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New ICF Potting System Overcomes Challenges for Manufacturers of Hollow Fiber Filters

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Hollow fiber is the technology of choice for today's water filtration. In everything from personal and home to industrial applications it provides maximum surface area in minimum space, but to be effective the fibers must be stabilized with some kind of "potting" material. The two traditional options for potting are polyurethane and epoxy, both of which can effectively do the job but each of which comes with challenges that must be addressed.

In the presence of moisture, curing polyurethane generates carbon dioxide, which forms bubbles in the curing material. This foam causes the material to expand as it hardens weakening the cured material and leading to potential leaks in the finished filter. Since this uncontrolled aspect of a carefully controlled process is unacceptable, manufacturers will go to great lengths to eliminate moisture from the potting process. This can be easily done, but the price can be high, typically entailing total elimination of moisture through meticulous climate control, which adds complexity and cost to the manufacturing process. And of course polyurethanes present the additional challenge of dealing with dangerous isocyanates. According to OSHA, "health effect of isocyanate exposure include irritation of skin and mucous membrane, chest tightness and difficult breathing … occupational asthma and other lung problems, as well as irritation of the eyes, nose, throat, and skin." OSHA Safety and Health Topics | Isocyanates

Epoxy, on the other hand, is not so susceptible to moisture, but the material generates a great deal of reaction heat as it cures. This heat actually has the potential to damage filter materials, but the big drawback is thermal expansion. Due to its reaction heat, epoxy expands as it cures and then contracts as it cools once the reaction is complete. The cooling can cause stresses and voids in the finished product and lead to cracking and other flaws. Manufacturers using epoxy can reduce this risk either by slowing the reaction to reduce the amount of heat generated or by cooling the material as it cures to reduce thermal expansion. Slowing the process can significantly increase process lead time and reduce manufacturing efficiency, while cooling adds both complexity and cost. But as with polyurethane these costly corrective actions are necessary if epoxy users want to produce a quality product.

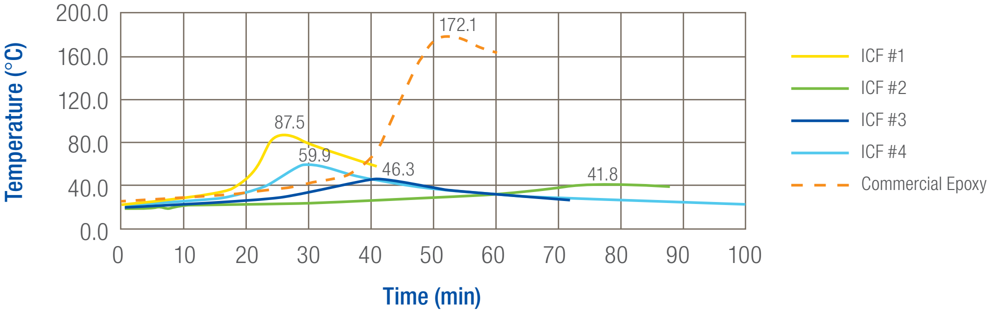
In many ways these two options, epoxy and polyurethane, are interchangeable; it's simply a matter of which set of problems—moisture and isocyanate with polyurethane or heat with epoxy—the manufacturer chooses. There is, however, a third option. New ICF adhesive is a thermosetting potting material that is not sensitive to moisture like polyurethane so it doesn't foam or require extreme climate control and doesn't contain isocyanates, eliminating the risk of exposure to this chemical. Chemically, this new option removes the cross-linking isocyanate group from the end of the polyurethane molecule and replaces it with a safer functional group (ICF). The ICF group performs a similar cross-linking function without isocyanate's liabilities and is activated by a catalyst to react with the third component of the mix. The

ICF system does not react with water to generate CO_2 bubbles like polyurethane reactive systems, and it has a lower heat of reaction compared to epoxy reactive systems.

In side-by-side testing, equal amounts of uncured polyurethane and ICF were "contaminated" with 0.10 percent water. After 60 minutes, as seen in the accompanying photo, the cured polyurethane had increased significantly in volume, while the ICF showed no foaming or expansion at all.

At the same time, ICF it doesn't generate the high amounts of heat that make epoxies so problematic and can damage finished filters, so there's no need to slow down the cure or install systems to counteract heat generated in the process. As shown in the following graph, heat generated by curing ICF generally goes up as gel time goes down, but even ICF's shortest gel time does not generate as much heat as epoxy. As a result ICF allows the manufacturing process to be sped up significantly without increasing the scrap rate.

Exotherm of ICF Vs. epoxy

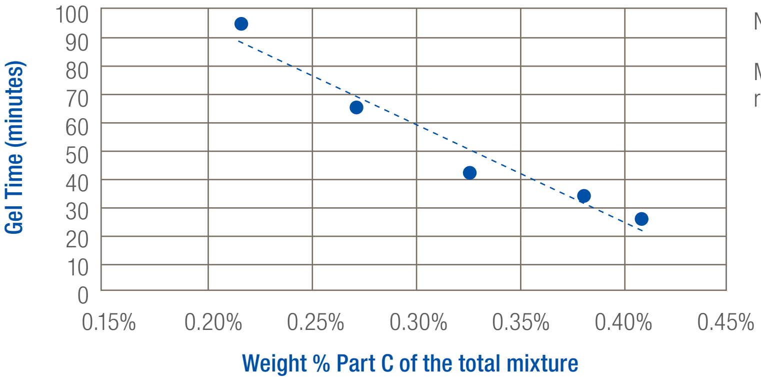


Heat generated by curing ICF varies with chosen gel-time but is significantly lower than heat generated by the curing of epoxy.

The bottom line is that ICF can be as effective a potting material as either polyurethane or epoxy without some of their significant challenges. Using ICF, fibers and air don't have to be meticulously dried, and the process doesn't require costly cooling or slowed curing in order to offset thermal expansion. And workers don't have to be protected from isocyanates.

One more big advantage of ICF is its flexibility. Unlike epoxy and polyurethane, both of which are two-part adhesives, ICF is a three-part material, giving process designers more control of the potting process. The three parts are a resin, a hardener, and a catalyst. Controlling the mix of those components allows manufacturers to independently control gel time, heat generation, and the hardness of the final product. In laboratory testing, gel time was varied by as much as 300 percent by adjusting the catalyst component of the mix.

Typical gel time of ICF system

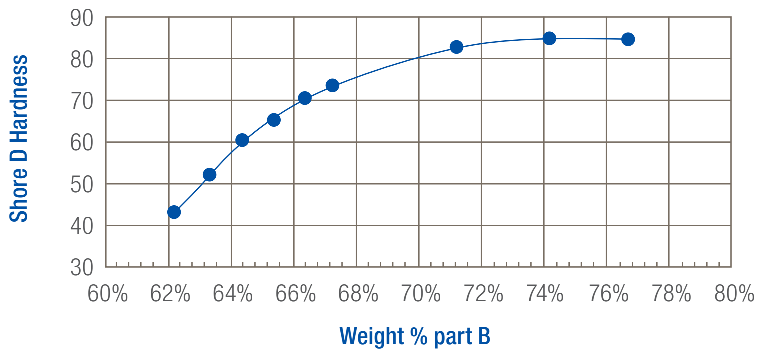


Note: Gel time at 23°C

Mix ratio of part A cross-linker to part B resin held constant at 1.0:3.3

This ability to control hardness gives manufacturers a great deal of process flexibility and potential for simplification. In traditional epoxy or polyurethane applications, hollow fibers are treated with multiple layers of potting material. The first layer is hard in order to stabilize the fibers; subsequent layers use softer potting material to protect the fibers from damage, since use of hard potting material throughout could crimp or shear off the fibers. Applying these multiple layers can complicate the manufacturing process. The versatile chemistry of ICF, on the other hand, allows fine control of the hardness of the material. Hardness of the ICF system can be tuned by changing the ratio of part A cross-linker to part B resin, allowing one potting material to do the job which previously required multiple potting materials.

ICF hardness as a function of part B weight %



Preparation of the three component system is relatively easy. Typically the part A cross-linker is premixed with part C catalyst at a ratio of about 100:1 part A to part C. The materials are low viscosity and relatively easy to mix. AC premixes are typically stable for up to 48 hours. It is possible to automate the AC premix preparation using equipment from vendors like Graco Inc.

Then there is the matter of chemical resistance. Hollow fiber filter elements can be subjected to a variety of chemicals including the materials they are filtering and chemicals used for cleaning and must be able to resist degradation. As shown in the chart above, ICF in various forms loses very little weight over long exposure to highly acidic and alkaline solutions or in long exposure to sodium hypochlorite bleach.

	ICF2000	ICF2001	ICF2002
Mix Viscosity (cP, at 25°C)	500	1000	750
Max Exotherm (°C)	80-85	70-80	
Gel Time (min. at 30°C)	40-45		45-50
Hardness	80D	70D	75D
Tg (°C)	40	33	37
Chemical Resistance pH 1 at 25°C, 28 days (weight change %)	0.6	0.9	0.7
Chemical Resistance pH 12 at 40°C, 28 days (weight change %)	1.4	1.9	1.7
Chemical Resistance 1500ppm NaOCl at 25°C, 28 days (weight change %)	0.6	0.9	0.7

The three component potting system of ICF1000 / ICF2002 / ICF3000 has received ANSI 61 certification from NSF and is safe for use in water filtration systems (NSF Product and Service Listings). NSF certifies materials for use in water filtration using ANSI Standard 61: *Drinking Water System Components – Health Effects*, developed in 1988. The NSF certification program is accredited by the American National Standards Institute. "NSF" is a registered certification trademark of NSF International.

Biography:

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