Viton™ Fluoroelastomers

Specifying the Right Materials of Construction for Nonmetallic Flue Duct Expansion Joints

Technical Information

Performance Capabilities of Fluoroelastomers vs. Other Nonfluorinated Hydrocarbon Elastomers

Elastomeric flue duct expansion joints provide a number of advantages compared with metal joints, including light weight, ease of installation, superior abrasion resistance, and much higher design flexibility in terms of accommodating ductwork movement and offset. It is important to realize, however, that any synthetic elastomer can be used in the manufacture of expansion joints. Joints made from any of these elastomers are virtually identical in appearance, but will vary drastically in their performance capabilities. The following discussion details why it is critically important to recognize the differences between the various elastomers and make certain that the proper material is used for specific expansion joint applications.

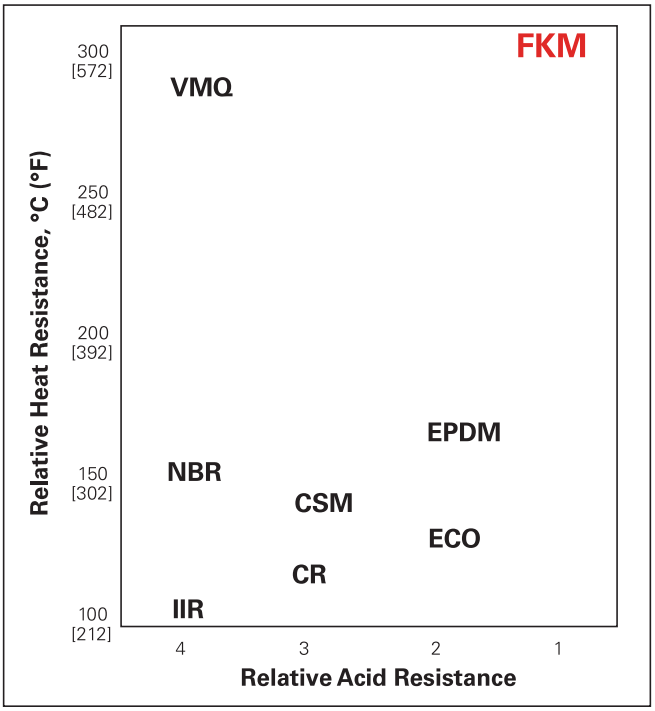
The synthetic elastomers listed in Table 1 vary significantly in terms of their resistance to heat and various classes of chemicals and fluids. Different types of elastomers will, for example, exhibit considerably different capabilities in terms of resisting property degradation caused by exposure to heat and acid.

Table 1. Synthetic Elastomers and Their ASTM Designations

Elastomer Name	ASTM Designation
Fluoroelastomer	FKM
Silicone	VMQ
Ethylene-Propylene	EP or EPDM
Chlorosulfonated Polyethylene	CSM
Chloroprene	CR
Butyl	IIR
Epichlorohydrin	ECO
Nitrile	NBR

Figure 1 depicts a relative rating of heat and acid resistance for vulcanizates based on a number of different elastomers. The Y-axis of the chart represents a maximum temperature at which a vulcanizate will retain at least 100% elongation at break after a 70-hr oven aging. The X-axis represents a relative rating of the elastomers' ability to resist attack from exposure to 3 molar sulfuric acid at 70 °C (158 °F).

Figure 1. Comparative Rating of Heat and Acid Resistance for Various Synthetic Elastomers



Relative heat resistance is based on ability to retain at least 100% Eb after 70 hr exposure.

Relative acid resistance—Fluid Sealing Association Rating: 1=Satisfactory, 4=Unsatisfactory

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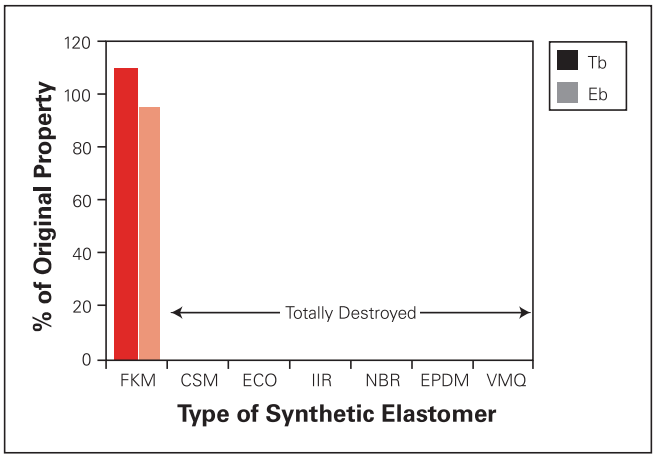
Viton™ fluoroelastomer provides an unequaled combination of resistance to heat and acid and is clearly the superior material for sealing applications in aggressive flue gas service. In addition, the results of 10 years of testing in a simulated flue gas test and more than 25 years of actual service in the FDEJ industry have proven that Viton™ B-type terpolymer FKM provides better long-term service than dipolymer types of FKM. It has also been established that the bisphenol cure system is superior to the older, diamine cure system used to vulcanize FKM.

The information presented in Figure 1 is based on two different, short-term test conditions. While these tests may be useful for determining baseline comparisons, the short-term and relatively mild acid temperature used in these tests do not adequately show the full degree of performance differences that exist among vulcanizates based on the various types of elastomers. Either longer term tests or more severe aging conditions better differentiate between elastomers. For example, as shown in Figure 2, vulcanizates made with fluoroelastomer, after aging for 168 hr in concentrated sulfuric acid at 150 °C (302 °F), showed little change in physical properties. The test samples based on all the other elastomers, however, were completely destroyed.

Figure 2. % Retained Physical Properties After 168 hr at 150 °C (302 °F) in Concentrated Sulfuric Acid



Is Specifying Fluoroelastomer Good Enough?

Unfortunately, specifying that "expansion joints shall be fluoroelastomer" will not necessarily guarantee that the buyer receives the best materials or the highest quality FKM joint. In the past, accusations have been made that in some instances joints have been bid that were represented as being fluoroelastomer or Viton™* joints, but which were, in fact, inferior in quality to what would be considered the industry standard. Increasingly, the industry has been asking for assistance in providing techniques that will guard against a buyer's being supplied with inferior materials.

Low-Cost Fluoroelastomer Materials

There are several techniques that have been used to manufacture cheaper fluoroelastomer joints. These methods include misrepresentation of bi-material constructions; joints that are light in terms of FKM content; the use of blends of FKM with other, nonfluorinated polymers; and the incorporation of various amounts of reclaimed FKM scrap. Any one of these techniques, used to reduce materials cost, will result in expansion joints that are inherently inferior to an all-virgin terpolymer FKM joint of the appropriate weight and thickness.

Bi-Material FDEJ Constructions

Bi-material FDEJs, such as those that have FKM on the gas side and a cheaper, less heat-resistant elastomer on the air side, simply will not last as long as all-FKM joints. They can, however, be suitable for low-temperature service (below 121 °C [250 °F]), and such types of joints may be suggested as an option. Reputable suppliers, however, will not claim nor encourage a buyer to believe that this type of construction is a Viton™ joint or a fluoroelastomer joint. Instead, they will point out that it is a less expensive option, based on FKM and another elastomer, that is designed for lower temperature service than 100% FKM.

Lightweight FKM

Another technique for providing lower cost FKM expansion joints includes rounding off thicknesses. For example, if a 1/4-in (6.4 mm) thick joint is specified, it is not uncommon to receive bids on joints that ultimately measure 3/16 of an inch (4.8 mm [0.188 in]) thick. There have been instances where excessively heavy grades of fabric reinforcement were used, which significantly

* Only Chemours manufactures Viton™ fluoroelastomers. Viton™ is a registered trademark that refers to a specific line of fluoroelastomers produced by Chemours; it is not a generic name for a class of material.

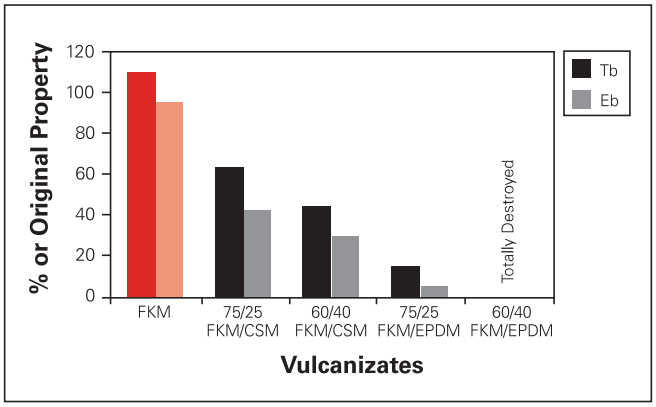
reduced the amount of fluoroelastomer in the finished joint. Experience has proven that FKM joints that are light in FKM simply do not hold up as long as heavier weight constructions. For example, in the mid- to late '70s, a power plant experienced 85% failure of its expansion joints within 18 months after installation. The specification for these joints said only that they were to be "1/4-in (thick), fluoroelastomer." The joints were found to contain two plies of 64-oz fiberglass reinforcement. More than 70 joints were replaced with 1/4-in thick joints made with Viton™ FKM, consisting of two plies of 22-oz fiberglass cloth, and they were all still in service as of 1994.

Blends of Hydrocarbon Elastomers with FKM

As indicated in Figure 3, elastomer compounds that consist of FKM blended with less expensive hydrocarbon elastomers exhibit much poorer heat and chemical resistance than FDEJs made with 100% fluoroelastomer.

The blends depicted in Figure 3 consisted of 75/25 and 60/40 blends of a bisphenol-cured, terpolymer FKM mixed with chlorosulfonated polyethylene. The hydrocarbon rubbers were formulated to provide the maximum resistance to heat and acid and employed a peroxide cure system. Even at 25%, by weight, the presence of the hydrocarbon rubbers in the Viton™ FKM resulted in significantly poorer resistance to hot acid than the vulcanizate based on 100% terpolymer Viton™ FKM.

Figure 3. Retention of Physical Properties of Vulcanizates Based on 100% Fluoroelastomer vs. Blends of FKM with Hydrocarbon Elastomers After 168 Hours at 150 °C (302 °F) in Concentrated H_2SO_4



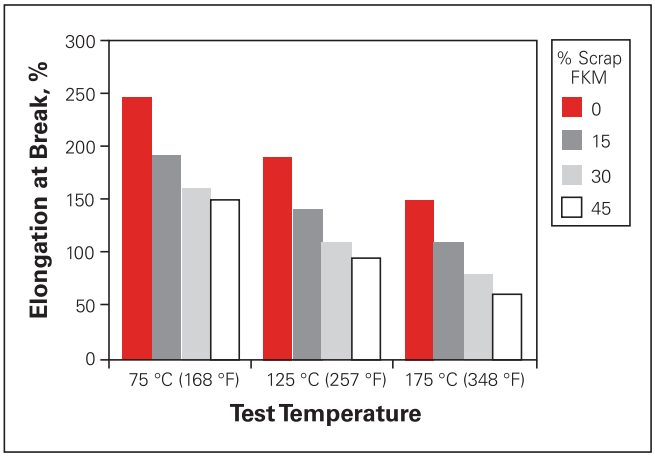
Re-Ground or Reprocessed FKM

A number of suppliers to the rubber industry engage in the collection, reclamation, and resale of cured FKM scrap. Reclaimed vulcanized scrap typically is mechanically ground, or reduced, and mixed with virgin FKM. The resulting mixture is then sold to rubber processors at considerably lower prices than virgin FKM. The incorporation of reprocessed (reclaimed) vulcanized FKM scrap into a compound measurably reduces the hot tear resistance and elongation capabilities of the resulting vulcanizate. As shown in Figure 4, the addition of as little as 15%, by weight, of reclaimed fluoroelastomer scrap results in a significant loss of hot elongation.

These two physical properties are critical characteristics for an expansion joint, particularly at the joint corners. Vulcanizates that have inadequate hot elongation capabilities will crack and tear in areas of high stress, even in normal service, within a short period of time.

The incorporation of re-ground fluoroelastomer scrap in FKM compounds does not significantly degrade the heat resistance of a fluoroelastomer vulcanizate. In addition, the use of reclaimed FKM scrap, even if it is based on dipolymer FKM, will have only a moderate deleterious effect on the acid resistance of the resulting vulcanizate. However, the inherent disadvantage incurred by the incorporation of reclaim, in terms of degraded resistance to tear and the ability to flex without breaking at high temperatures, is sufficient reason for ensuring that expansion joints do not contain any reprocessed FKM scrap.

Figure 4. Effect of Reprocessed FKM Scrap on High-Temperature Vulcanizate Elongation



How to Specify Fluoroelastomer for Use in FDEJs

The previous discussion outlined why Viton™ fluoroelastomer is the best material of choice for expansion joints used in high-temperature, highly corrosive flue gas. How then do buyers ensure that the expansion joints they have ordered will be based on the optimum compound formulation: one that consists of 100% virgin terpolymer FKM, cured with the bisphenol cure system? There are several approaches; any one of which can be used to ensure that, if expansion joints made with Viton™ fluoroelastomer are specified, high-quality joints will be supplied.

Fluid Sealing Association Specification for FKM Used in FDEJs

Over the past several years, Chemours has worked closely with other members of the Fluid Sealing Association (FSA) to develop a standard for the fluoroelastomer portion of FDEJs that are marketed as Viton™ or fluoroelastomer joints. The FSA recently issued a standard that addresses this issue. FSA-DSJ-401-09 covers the fluoroelastomer used in the manufacture of expansion joints for service in high heat and where corrosive flue gases are present. The standard states that the polymer shall be based on 100% virgin fluoroelastomer terpolymer, of at least 68%, by weight, fluorine content. In preparing elastomer vulcanizates, a number of other materials are generally added to the base polymer, including cure system, metal oxides (which facilitate cross-linking), and a filler (to improve mechanical strength). Carbon black is the only acceptable filler for use in acid service. The FSA standard further specifies that the polymer compound shall contain no less than 70%, by weight, of fluoroelastomer (the remaining 30% will consist of other compounding ingredients). The standard points out that the bisphenol type of cure system shall be used and that no amount of reprocessed or re-ground fluoroelastomer scrap or non-fluoroelastomer polymer is acceptable.

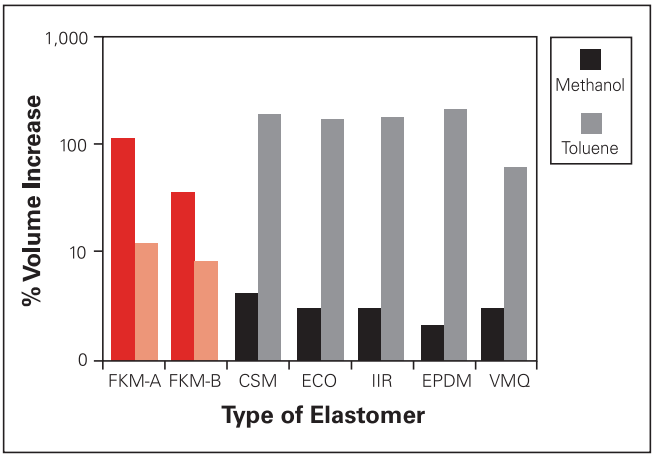
The standard lists required minimum values for various physical properties and is an excellent basis for a specification to help ensure that only the highest quality FKM joints are supplied.

Volume Increase Tests in Toluene and Methanol

As part of an effort to provide the power industry with means by which inferior-quality joints being sold as fluoroelastomer could be identified, Chemours developed two simple fluid immersion tests (based on ASTM test method D471). These tests are capable of determining whether or not the elastomer portion of an expansion joint construction is based entirely on fluoroelastomer or instead based on a hydrocarbon rubber or a combination of FKM and hydrocarbon rubber. The tests can also indicate whether the expansion joint, if it is based on FKM, consists of a terpolymer or dipolymer type and can serve to indicate the presence of undesirable dipolymer FKM scrap.

Vulcanizates based on all types of fluoroelastomer exhibit outstanding resistance to aromatic fluids. When immersed in toluene for 70 hr at room temperature, all FKM vulcanizates will typically exhibit less than 20% volume increase. Figure 5 compares the volume increase of di- and terpolymer Viton™ polymers with that of various hydrocarbon rubbers, all of which exhibit volume increase, or swell, in excess of 100% (please note the use of a logarithmic scale to depict volume increase). This simple test clearly differentiates between FKM and hydrocarbon rubbers.

Figure 5. % Volume Increase for Various Elastomers in Methanol and Toluene at 23 °C (73 °F)



The reinforcement materials used in FDEJs do not significantly affect the values of volume increase. Thus, this simple test can be used in checking finished expansion joint constructions. A sample of an actual joint, consisting of either single- or double-ply fiberglass, aramid, or wire reinforcement, will exhibit substantially the same volume increase as the elastomer component only. Thus, if a sample of an expansion joint exhibits a volume increase greater than 25%, it indicates that at least some amount of hydrocarbon rubber is present, either as a component of a blend or as one of the plies, or layers, of the joint.

While all fluoroelastomers exhibit excellent resistance to aromatic fluids, such as toluene, vulcanizates based on di- and terpolymer (A and B types) of fluoroelastomer exhibit significantly different degrees of volume increase in methanol. After immersion in methanol for 70 hr at room temperature, a vulcanizate based on 100% terpolymer, Viton™ B-type, will typically exhibit less than 40% swell. A vulcanizate based on a dipolymer, or A-type, however, will show volume increase ranging from 85–105%. Thus, if an FDEJ construction exhibits volume increase in methanol in excess of 40%, it is likely that the vulcanizate contains some amount of dipolymer, either as a poor choice of base polymer or in the form of some amount of incorporated, reprocessed, dipolymer FKM scrap.

Summary

Fluoroelastomer is the best choice of materials for demanding flue duct expansion joint applications. Specifications for fluoroelastomer expansion joints must be written precisely, noting which materials are to be used and what types of materials are not to be used. In writing specifications for fluoroelastomer expansion joints, be sure to specify the following:

- Only 100% virgin terpolymer fluoroelastomer containing at least 68%, by weight, fluorine is used.
- The elastomer compound shall contain no reprocessed fluoroelastomer scrap.
- The elastomer compound shall contain no non-fluoroelastomer, hydrocarbon rubber.
- The elastomer compound used in the expansion joint must contain 70%, by weight, of the (100%) virgin terpolymer FKM.
- The remaining 30% of the elastomer compound must consist only of carbon black filler, metal oxide acid acceptors, process aids, and curatives.
- Records of the materials used in the manufacture of the expansion joints and physical property results of tests run on the FKM compound must be available on request.

For more information, visit Viton.com

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