become a problem. "The shearing action of the water flowing through the PVC system was also creating higher than desired concentrations of particulate matter."

"For larger line-width technologies, the old PVC water system was adequate," Raver said. "However, as Bell Labs began moving towards more far-reaching research work, we realized that our choice of materials for the water supply system would play a prominent role in our ability to produce high-quality, advanced submicron technology semiconductors."

In fact, Raver noted that the technology currently being developed at the "Blue Zoo" will be used well into the 21st century. Bell Labs' ability to compete technologically in the international marketplace is highly dependent on achieving ultra "fine-line" wafer technology, that is, line widths in the range of 0.1 micron and smaller.

The new water system makes use of a high-performance fluoropolymer, KYNAR polyvinylidene fluoride (PVDF), manufactured by Elf Atochem North America, Inc. (Philadelphia, PA). Unpigmented, natural KYNAR resin is one of the most chemically inert engineering polymers. Widely used in the pharmaceutical and biotechnology industries, this unique fluoropolymer is increasingly finding its way into other high-technology areas such as semiconductor electronics, involving crystal growth as well as wafer production.

Supplied by Plastic Piping Systems, Inc., Piscataway, NJ, and Ultrapure Technologies, Lafayette, NJ, the KYNAR PVDF components comprise the piping, valves, and processing sinks of the new water supply system at Bell Labs. Made by Sanitech of Sparta, NJ, these high-purity components—sold under the Sani-Pro® K tradename—are available in a variety of shapes, sizes, and styles. Designed for on-the-job fabrication and installation, Sani-Pro K tubing is easily cut to a desired length and deburred using Sani-Pro K accessories. Tube ends are formed with the Sani-Pro Flange Former, a simple-to-operate, portable machine that forms precise ferrules. They now have seamless butt connection (end to end).

The KYNAR PVDF piping in Bell Labs' system ranges in size from $^{1}/_{2}$-inch up to 2 inches. Two types of valves—manual diaphragm and three-way solenoid ball valves—are used in the installation. An important element in the system is the KYNAR PVDF tubing

which is used to contain several different kinds of corrosive acids and solvents, including hydrogen peroxide, sulfuric acid, photo resist solvents, and mixtures of hydrogen fluoride. The system uses a common process, reverse osmosis (RO), and features an output of 18 megohms. Unlike the previous system, however, the new installation will virtually eliminate the TOC contamination problem that plagues most PVC-based water systems.

Raver sees the new KYNAR PVDF installation as a kind of breakthrough. "By going with the KYNAR system, we're moving in the direction of ultimate purity," he said. "There is a huge technological benefit to by gained, namely a vastly increased packing density for our wafers."

The ability to "fine-line" toward the 0.1 micron range will give Bell Labs a number of competitive advantages and move the company much closer to its goal of producing high-density circuits without increasing the size of the chip. Raver also expects the switching speeds of Bell Labs' chips to increase dramatically as the geometries become smaller.

Besides the technological edge which will result from the new KYNAR PVDF installation, there are a number of significant manufacturing benefits to consider.

"If the KYNAR system works the way we believe it will, we should see our processing time drop considerably while our yield of working devices increases," Raver said.

He also expects the new system to provide reliable performance over a longer period of time and to help reduce capital costs since the piping can be disconnected and saved. Also, because of the PVDF resin's unique properties, the joints can be formed at a remote location and simply clamped in place as needed right in the cleanroom, usually during normal working hours. This quick-connect, quick-disconnect method of joining the KYNAR PVDF components provides Bell Labs with maximum flexibility to accommodate future changes in system design. This feature will also help in coping with any impurities that do occur by making it easy to isolate a small section of the installation.

Installation is provided by trained personnel to ensure quality.

KYNAR RESIN COMPONENTS RESIST CHEMICAL ATTACK IN OZONATION SYSTEMS

The use of ozone in ultrapure water processing has proven to be a rapid and reliable method of microbial control. Although deionization, reverse osmosis, and ultrafiltration are widely used to remove chemicals, particulate matter, and dissolved solids, these methods alone are not enough to ensure the purity needed in many critical applications. For instance, they cannot effectively control total organic compounds (TOCs) or bacteria which contaminate water storage and distribution systems. With the help of a properly designed ozone system, TOCs and microbial plate counts can be maintained within acceptable limits.

Ozone is a powerful oxidizing agent characterized by a high degree of chemical instability; for this reason, ozone must be generated on-site either electrolytically or by barrier discharge.

Ozonation of ultrapure water is considered a "clean" process and does not produce any undesirable chemical by-products. Unlike traditional chemical disinfectants, ozone dissipates from the treated water due to its own natural decay properties. Because of this, ozone is gaining increasing popularity in electronics, pharmaceuticals, and other ultrapure water-dependent industries.

However, the same aggressive nature which gives ozone the ability to attack and kill microorganisms also makes it especially tough on the materials which come in contact with it. Choosing the right materials is critical to the life and efficiency of the system. For system manufacturers like Griffin Technics, Inc., of Lodi, NJ, KYNAR polyvinylidene fluoride (PVDF) is the right choice for injection nozzles, tubing, and other constructions.

Griffin is a recognized leader in the design and manufacture of ozonation systems and related equipment, supplying electrolytic and barrier discharge systems ranging from the smallest size to the largest. According to Gaspar Lesznik, Griffin's project manager, there are only three acceptable materials for use in ozonation systems: KYNAR PVDF, high-grade stainless steel, and other fluoropolymers. The material selected depends on the customer's needs and the type, size, and overall cost-effectiveness of the system.

"KYNAR PVDF is an excellent material for all types of ozonation systems,"

KYNAR PVDF, microprocessor controlled solid-state circuity, and premium grade materials are utilized for purification processes by Griffin Ozonation Systems.

Ozone is generated and dissolved directly into the water being treated by the Membrel® Ozone Generation System.

said Lesnik. "In certain markets like electronics and pharmaceuticals it is an absolute necessity."

KYNAR PVDF resin offers important high-purity advantages over stainless steel and surpasses other fluoropolymers in terms of cost savings and mechanical strength. "In applications where both purity and strength are required," he added, "KYNAR PVDF is the ideal choice."

ELECTROLYTIC PROCESS

The electrolytic process uses electrolytic cells, containing cathodes and anodes, to generate ozone from pure, demineralized water. In the cell, water is decomposed into hydrogen and oxygen atoms by an electric current. An anode with a high-oxygen overpotential is used to encourage the formation of ozone by catalytic influence. The hydrogen waste is vented and the oxygen and ozone are fed back into the main system. The ozone itself is dissolved into the water as soon as it is formed, making it possible to ozonate ultrapure water with minimal equipment.

The electrolytic process is unique because it produces small highly concentrated amounts of ozone—normally around 16 to 20 percent—making it ideal for the level of disinfection and purification required by the pharmaceutical, electronics, and food/processing industries. This process, however, is exceptionally tough on equipment.

(continued...)

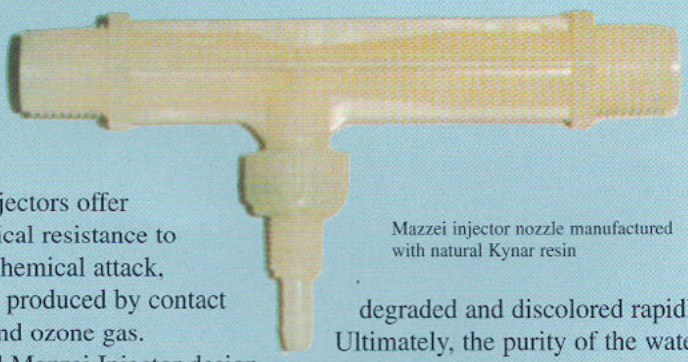
INJECTORS MADE FROM KYNAR RESIN OFFER AN EFFICIENT SOLUTION FOR ADVANCED MICRO DEVICES

An electrolytic ozonation system supplied by Griffin Technics now plays a key role in one of the highest purity water systems in the world. This MEMBREL® system, installed at the Submicron Development Center of Advanced Micro Devices (Sunnyvale, CA), offers an efficient, reliable method for controlling biological material.

Advanced Micro Devices is a leading manufacturer of semiconductor devices for the electronics industry. The Submicron Development Center makes use of the latest clean-room technology to ensure production of the highest quality wafers possible. Besides deionization (DI), reverse osmosis (RO), and ultrafiltration, ozonation is central to maintaining water purity.

An integral part of the MEMBREL ozonation system is the high efficiency, venturi-type, differential pressure injectors supplied by Mazzei Injector Corporation (Bakersfield, CA).

Molded from natural FDA-approved KYNAR PVDF, these injectors offer excellent chemical resistance to most kinds of chemical attack, including those produced by contact with chlorine and ozone gas.



Mazzei injector nozzle manufactured with natural Kynar resin

The patented Mazzei Injector design—available in many sizes—permits suction to be created with less than an 18-percent loss in pressure between the inlet and outlet of the injector. The end result is the highest efficiency injectors available for the mass transfer of ozone gas into water.

Because of the highly aggressive nature of ozone gas, using a compatible material for these injectors was critically important.

According to James McKeith, senior ultrapure water engineer, Advanced Micro Devices, "We used to use injectors made from PVC, but this material degraded and discolored rapidly. Ultimately, the purity of the water supply was jeopardized."

Injectors and other components made from PFA were prohibitive for both cost and performance reasons.

High-performance injectors made form KYNAR PVDF, similar to those supplied by Mazzei, offer superior mechanical strength and excellent resistance to the extreme oxidizing effects of ozone.

By paying careful attention to the materials selected for key components, suppliers like Griffin and Mazzei can continue to offer innovative system solutions designed for maximum performance in even the harshest environments.

"Because the electrolytic process produces the most aggressive ozone environment obtainable, KYNAR PVDF is essential for fittings, nozzles, and piping," noted Lesznik.

Griffin markets an electrolytic system, MEMBREL®, which is manufactured by Ozonia Ltd., Duebendorf, Switzerland. KYNAR PVDF constructions include all integral pipe fittings and tubing used to connect the electrolytic ozonation cells to the main system header. These fittings not only have to remain absolutely tight over many years, but they also have to insulate the cells electrically and at the same time withstand the extremely high ozone concentrations produced. KYNAR PVDF is ideally suited to meet all these demands.

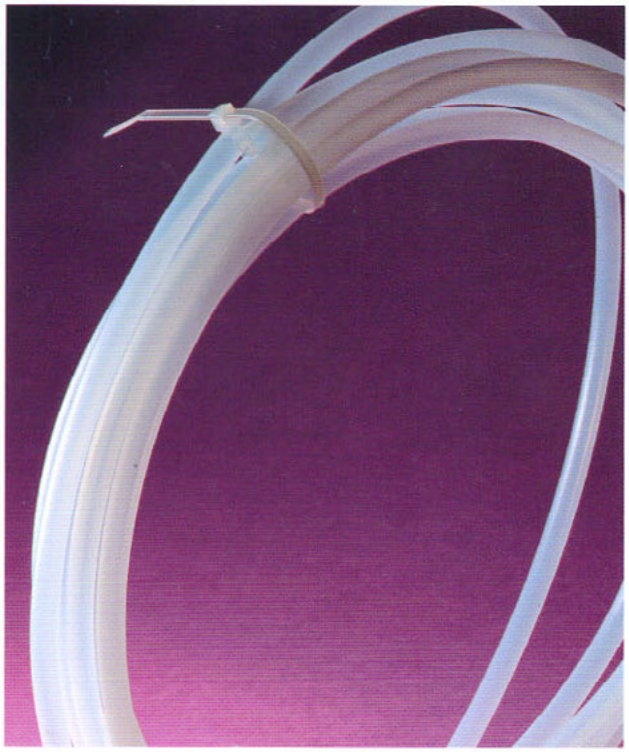
BARRIER DISCHARGE PROCESS

With Griffin's barrier discharge system, dry oxygen gas is fed into the ozone generator, passed through an intense electrical discharge, and partly converted to ozone. The ozone is then fed into the water storage tank where high-efficiency venturi injectors blend the gas with the water to be treated. Although ozone concentrations are considerably less with this process—up to 10 percent—the demands placed on the system materials are still tremendous.

Again, KYNAR PVDF provides the right combination of high purity, mechanical strength, and ozone resistance. High-performance PVDF injectors for this type of system are supplied by Mazzei Injectors, Bakersfield, CA. These are venturi eductors in pipe sizes up to 4". The internal PVDF piping is supplied by companies such as Sanitech, Andover, NJ, in a number of sizes ranging from fractional tubing to large spool pieces. In many cases the storage tank is also lined with PVDF, depending on the needs of individual customers.

In both systems KYNAR resin plays an important role because of PVDF's unique balance of properties. "The systems are incredibly easy to install and maintain, due in large part to the long-term durability of KYNAR PVDF," noted Lesznik. In fact, Lesznik cited a prototype electrolytic ozone generator in Switzerland which has been operating for 15 years with its original PVDF fittings! Now that, as they say, is performance!

Note: Membrel® is a registered trademark of Ozonia, LTD.



Flexible tubing made from KYNAR FLEX® PVDF is chemically resistant to handle the most corrosive fluids.

KYNAR® PVDF Piping and the Flo-Fusion Joining Method Used For Sensitive Pharmaceutical Applications

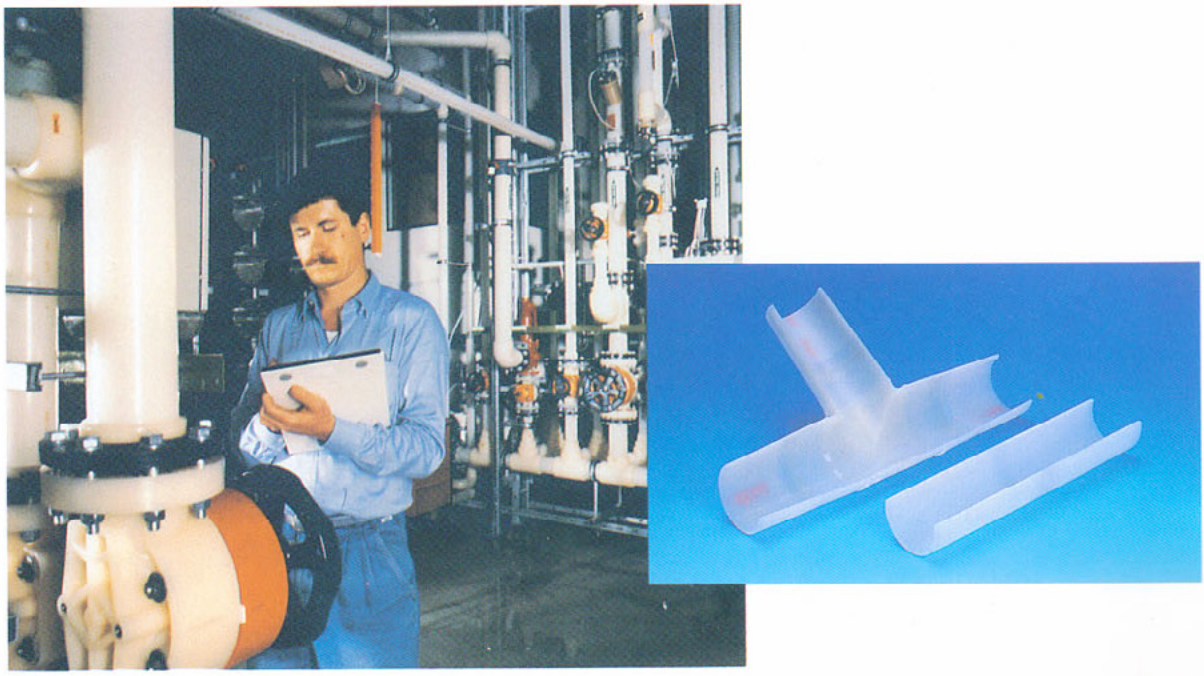
The applications of KYNAR PVDF piping in the pharmaceutical industry have been greatly increased due to the new joining method developed by George Fischer. The new Flo-Fusion process utilizes an inflatable bladder and an external heating ring to produce thermoplastic welds as smooth as the pipe walls. This new piping system is currently being used for some of the most stringent high-purity applications, including semiconductor and pharmaceutical purified water and water for injection. The new Flo-Fusion process eliminates welding beads which allow greater use of plastics to replace traditional materials such as stainless steel.

One recent application included the installation of SYGEF at a major pharmaceutical manufacturer for one of its process lines. Standard 316 L stainless steel would have been subject to corrosion, resulting in contamination problems. Design engineers decided to use the SYGEF Flo-Fusion piping after extensive in-house and independent laboratory testing.

The KYNAR PVDF piping system provided the chemical resistance and noncontamination material needed for the sensitive application. Clamp connections were used for valves and equipment tie-ins when a welded joint could not be used.

The mirror finish of KYNAR PVDF piping has been evaluated to be as inhospitable to the growth of microorganisms as polished glass. KYNAR PVDF is an ideal material for high-purity water and process applications. In addition, this mirror finish will remain for as long as the system is used. Stainless steel, which can become pitted and corroded, has a limited service life.

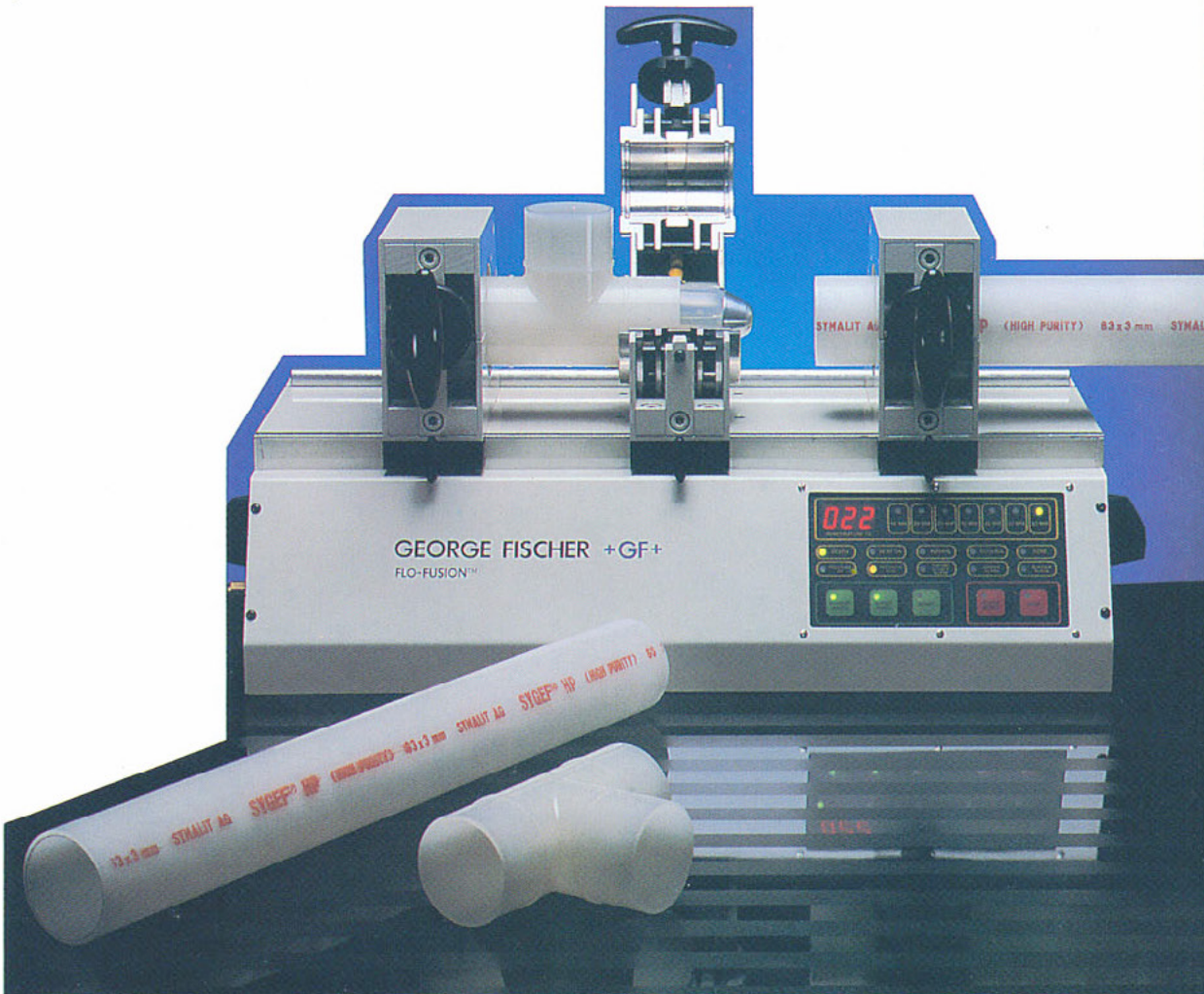
The electronics industry has long enjoyed the benefits of KYNAR PVDF piping for critical D.I. water use. The submicron densities of today's semiconductors would be impossible to achieve without noncontaminating piping materials such as KYNAR PVDF. While the pharmaceutical industry has been primarily concerned about



bacteria, the semiconductor industry is concerned about all sources of contamination. As pharmaceutical products become more sensitive to trace contaminants, more and more noncontaminating materials such as KYNAR PVDF will be used to improve design and purity levels of finished products.

Even some of the supporting industries that serve the pharmaceutical industry have learned the benefits of KYNAR PVDF piping materials. Ionics Ultra Pure Water, Campbell, CA, has been using SYGEF HP piping for the most demanding high-purity applications. According to Tom Heredia, vice president and general manager, "With SYGEF piping I'm sure my customers are provided with the highest quality water possible. We are seeing more and more high-purity PVDF being used in all industries. Ionics is a leader when it comes to pure water technology, and SYGEF HP is an important part of our program."

As industries demand increasingly higher levels of product purity, KYNAR PVDF piping and the Flo-Fusion joining methods will provide a superior alternative to traditional materials and assembly techniques. Higher purity levels, earlier installation, superior surface finish, and a proven track record all add up to wider use of KYNAR piping systems for pharmaceutical applications.



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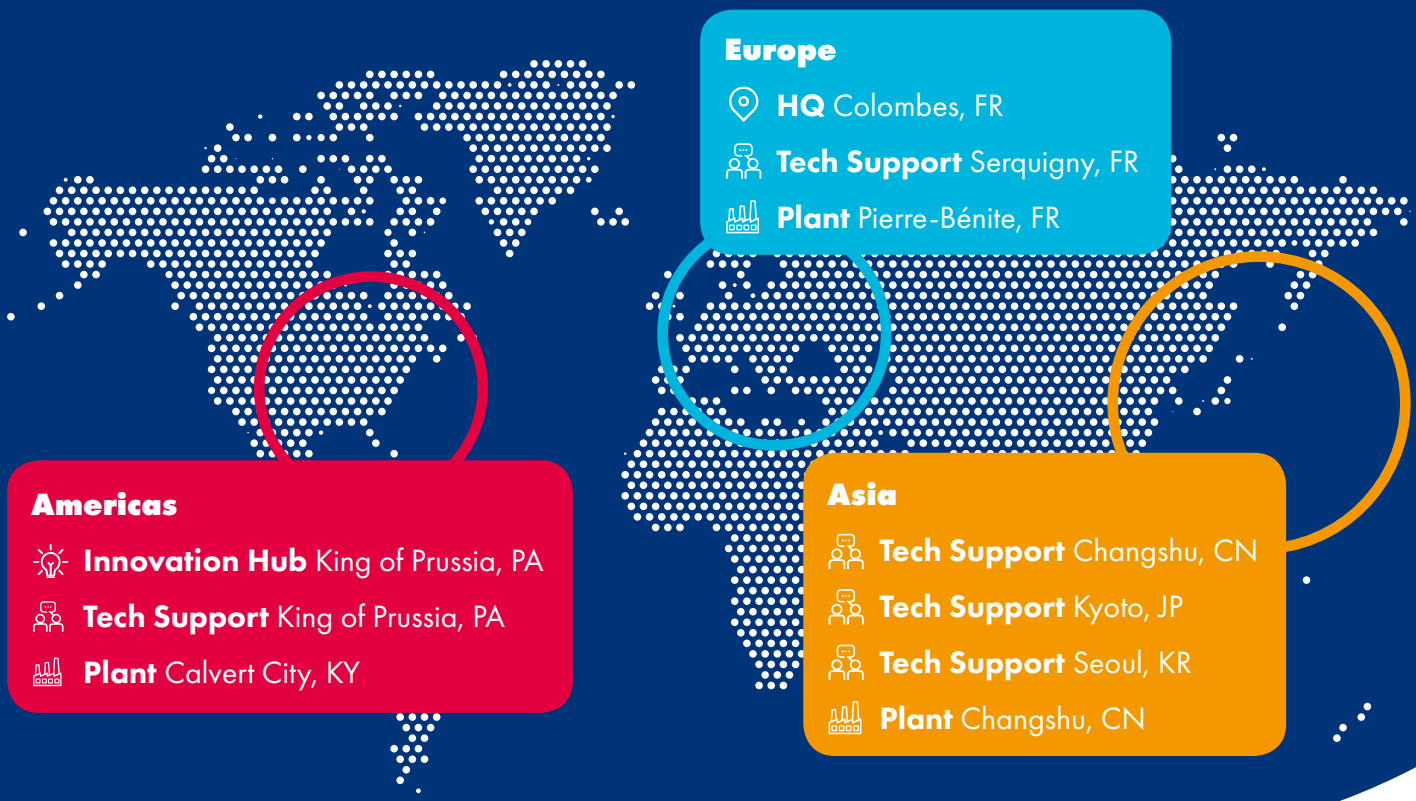

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