DuPont Elastomers

Leak Prevention of Reformulated Fuels and Oxygenates

Sealing Solutions to Protect the Environment and Meet Regulatory Requirements

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Executive Summary

The fuels industry is undergoing sweeping changes as a result of the 1990 Amendments to the Clean Air Act (CAA). This legislation directly impacts every partner in the supply and distribution chain. Although there are many uncertainties about requirements for future fuel formulations, one thing is certain — oxygenates will continue to play a major role.

The use of oxygenates presents a tremendous challenge to the fuels industry, since neat oxygenates and oxygenated fuels are incompatible with some materials of construction. Ensuring materials compatibility is a major issue because component failure can result in costly shutdowns, safety hazards and environmental violations.

The good news is that there are proven solutions currently available. However, selecting the "best" product may not be an easy task. That's because each product provides a unique combination of features and benefits that must be evaluated against the particular requirements of a sealing application. Life-cycle costs and value-in-use must also be considered.

This paper, which is divided into several sections, provides in-depth discussions and valuable comparative data to help you select the optimum product for your application.

The **Background** section includes a discussion of the CAA legislation, the role of the Environmental Protection Agency (EPA) and the EPA's fuel models. A perspective of the uncertainties, issues and opportunities created by the regulations is also included.

The section entitled **Seal Incompatibility with Some Fuels Presents Problems** explores the complex issues that must be considered before selecting materials of construction. This is followed by a general overview of the **Technical Solutions for Sealing Systems Available Today.**

Evaluating the Options provides an in-depth look at six high-performance elastomeric candidates for use in oxygenates and oxygenated fuels. This section includes comparative test data that highlights candidate sealing materials for oxygenated fuel service. The importance of considering the value-in-use of seals in critical applications is also presented.

Guidelines for **Selecting the Best Solution for Sealing Oxygenated Fuels** are explored next. This section also contains concise summaries that can be very useful for seal selection.

A list of technical papers and reports suggested for additional reading is provided after the conclusion.

Background

In November 1990, President George Bush signed what has been called the most far-reaching environmental legislation since the 1970s — the Amendments to the Clean Air Act (CAA). This legislation calls for the reduction of air pollutants from a variety of sources, including factories, power generating facilities and automobiles.

Some experts believe that these amendments "...will result in the most sweeping changes to the petroleum and automobile industry since the discovery of oil in 1850 and the use of the production line by Ford in the 1920s."[1] Others believe that it "...will present a significant number of problems...but will also present a number of strategic opportunities."[2] Everyone agrees that it will no longer be "business as usual."

Looking specifically at the requirements set for reducing automotive pollution, the Amendments:

- Require automobile manufacturers to reduce emissions of hydrocarbon and nitrogen oxides (NOx) by approximately one-third, beginning with 1994 model-year cars and
- Require the use of cleaner-burning fuels in U.S. cities that are in violation of carbon monoxide standards (designated nonattainment areas), beginning in November 1992.

One of the first major programs of the 1990 CAA Amendments to be implemented was the oxygenated-fuels program. Under this program, gasoline sold or distributed in the nonattainment areas during winter months must have a minimum oxygen content of 2.7 wt%. Currently, this program affects approximately 25% of the U.S. gasoline market. However, in the future, additional areas will be required to participate and other areas may voluntarily "opt in" to this program.

Role of the EPA

The Environmental Protection Agency (EPA) was charged with promulgating the necessary supporting regulations to achieve the objectives of the CAA Amendments. The EPA is using a regulation-negotiation process, commonly known as "reg-neg," to determine requirements for 1995 and later fuels. Designed to expedite the procedure for proposing and finalizing regulations, the "reg-neg" process has been impacted by political decisions that have resulted in long delays in issuing final regulations and a greater degree of uncertainty about the future.

Fuel Models

The EPA issued an interim Simple Model, developed by the "reg-neg" process, to guide petroleum refiners on fuel composition until the Complex Model is finalized. Basically, the Simple Model requires that fuel sold in nonattainment areas feature:

- Minimum 2 wt% oxygen;
- Maximum 1 vol% benzene;
- No heavy metals; and
- Summer Reid vapor pressure (Rvp) of 7.2 psi in southern areas and 8.1 psi in northern areas during the high-ozone season.

The Simple Model also limits sulfur, ASTM T_{90} and olefins to the average values of the refiner's average 1990 gasoline.

Although the Complex Model, still in the "reg-neg" process, has not yet been issued in its final form, one thing is certain — it will be much more restrictive than its predecessor, placing what many believe to be excessive compliance and enforcement burdens on the industry.

Based on preliminary drafts, it appears that the Complex Model will weigh critical parameters of individual fuels in terms of emissions and toxics, rather than placing finite limits on fuel characteristics. In response to industry comments, the EPA recently agreed to take measures to simplify the model, such as reducing the number of interactive volatile organic compound (VOC) and NOx terms, and narrowing the number of vehicle technology groups. The final rule issuance is expected by the end of 1993.

Meeting Regulations with Oxygenates

To meet the federal requirement for higher fuel oxygen content, chemicals containing oxygen must be added to the fuel blend. The fuel industry has found several practical options to supply oxygen using alcohols and ethers.

Currently, many oxygenates are being used or evaluated, including: methyl tertiary butyl ether (MTBE), ethyl tertiary butyl ether (ETBE), tertiary amyl methyl ether (TAME), di-isopropyl ether (DIPE), methanol (MeOH) and ethanol (EtOH). At this time, the four leading candidates are MTBE, ETBE, MeOH and EtOH.

MTBE, which has been used for nearly 10 years as an octane enhancer, has become the oxygenate of choice. According to recent industry estimates, it now accounts for between one-third and one-half of all the oxygenates being used. There are many reasons why MTBE is the most widely used oxygenate:

- It can be easily manufactured and blended.
- It is compatible with all fuel components.
- It has a low blending Rvp.
- It is a fungible product and thus can be transported easily by pipeline.
- It does not require special handling to avoid water contamination (as is the case with alcohols).

EtOH is the second most widely used oxygenate. It has a long history of use as a fuel component. However, the reason for its broad consideration as an oxygenate is based not solely on technical merit, but also on federal and state subsidies. Through the year 2000, gasohol blenders expect to enjoy a federal income tax credit of 5.4¢ per gallon. And, the ethanol content of ETBE is now eligible to receive this income tax credit. State subsidies range from reduced motor gasoline taxes and sales taxes to tax incentives for ethanol production. Some of the technical drawbacks associated with EtOH include:

- The water it scavenges in distribution and storage systems becomes entrained in the fuel blend.
- The entrained water can lead to haze problems, increased corrosion rates and possible phase separation.
- The increased corrosion rates associated with EtOH make it undesirable for pipeline distribution.

There is a great amount of uncertainty in the fuels industry today. The long-awaited Complex Model is still being "refined" by the EPA and politics are continuing to play an important role in shaping the future of this industry.

Sweeping Changes — The Only Certainty

The one point that everyone can agree upon is that the 1990 Amendments to the CAA will result in sweeping changes to the fuel industry, impacting every partner in the supply chain. Anticipated problems include: increased operating, storage and transportation costs; added capital expenditures; product exchange complications; legal liability; potential product degradation; and scheduling difficulties due to the increased number of different products being distributed.

Some industry experts predict that it will cost as much as $75 billion to upgrade the fuels industry to meet these new environmental requirements. And, due to the lack of certainty surrounding requirements for future fuel formulations, it is often difficult for companies to obtain financing.

Seal Incompatibility with Some Fuels Presents Problems

A common problem facing every partner in the supply chain is the incompatibility of neat oxygenates and oxygenated fuels with some materials of construction. Metals are not a problem, but some plastics and elastomers are. Materials compatibility is a major issue because component failure can result in costly shutdowns, safety hazards and environmental violations.

Companies involved in the manufacture, storage and distribution of oxygenates and oxygenated fuels must carefully consider a myriad of interwoven issues before making any decisions about which materials of construction to use.

For example, the logistics of shipping and storing fuels is becoming more and more complex. As regulations continue to evolve and to become more stringent — with local, regional and seasonal variations permitted — the total number of fuel products will grow to an unprecedented number. Conceivably, if products meet only minimal specifications, as many as 50 different fuels could be on the market before the end of the decade. Materials of construction will have to be chosen for their compatibility with the known "bad actors."

For many people in the fuels industry, the issue of legal liability often causes the greatest concern. That's because, according to EPA regulations promulgated to support the CAA Amendments, *every party in the fuel distribution chain is responsible* for preventing the sale of any off-spec fuels within applicable control areas. If a violation is detected, everyone upstream can be held liable. What's more, the EPA can hold operations managers *personally responsible* for corporate environmental violations, such as contamination of groundwater caused by a leaking storage tank. Each year, the number of managers who are criminally prosecuted for environmental violations steadily increases.[3]

Another issue of primary concern is keeping a sharp focus on the bottom line — maximizing profits and minimizing expenses. However, when making materials choices, the initial purchase cost must be evaluated in terms of value-in-use. By considering both the *performance* and the *life cycle cost* of a material, companies can ensure that long-term profit objectives are met and accidents, due to component failure, are prevented.

Last, but not least, in the list of issues to be evaluated is environmental responsibility. In addition to ensuring that their companies are in compliance with the law, most managers want to be good environmental stewards, leading their companies beyond mere compliance and toward environmental excellence.

Technical Solutions for Sealing Systems Available Today

Proper material selection for each component (vessels, pipes, valves, pumps, etc.) used in petroleum industry facilities has always been crucial for ensuring safe, reliable and cost-effective operations. In the past, selecting materials of construction for these components was a relatively easy task. However, the increasing use of oxygenates and oxygenated fuels has presented new challenges for materials specialists.

Metallic materials for handling oxygenates and oxygenated fuel blends are well defined, and the selection process is generally straightforward. However, nonmetallic components of the systems — specifically polymeric components of sealing devices — present different issues. These components may be subject to swelling, as well as reductions in physical properties and mechanical strength, which can result in some loss of effective sealing capability.

The loss of sealing capability is a function of numerous variables, including:

- Oxygenate class — ether or alcohol;
- Type of ether (MTBE, TAME, ETBE, etc.);
- Type of alcohol (MeOH, EtOH, etc.);
- Composition of ether and/or alcohol blends;
- Oxygenate concentration in the fuel;
- Time, temperature and pressure of exposure: and
- Seal design.

Historical Experience

Industrial experience in successfully sealing oxygenates and oxygenated fuels has been varied. But due to the dynamics of this industry, the conclusions are often not well documented in the form of industry standards. This situation has led to a degree of uncertainty and confusion about how to select sealing materials that will cost effectively prevent equipment failure, expensive downtime and dangerous leakage problems. But this confusion is unnecessary. Media compatibility and performance capabilities of polymeric sealing systems are well documented. This information can facilitate the selection of the optimum sealing material.

There are many polymeric materials available for use in the fabrication of sealing components. For ease of discussion, they can be grouped into two broad categories — plastics and elastomers. Products within each category are manufactured and marketed by numerous companies, including DuPont.

Over the years, DuPont has developed a broad range of polymers for use in sealing devices. In addition to this extensive offering of proven products, DuPont brings a valuable perspective to the many sealing challenges facing the fuels industry. That's because DuPont not only manufactures polymeric materials used in seals, but also relies on proper materials selection and proven seal performance to ensure that the day-to-day operations of its global chemical and petroleum facilities are both safe and cost effective. Sealing components manufactured of DuPont polymers play an important role in providing the uninterrupted service required to meet safety and profit objectives — not just at DuPont facilities, but at chemical and petroleum industry plants throughout the world.

Evaluating the Options

As previously mentioned, polymeric materials for the fabrication of sealing components can be broadly classified as either plastics or elastomers. This paper focuses on several high-performance elastomers that have demonstrated excellent sealing performance in all stages of oxygenate and oxygenated fuel manufacture and handling.

An overview of the product flow of an oxygenate/oxygenated fuel — from manufacture to consumer purchase — is shown in Table I. As noted, every phase utilizes equipment that requires seals. These highly engineered pieces of equipment are designed to manage and contain a broad spectrum of fluids under a variety of operating conditions. However, the safe handling of these fluids largely depends upon the quality of the seals. Seals are usually designed to be both pliant and conformable. As a result, the elastomeric conforming seal is often the first component to leak or fail in a fluid handling system.

Selecting the appropriate elastomer for reliable seals against oxygenates and the many different options for oxygenated fuels can be very challenging. There are several classes of elastomers, each offering a different level of performance in petroleum products.

Although many performance criteria may be used to evaluate and quantify elastomer resistance to different media, one relatively straightforward measurement is the percent of volume swell in a particular medium under specified conditions of time and temperature. Generally, the lower the volume swell, the more resistant an elastomer is to the medium, and the better sealing performance can be expected.

In Figures 1 through 6, the relative resistance of six elastomeric sealing materials to various oxygenates is shown. The data presented in these figures were obtained in tests per ASTM D471. Neat MTBE, the most aggressive ether oxygenate, was evaluated in Figure 1. Increasing concentrations (0 to 100%, by volume) of MTBE, ETBE, TAME, MeOH and EtOH in ASTM Reference Fuel C* were used in Figures 2 through 6, respectively. Within each figure caption, the elastomeric materials are rated for use in that media.

Table I. Oxygenate and Oxygenated Fuel Product Flow

Product Flow	Equipment Requiring Seals
Manufacture of oxygenates	Vessels, pipes, valves, pumps, compressors, etc.
Oxygenate blending with fuel	Blending station pumps, valves, compressors
Transportation	Pipeline, rail, barge, trucks
Storage	Tank farms, transfer equipment, vapor recovery
Service station	Tanks, pumps, vapor recovery

*ASTM Reference Fuel C is defined as a blend of toluene/iso-octane (50/50, vol/vol).

The following are brief summaries of the data presented in each figure, as well as the conclusions that can be drawn from that data.

Figure 1 — Relative resistance to neat MTBE, the most aggressive of the ether oxygenates.

As shown, compounds of VITON® A-401C, VITON GF and VITON GFLT swell excessively in a very short time. Therefore, they are *not* recommended for use in neat MTBE.

ZLX 93004* swells moderately (<30% volume increase) and quickly achieves an equilibrium value. Thus, it is suited for use in neat MTBE.

ZALAK™ 250GP and KALREZ® 4079 exhibit the lowest volume swell in neat MTBE (<10% volume increase). Because they offer outstanding resistance to neat MTBE, both of these materials are suggested for use where the ultimate in sealing performance is required.

Figure 2 — Relative resistance to increasing concentrations (0 to 100%, by volume) of MTBE in ASTM Reference Fuel C.

As shown, each elastomeric sealing material exhibits its low volume swell at low MTBE concentrations

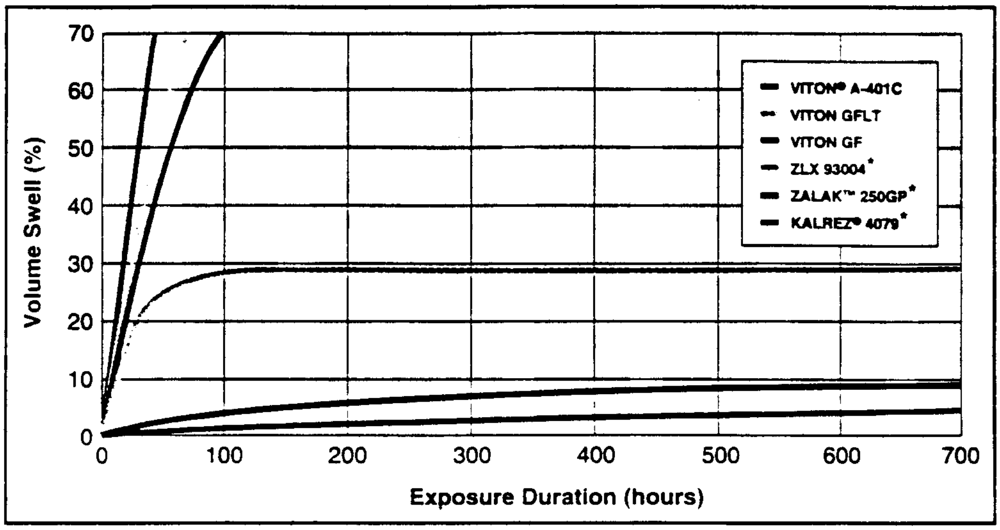


Figure 1. Relative Resistance to Neat MTBE. (Immersion at 40°C [104°F], per ASTM D471.) Elastomeric Materials with an * Are Suggested for Use.

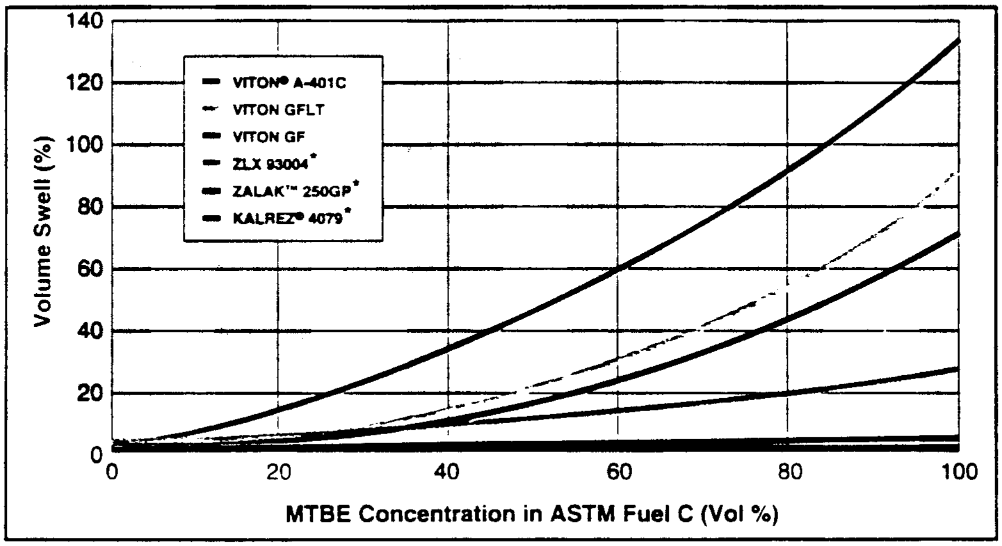


Figure 2. Relative Resistance to Increasing Concentrations of MTBE in ASTM Reference Fuel C. (Immersion for 168 hours at 23°C [73°F], per ASTM D471.) Elastomeric Materials with an * Are Suggested for Use at All Concentrations. VITON® A-401C, VITON GF and VITON GFLT May Be Considered for Use at Concentrations <20%, by Volume.

*ZLX 93004 is an experimental formulation within the family of ZALAK™ high-performance seals.

(<20%, by volume) in ASTM Reference Fuel C. Thus, any of these materials are suggested for use in all commonly encountered commercial MTBE oxygenated fuels.

However, at MTBE concentrations >20%, by volume, the blends aggressively swell seals of VITON® A-401C and, to a lesser extent, seals of VITON GF and VITON GFLT. Therefore, none of these three products is recommended for use in fuel blends containing levels of MTBE >20%, by volume. (Note that this concentration is well below the levels of commercially available MTBE oxygenated fuels.)

Three products, ZLX 93004, ZALAK™ 250GP and KALREZ® 4079, may be suitable for use at *all* MTBE/fuel blend concentrations.

Figure 3 — Relative resistance to increasing concentrations (0 to 100%, by volume) of ETBE in ASTM Reference Fuel C. Compared to MTBE and TAME, ETBE is the least aggressive ether oxygenate toward elastomeric materials.

As shown, each candidate offers excellent resistance to swelling (<10%, by volume) in all concentrations of ETBE. Thus, in most applications involving ETBE, any of these sealing materials can be considered for use.

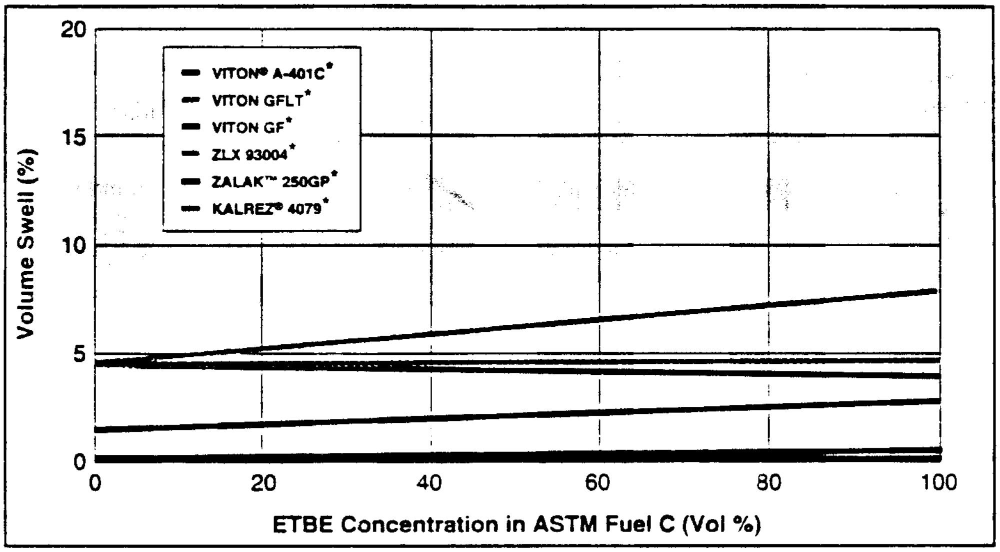


Figure 3. Relative Resistance to Increasing Concentrations of ETBE in ASTM Reference Fuel C. (Immersion for 168 hours at 23°C [73°F], per ASTM D471.) Elastomeric Materials with an * Are Suggested for Use at All Concentrations.

Figure 4 — Relative resistance to increasing concentrations (0 to 100%, by volume) of TAME in ASTM Reference Fuel C. Compared to MTBE and ETBE, TAME is intermediate in aggressiveness toward elastomeric materials.

As shown, seals of VITON® A-401C and VITON GFLT begin to swell significantly at concentrations between 30% and 40%, by volume, of TAME. Thus, VITON A-401C and VITON GFLT are suggested for use only in fuel blends containing <30%, by volume, of TAME. (Note that this concentration is well below the levels of commercially available TAME oxygenated fuels.)

Seals of VITON GF, ZLX 93004, ZALAK™ 250GP and KALREZ® 4079 all demonstrate excellent resistance to swelling over the entire concentration range (0 to 100% TAME). Thus, these materials are viable options for use at all fuel/TAME blend compositions.

Figure 5 — Relative resistance to increasing concentrations (0 to 100%, by volume) of MeOH in ASTM Reference Fuel C. MeOH is the most aggressive of the alcohol oxygenates toward elastomeric materials.

As shown, VITON A-401C begins to swell significantly (>30%, by volume) at MeOH concentrations above 20%, by volume. Thus, seals of

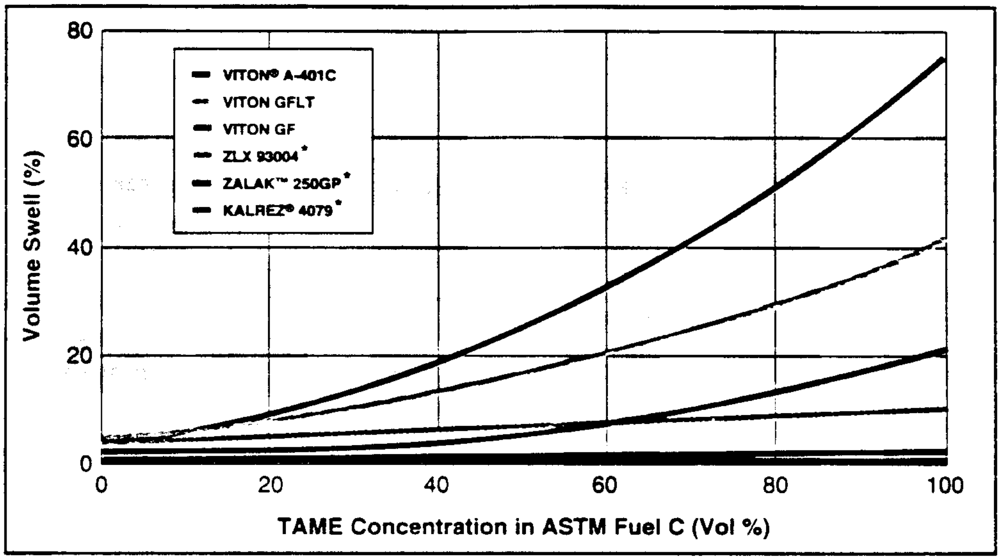


Figure 4. Relative Resistance to Increasing Concentrations of TAME in ASTM Reference Fuel C. (Immersion for 168 hours at 23°C [73°F], per ASTM D471.) Elastomeric Materials with an * Are Suggested for Use at All Concentrations. VITON® A-401C, VITON GF and VITON GFLT May Be Considered for Use at Concentrations <20%, by Volume.

VITON® A-401C are *not* recommended for use in fuels containing MeOH at any concentration.

In contrast, seals of VITON GF, VITON GFLT, ZLX 93004, ZALAK™ 250GP and KALREZ® 4079 offer exceptionally good resistance to swelling across the entire concentration range. Thus, each of these materials can be suggested for use in neat MeOH and MeOH fuel blends of any composition.

Figure 6 — Relative resistance to increasing concentrations (0 to 100%, by volume) of EtOH in ASTM Reference Fuel C. EtOH is a far less aggressive oxygenate than MeOH toward elastomeric materials.

As shown, all of the seal materials adequately resist swelling (<20%, by volume) at all concentrations of EtOH. Seals of VITON A-401C, VITON GF, VITON GFLT, ZLX 93004, ZALAK 250GP and KALREZ 4079 offer exceptionally good resistance to swelling across the entire concentration range. Any of these materials can be considered for use in neat EtOH and EtOH/fuel blends of any composition.

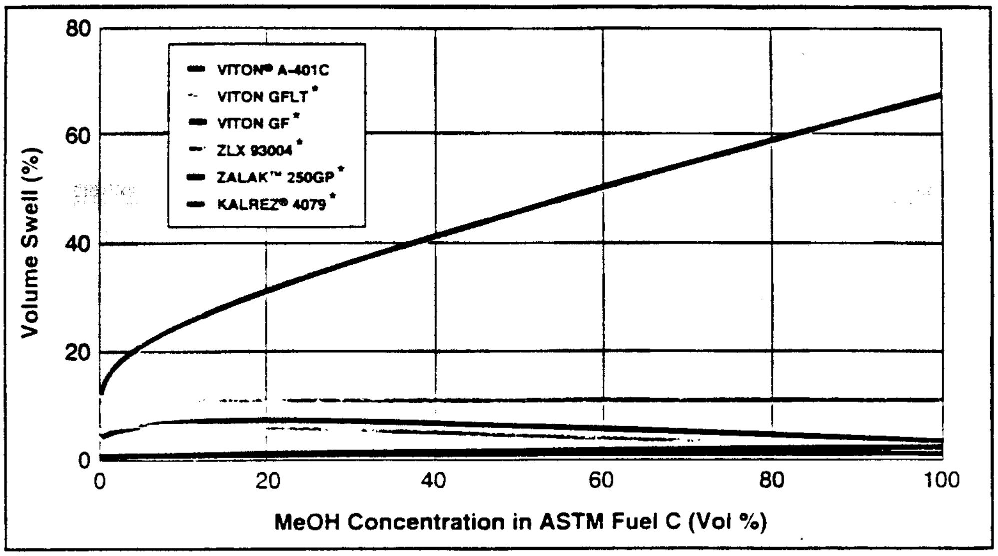


Figure 5. Relative Resistance to Increasing Concentrations of MeOH in ASTM Reference Fuel C. (Immersion for 168 hours at 23°C [73°F], per ASTM D471.) Elastomeric Materials with an * Are Suggested for Use at All Concentrations.

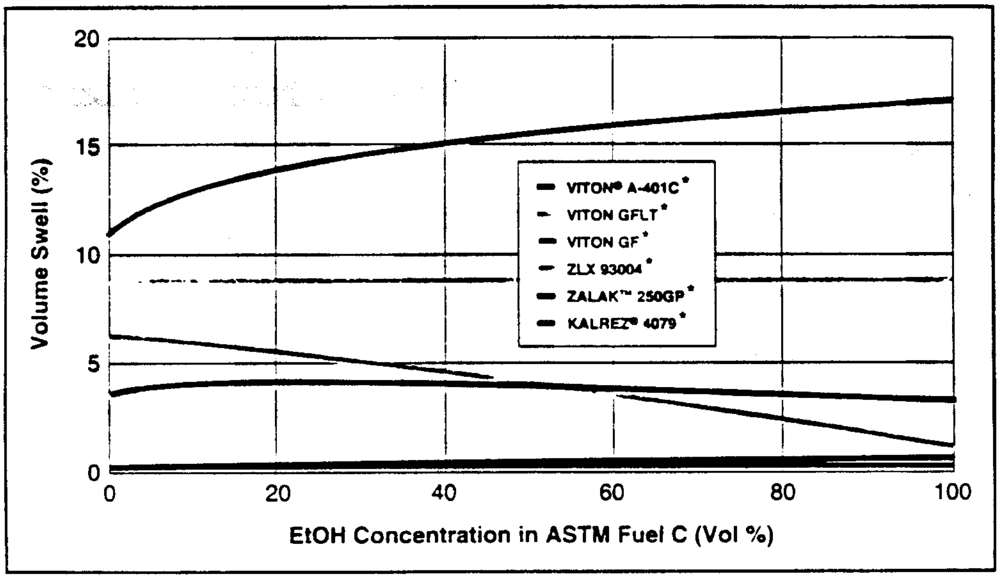


Figure 6. Relative Resistance to Increasing Concentrations of EtOH in ASTM Reference Fuel C. (Immersion for 168 hours at 23°C [73°F], per ASTM D471.) Elastomeric Materials with an * Are Suggested for Use at All Concentrations.

Summary of Sealing Capabilities

Media Resistance

Table II summarizes the findings and conclusions drawn from Figures 1 through 6. This table can help materials specialists select appropriate sealing materials that are fully compatible with both neat oxygenates and oxygenated fuel blends. By ranking the sealing materials against the degree of universal sealing capability, the decision-making process is made easier, allowing the materials specialist to select the appropriate elastomeric seal that will afford the *desired sealing performance and reliability*, regardless of the many uncertainties surrounding oxygenate types, concentrations and overall fuel compositions.

Table II. Value Ranking of Elastomer Performance in Neat Oxygenates and Oxygenated Fuels

			Compatibility with Oxygenates and Oxygenated Fuels (Types/Concentrations)	
Value Ranking	**Engineered Seal Material**	**Trade Name**	**Ethers**	**Alcohols**
Outstanding	Perfluoroelastomer Seals	KALREZ® 4079[1]	all/all	all/all
Excellent	High-Performance Seals	ZALAK™ 250GP[1]	all/all	all/all
Superior	High-Performance Seals	ZLX 93004[1]	all/all[2]	all/all
Very High	Highly Fluorinated Elastomers	VITON® GFLT[3]	all/except MTBE or TAME >20% by vol.[4]	all/all
High	Highly Fluorinated Elastomers	VITON® GF[3]	all/except MTBE >20% by vol.[4]	all/all
Medium	Fluorinated Elastomers	VITON® A-401C[3]	ETBE/all TAME/not recommended MTBE/not recommended	EtOH/all MeOH/<20% by vol.[5]
Limited	Fluorinated Elastomers	TFE/P	Limited utility based on either excess swell in some oxygenates, components of fuels and/or temperature considerations	
	Fluorinated Elastomers	Fluorosilicones		
	Non-Fluorinated Elastomers	Hydrogenated Nitriles		
	Non-Fluorinated Elastomers	Nitriles		

[1] Sealing products are directly available from DuPont and its authorized distributors.

[2] 100% MTBE causes moderate swell (≤ 25%).

[3] DuPont supplies polymer to seal manufacturers.

[4] MTBE and/or TAME concentrations >20% should be assessed for appropriateness.

[5] MeOH concentrations should be assessed for appropriateness.

Temperature Performance Range

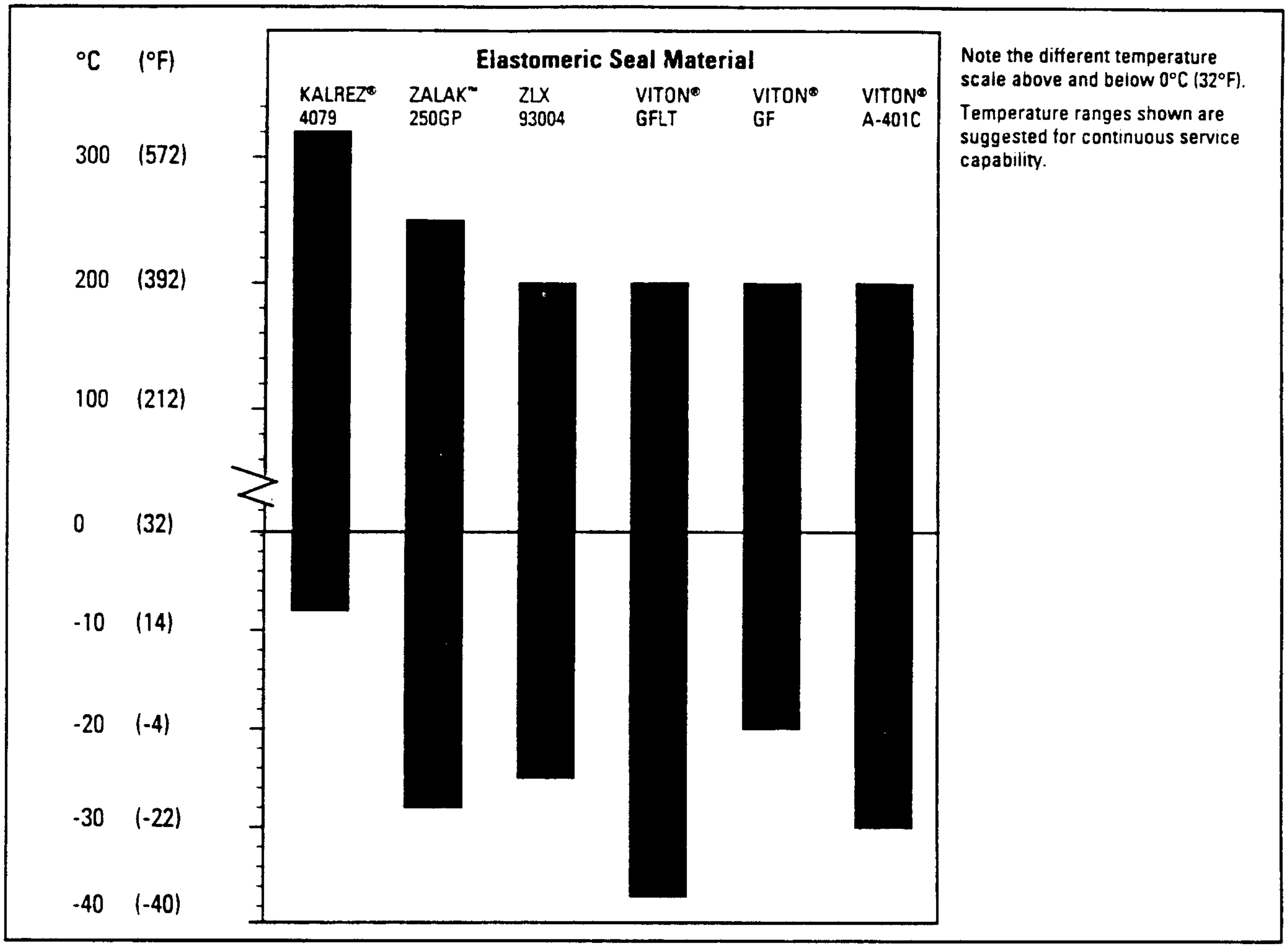
Another important criterion of seal performance is the *breadth of the temperature range* within which a seal can be suggested for continuous use. Depending upon the application, media, equipment engineered design and geographical region, *both high- and low-temperature performance ranges may be important.*

Figure 7 compares the continuous service temperature performance ranges of the six elastomer sealing materials previously discussed.

As shown, KALREZ® 4079 exhibits the highest temperature range of sealing capability, offering sealing performance at temperatures in excess of 315°C (599°F).

Within the family of ZALAK™ products, both ZALAK 250GP and ZLX 93004 exhibit good high-temperature sealing capability, as well as low-temperature sealing performance.

Seals of VITON® GFLT demonstrate *superior* low-temperature sealing performance in both static and dynamic applications. On the other hand, seals of VITON GF and VITON A-401C offer high-temperature capability equivalent to that of VITON GFLT, but are somewhat deficient in their respective low-temperature sealing capabilities.



Note the different temperature scale above and below 0°C (32°F).

Temperature ranges shown are suggested for continuous service capability.

Figure 7. Continuous Service Temperature Performance Range.

Value Assessment

As is often the case, initial cost is one important element in the decision-making process. Figure 8 illustrates the purchase cost vs. value/performance relationship of the fluorinated elastomer sealing materials discussed in this paper. In this context, value/performance is defined as:

- Appropriate resistance to anticipated media:
  - — aliphatics
  - — aromatics
  - — oxygenates
  - — blends of oxygenates
  - — oxygenated fuels
- Sealing performance over anticipated temperature and pressure ranges
- Long-term seal performance:
  - — normal operation conditions
  - — upset conditions
  - — environmental compliance
- Low permeability to fuels and oxygenates to reduce VOC levels
- Minimization of downtime, replacement costs, record keeping and VOC monitoring frequency
- Ability to handle unanticipated performance demands

In addition to the tangible elements listed above, an important intangible — peace of mind — should be considered when evaluating the value-in-use of seals in these critical applications. When the concern of component failure is reduced — or eliminated — managers, engineers, maintenance and safety personnel can rest assured that daily operations won't be interrupted and environmental mishaps will be avoided.

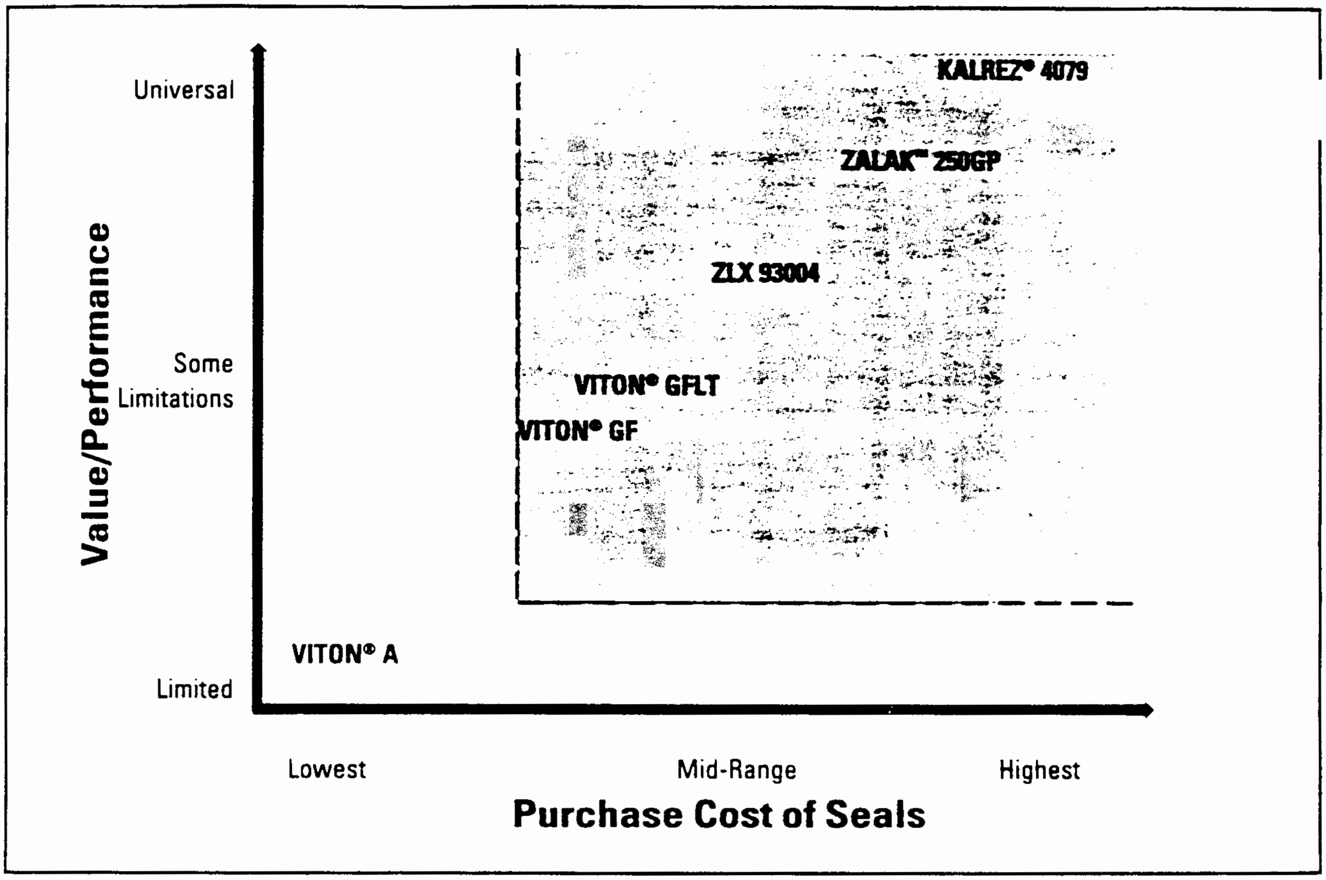


Figure 8. Purchase Cost vs. Value/Performance of Fluorinated Sealing Materials in Oxygenates and Oxygenated Fuels

Selecting the Best Solution for Sealing Oxygenated Fuels

Although future fuel formulations are uncertain, there are two known factors. First, the use of oxygenates will continue. Second, MTBE — the most highly aggressive ether — accounts for one-third to one-half of all oxygenates used today. Based on industry projections, MTBE is expected to continue to serve as the oxygenate of choice for the remainder of the decade, with EtOH supplementing the oxygenate supply. The role of other oxygenates, such as MeOH, ETBE and TAME, is less well defined.

When selecting materials of construction, it is important to remember that each candidate offers a unique combination of features and benefits that must be evaluated against the particular requirements of an application. It is essential to choose the candidate that offers optimum performance capability and protection against failure, given the anticipated parameters of the specific application.

As previously stated, DuPont offers a range of proven products to meet the evolving needs of the fuels industry. Here are concise summaries describing how these candidates might best be used. (These summaries are just brief overviews; for more detailed information, contact DuPont.)

VITON® A-401C is an excellent sealing material in neat EtOH and ETBE, as well as at all concentrations of either oxygenate in reformulated fuels. However, VITON A-401C is not recommended for use as seals in neat MeOH, TAME or MTBE, nor at concentration levels of these oxygenates above 20 volume percent. Based on these limitations, the other materials discussed below may offer greater value/performance as an oxy-fuel sealing material.

VITON GF is an excellent candidate for service in all reformulated gasolines blended with oxygenates to levels defined by current regulations. In addition, it may be considered for use in many neat oxygenates other than MTBE. Based on these factors, service involving the storage and distribution of reformulated gasolines are likely applications.

VITON GFLT is an excellent candidate for service in all reformulated gasolines blended with oxygenates to levels defined by current regulations, as well as in many neat oxygenates (except MTBE and TAME). VITON GFLT offers an additional important performance feature because it extends the low-temperature sealing capabilities of these fluorinated elastomers to values approaching -40°C (-40°F) in static seal applications. Based on this important combination of features, service involving storage and distribution of reformulated gasolines, *even in cold climates*, are likely applications.

ZLX 93004 represents exceptional high-performance elastomeric seals, designed for service in most neat oxygenates of the alcohol and ether classes (only neat MTBE causes moderate swell). It is suitable for all oxygenated fuels, regardless of composition. Based on these factors, service involving oxygenate manufacture, blending, storage and distribution are likely applications.

ZALAK™ 250GP is an outstanding candidate for applications involving all neat oxygenates and gasoline blends at any concentration. Service involving oxygenate production, distribution, storage gasoline blending and distribution are likely applications.

KALREZ® 4079 provides premier performance in all oxygenates and reformulated gasolines, delivering the ultimate in compatibility, reliability and quality. Demanding service involving versatility in any neat oxygenate, blends and reformulated gasolines are likely applications.

Conclusion

The 1990 Amendments to the CAA are causing dramatic changes within the fuel industry. Although future fuel formulations are uncertain, it is quite clear that the use of oxygenates is here to stay. Every partner in the manufacture and supply chain — from the refiner to the retailer — must make major decisions about the future based on financial, legal, logistical and environmental concerns.

One issue that every partner in the manufacture and supply chain must address is the fact that oxygenates and oxygenated fuels are incompatible with some materials of construction currently in use. The good news is that reliable technical sealing solutions are readily available. Companies, such as DuPont, have a broad offering of proven products to meet the changing sealing needs of the fuels industry.

Selecting the best sealing solution for a particular application need not be difficult. The features and benefits of fluorinated elastomer candidates can be carefully weighed against the anticipated requirements of the application. Even when existing requirements change due to evolving regulations and changes in political policies, a conservative approach and the selection from high value-in-use sealing materials minimize the potential risk of seal failure and the often disastrous consequences.

DuPont's technical staff is available to help you thoroughly evaluate the various fluoroelastomer candidates for selection and use as sealing materials. They are armed with the detailed technical reports and supporting data you need to make an informed decision. For assistance, call DuPont at 1-800-452-1454.

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