Birth of the General-Purpose, High-Performance ePTFE/Graphite Packing Fiber

By **Carl Jones**
FSA Member, W.L. Gore & Associates

A great innovation in compression packing was the development of a new material class by Ritchie Snyder of W.L. Gore & Associates in 1981. He envisioned a single material that would allow for broad standardization across a wide range of applications. It would deliver the chemical compatibility of polytetrafluoroethylene (PTFE) and graphite, with the mechanical strength of the then newly expanded PTFE material (ePTFE).

Over the next 35 years, many pulp and paper, chemical, mining and power companies have standardized their plants with this new material class of ePTFE/graphite packing fiber.

Prior to this breakthrough, end users working in chemical applications had one option for standardization: a natural mineral fiber known as asbestos, which was effective because of its chemical inertness and high temperature rating.

By the late 1970s and early 1980s, however, it was actively being eliminated from the market because of health concerns. As an alternative, pure PTFE was substituted, but it was a poor replacement because of its inherent creep, mechanical weakness and high coefficient of thermal expansion.

It was also a heat insulator with a low thermal conductivity of only 0.25 watts per meter per degree Kelvin (W/m K) and shaft speed and temperature limits of 2,000 feet per minute (ft/min) and 260 C (500 F), respectively. This material required strict adherence to the installation procedure and operator knowledge. Any overtightening could lead to a negative feedback loop of increased heat, leading to more expansion, friction and heat. These effects would damage the shaft or sleeve as a result of crystallization of the PTFE, leading to premature failure.

Graphite was a great material for conducting heat. While dimensionally stable and capable of operating at higher temperatures, graphite lacks mechanical strength and makes maintaining a lower leakage rate difficult.

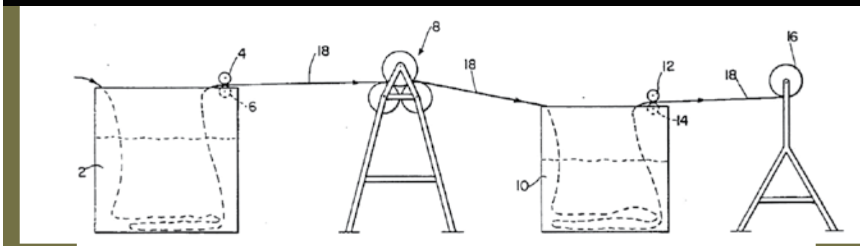
Because of inherent limitations, other material class options fell short of meeting the need for a general-service packing for standardization, including:

- *Natural fibers:* The chief advantage of flax, ramie, jute and cotton is low price, but performance is negatively impacted by limitations, including poor chemical resistance (5-9 pH), low heat resistance (98 C/208 F) and speed (1,000 ft/min).
- *Aramid fibers:* They are divided into two categories: para-aramid and meta-aramid. They are differentiated by the type of monomer that determines molecular structure of the polymer chain. Para-aramids are bright yellow, while meta-aramids are white. Para-aramids have high tensile strength and cut resistance, and can be up to five times the strength of steel wire of the same weight. However, chemical resistance is limited to a 4-11 pH range, temperatures up to 120 C (248 F) and speeds up to 1,500 ft/min. Meta-aramids are chemically resistant with a 1-13 pH range and temperature resistance up to 270 C (518 F), above which glass transition limits its use.
- *PTFE:* Although PTFE is a chemically inert material with a 0-14 pH capability, very low friction and self-lubricating properties, it is limited by mechanical strength, coefficient of thermal expansion and creep. It is good for shaft speeds up to 2,000 ft/min and a maximum temperature of 260 C (500 F).
- *ePTFE:* This material has the same chemical and thermal expansion properties as PTFE but with higher mechanical strength and lower creep. It can

operate at shaft speeds up to 3,600 ft/min. In some cases, the material can exceed the max temperature of PTFE by up to 20 percent.
- *Carbon/graphite:* This material has a range of properties depending on the graphite/carbon makeup and the mixture selected. The most common offerings can handle shaft speeds up to 4,000 ft/min and temperatures up to 260 C (500 F) in centrifugal pumps. They can also come in higher-purity forms, operating in valves up to 675 C (1,247 F).

Some end users opted for carbon/graphite composite packings, which had a much better thermal conductivity of 10.83 to 13.97 W/m K, or up to 55 times more than PTFE. Speed and temperature limitations were also higher at 4,000 ft/min and 675 C (1,247 F).

Figure 1. Graphic from the patent for the ePTFE/graphite invention *(Graphics courtesy of the author)*

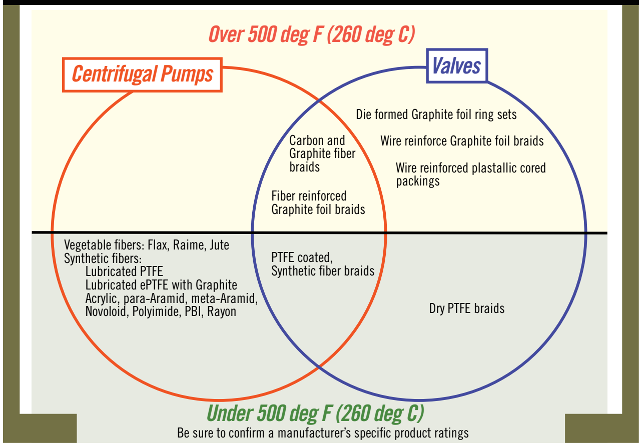


Carbon also had better dimensional stability, with a coefficient of thermal expansion of 3.9×10^{-6} inch per inch per degree Fahrenheit (in/in/F) versus PTFE's 7×10^{-5} in/in/F, or 18 times less thermal expansion than PTFE.

Snyder envisioned capturing the best attributes of two materials—pure graphite and the new ePTFE—eliminating many of the weaknesses of each. By combining them using the high-strength ePTFE structure in place of the conventional PTFE and adding a proprietary mixture of high-grade pure graphite and silicone oil, he created a homogenous ePTFE/graphite (G-Graphite, F-Fluorine, O-Oil) material. He filed for patent in 1979, and the resulting product was commercialized in 1981 (see Figure 1).

This was a major breakthrough in compression packing technology because

Figure 2. Packing recommendations for valves and centrifugal pumps



of its low coefficient of friction, wide chemical compatibility, low leak rate, long life and suitability for a broad range of applications as a general-purpose packing (see Figure 2).

More than 35 years later, various manufacturers provide a range of ePTFE/graphite compositions using different expanded PTFEs, lubricants and graphite combinations, and this material class is still the standard by which all general-service packings are measured. Those who work with compression packing today owe a debt of gratitude to one of the great industry pioneers, whose creativity introduced this breakthrough technology.

In light of an increased emphasis on sustainability, the ePTFE/graphite material is once again—35 years after its introduction—emerging as an important solution for optimizing resources used in the operation of centrifugal pumps. ■

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Carl H. Jones is the global product specialist for packing fibers sealant technologies at W.L. Gore & Associates. He has a B.S. in chemical engineering and an MBA in finance, with more than 30 years of experience in the fluid sealing industry.