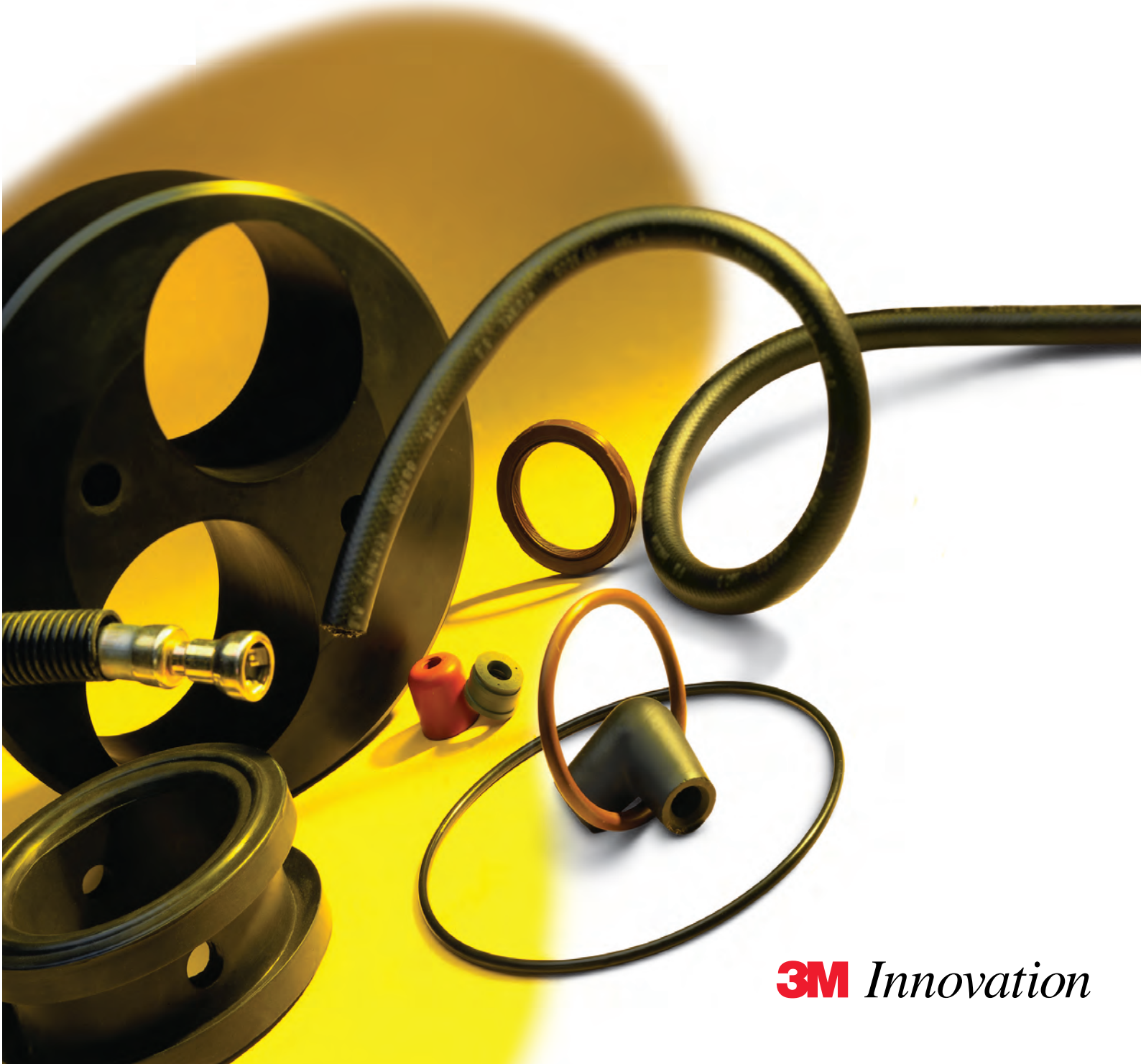
dyneon

A 3M Company

High Performance Fluoroelastomers

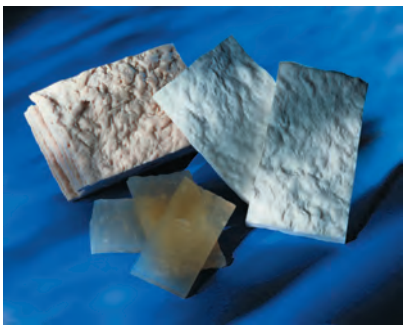
Product Comparison Guide



3M Innovation

How to use this Guide

With harsher chemical environments, broader temperature ranges and more complex and demanding designs, sealing applications are more extreme than ever before. There are also more elastomer options than ever before. Combine all of these issues and today's rubber chemists and design engineers face some tough decisions when it comes to material specification.



Dyneon™ Fluoroelastomers

Dyneon's technical expertise and commitment to customer service help take the guesswork out of choosing the right fluoroelastomer for your application. This product comparison guide is designed to address the basic considerations when formulating a fluoroelastomer compound: "What is the environment?" "What is the application?" "What is the manufacturing process?" and "What is the part profile?" The answers to these questions will help narrow your search for a fluoroelastomer that will deliver optimal performance.

When you need further clarification or have a particularly challenging application, our Application and Product Development Engineers and Chemists are ready to help. You will find our contact information on the back cover of this brochure.

Table of Contents

THE DYNEON™ FLUOROELASTOMER PRODUCT FAMILY INCLUDES...

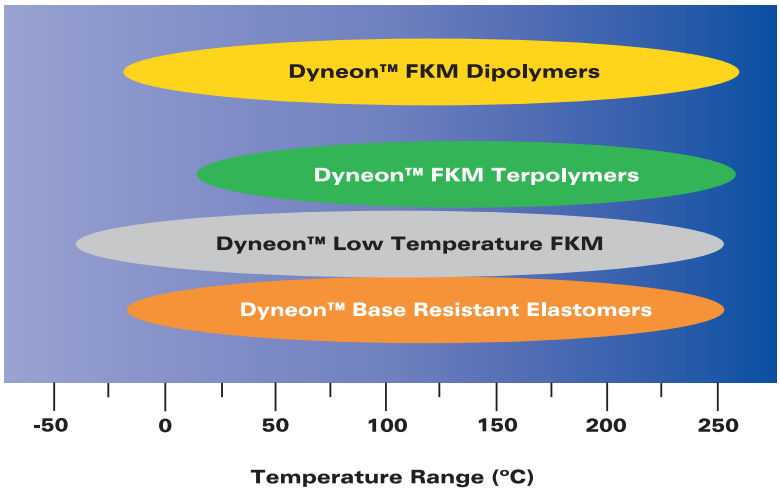
- **Fluoroelastomer (FKM) dipolymers and terpolymers containing 65-71% fluorine**
- **Base Resistant Elastomer (BRE) dipolymers and terpolymers**
- **Low fluorine terpolymers**
- **MIP Fluoroelastomers for improved productivity**
- **Low Temperature Fluoroelastomers**

What is the Environment?

The first step in selecting the proper Dyneon™ Fluoroelastomer for your application is to consider the service environment – the chemicals and temperatures your part will encounter. The charts below illustrate the broad chemical and temperature resistance of Dyneon Fluoroelastomers. Use these charts to guide your search for the Dyneon Fluoroelastomers that will deliver the desired performance for the environment.

If you do not find your chemical class here, please contact us at one of the locations on the back of this brochure or visit our web site, **www.dyneon.com**, for more information.

Effective temperature range of Dyneon™ Fluoroelastomers



Range based on retention of physical properties.

CHEMICAL RESISTANCE

	Dyneon™ Low Temperature Fluoroelastomers	Dyneon™ Fluoroelastomers		Dyneon™ Base Resistant Elastomers	
	LTFE 6400X (67.1% F)	Dipolymers (66% F)	Terpolymers (68-71% F)	Dipolymers	Terpolymers
Oxidation	:	:	:	:	:
Ozone	:	:	:	:	:
Radiation	:	:	:	:	:
Water < 100°C (212°F)	:	:	:	:	:
Water > 150°C (302°F)	:	1	1	:	1
Lubricants	:	See transportation applications on page 4.			
Steam	:	:	:	:	:
Alkali (Dilute < 5%)	:	:	:	:	:
Alkali (Concentrated)	:	–	–	:	:
Acids	:	:	:	:	:
Alcohol (Methanol)	:	–	:	:	:
Alcohols (Other)	:	:	:	:	:
Aliphatic Hydrocarbons	:	:	:	:	:
Aromatic Hydrocarbons	:	:	:	–	1
Fuels	:	See transportation applications on page 4.			

: Excellent Resistance (little or no effect)
1 Good to Excellent Resistance (moderate effect)
– Not Recommended (substantial effect)
Ratings based on retention of physical properties.

What is the Application?

DID YOU KNOW...

- **The specific gravity of Base Resistant Elastomers (BREs) is lower than standard fluoroelastomers.**
- **Dyneon has FE grades that extrude well without the need for a process aid.**
- **Fluoroelastomers can be bonded to plastics and sulfur- or peroxide-cured elastomers.**
- **Fluoroelastomers can be compounded to pass a -40°C mandrel flex test and to be conductive.**

Transportation

The use of fluoroelastomers in transportation (automotive, aerospace, small engine, etc.) sealing applications has increased dramatically in recent years due to changing operating conditions.

Powertrain

Extended service life warranties demand more from powertrain seals. Due to their excellent chemical and temperature resistance, Dyneon™ Fluoroelastomers offer improved sealing and wear resistance in powertrain applications that encounter aggressive fluids such as gear lubricants, transmission fluids and engine oils.

Lubricant Applications

Valve stem seals, rotary shaft seals (axle pinion seals, gear boxes, transmission seals, transfer case input/output seals), engine gasket seals, oil pan seals, cylinder liner seals, engine head gaskets

What's important for optimum performance?

- Chemical resistance to powertrain lubricants (amine resistance) and coolants
- Adhesion to metal or plastic substrates
- Service life

Fuel Systems

Regulations around the world continue to adopt more stringent fuel emission standards. Dyneon™ Fluoroelastomers are commonly used in fuel system applications because of their excellent permeation resistance, effectiveness as barriers against evaporative emissions, chemical resistance to a broad variety of fuels and long-term durability.

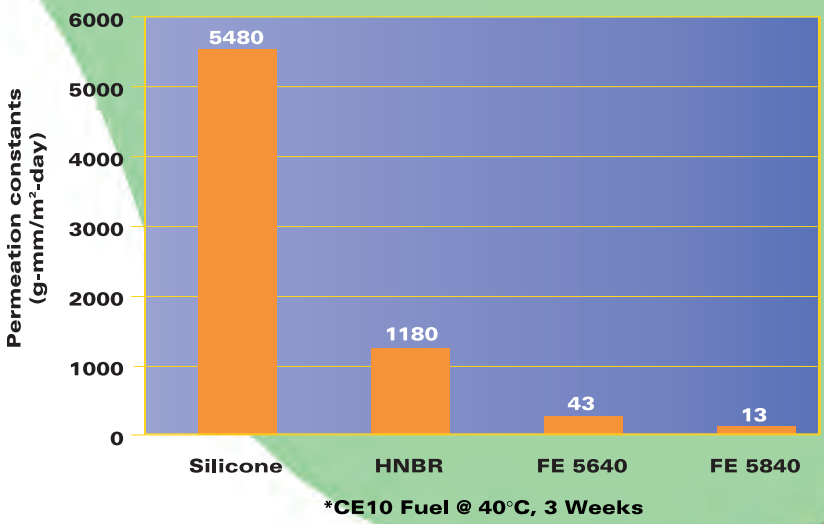
Fuel Applications

Fuel line hose, filler neck hose, chemical transport hose, in-tank hose, injector o-rings, gas caps, sender seals

What's important for optimum performance?

- Chemical resistance to a wide range of fuels
- Permeation resistance (See chart at left)
- Volume swell and property changes over time
- Performance over temperature range
- Sealability

Permeation data for elastomers commonly used in automotive applications



*CE10 Fuel @ 40°C, 3 Weeks

*CE10 = 90% RFC and 10% Enthanol
(RFC = 50% Toluene and 50% IsoOctane)

FUEL AND LUBRICANT RESISTANCE

			Dyneon™ Fluoroelastomers				Dyneon™ Base Resistant Elastomers			
			Dipolymers (66% F)		Terpolymers (68-71% F)		Dipolymers		Terpolymers	
			Rating	(Volume Swell)	Rating	(Volume Swell)	Rating	(Volume Swell)	Rating	(Volume Swell)
Fuels	RFC (50% Toluene, 50% IsoOctane)	23°C, 7 days	:	(5)	:	(2)				
		60°C, 7 days	1	(15)	1	(11)				
	RFC/MeOH (15/85)	60°C, 7 days	–	(89)	1	(18)				
	RFC/MeOH (80/20)	23°C, 7 days	–	(37)	:	(5)				
		40°C, 7 days	–	(41)	:	(10)				
	RFC/EtOH (90/10)	23°C, 7 days	1	(4)	1	(2)				
		40°C, 7 days	1	(20)	1	(16)				
		60°C, 7 days	–	(27)	1	(13)				
	RFD/EtOH (75/25)	23°C, 7 days	1	(12)	:	(3)				
		40°C, 7 days	–	(27)	:	(10)				
		60°C, 7 days	–	(35)	1	(16)				
	Peroxidized RFC, PN90	60°C, 7 days	1	(15)	1	(12)				
EP Gear Lubricants	Chrysler™ MS-9763	150°C, 7 days	–	(0.9)	–	(1.8)	:	(5.4)	:	(1.6)
		125°C, 42 days	–	(0.6)	1	(1.2)	:	(3.5)	:	(1.6)
	Chrysler™ MS-9020	150°C, 7 days	–	(1.3)	–	(1.3)	:	(4.2)	:	(2.5)
	Unocal™ 98-01-04 MPF Gear Oil - SAE 90	150°C, 7 days	1	(3.1)	:	(2.8)	:	(5.9)	:	(3.5)
Engine Oils	Mobil™ 1 5W-30	150°C, 7 days	–	(0.8)			:	(5.1)	:	(2.8)
	Chrysler™ MS-6395H (Mobil Type SJ)	150°C, 7 days	:	(0.5)	:	(0.6)	:	(7)	:	(2.6)
	SAE SF 105G Reference Oil	150°C, 7 days	–	(1)	–	(1)	:	(7)	–	(3)
	IRM 902 Reference Oil	150°C, 7 days	:	(1.1)	:	(1.1)	:	(5.5)	:	(2.7)
	IRM 903 Reference Oil	150°C, 7 days	:	(2.6)	:	(2.4)	:	(17.7)	:	(7.4)
	BP Caecilia C 20	150°C, 168 h	–		–	(2.6)			:	(3.5)
		180°C, 168 h	–		–	(4.2)			:	(4.4)
Transmission Fluids	Chrysler™ MS-9602	150°C, 7 days	1	(0.9)	1	(0.5)	:	(5.4)	:	(2.1)
		125°C, 42 days	1	(0.9)	1	(0.6)	:	(4.1)	:	(2)
	Chrysler™ MS-7176	150°C, 7 days	1	(0.4)	1	(0.2)	:	(5.6)	:	(1.8)
		125°C, 42 days	:	(0.3)	:	(0.2)	:	(3.9)	:	(1.2)
	Dexron™ III (Petro Canada F-30102)	150°C, 7 days	1	(2)	1	(2)	:	(8)	:	(4)
	Dexron™ III (Texaco OEM)	150°C, 7 days	1	(2)	1	(2)	:	(10)	:	(3)
	Ford - Exxon Type B	150°C, 7 days	1	(0.4)	1	(0.4)	:	(4.1)	:	(2)
	Ford - Exxon Type C	150°C, 7 days	1	(1)	1	(1)	:	(7)	:	(3)
	Ford - Exxon Type D	150°C, 7 days	1	(2.3)	1	(1.7)	:	(6.8)	:	(3.2)
	Ford - Exxon Type H	150°C, 7 days	1	(1.4)	1	(1.4)	:	(7.7)	:	(2.4)
Bearing Grease	Amoco™ Rycon Premium WA 1272	150°C, 7 days	–	(3)	–	(2.9)	:	(5.8)	–	(4.4)
Brake Fluids	Wagner™ 21B (DOT 3)	150°C, 7 days	–	(25)	:	(4.7)	:	(5)	1	(11.3)
	Castrol™ (Dot 3/4)	150°C, 3 days	–	(28)	1	(28)				
	Delco™ Supreme 11	125°C, 3 days					:	(5.5)	1	(21)
Coolants	AC Delco Dex-Cool™ #10-101	150°C, 21 days	–	(5)	–	(4)	:	(3)	:	(7)
	Caterpillar™ Heavy Duty #8C-3684	150°C, 21 days	1	(23)	1	(16)	:	(3)	1	(12)
	Valvoline™ Zerex™	107°C, 7 days	:	(0.5)	:	(1.1)	:	(0.6)	:	(0.5)
	Prestone™ Low Tox	107°C, 7 days	:	(1.2)	:	(0.5)	:	(0.7)	:	(0.4)
	Prestone™ Extended Life	107°C, 7 days	:	(0.6)	:	(0.9)	:	(1.3)	:	(1.5)
	AC Delco Dex-Cool™ Extended Life	107°C, 7 days	:	(1)	:	(0.8)	:	(1)	:	(0.6)

Dyneon™ BREs are not recommended for fuel applications

: Excellent Resistance (little or no effect)
1 Good to Excellent Resistance (moderate effect)
– Not Recommended (substantial effect)

Volume swell is not always indicative of chemical attack.
Ratings based on retention of physical properties.

What is the Application?

Pharmaceutical & Food Processing

Often used in sealing/fluid handling systems, Dyneon™ Fluoroelastomers help extend the life of capital equipment by providing long-term sealing and protection against high temperatures and corrosive chemicals.

Applications

Butterfly valves, ball valves, pumps, o-rings, hoses, gaskets, linings, diaphragms, seals

What's important for optimum performance?

- Broad chemical resistance
- Long-term durability
- Excellent heat resistance
- Purity requirements

Fluid Handling and Environmental Control Systems

Pumps, valves, tubing, hose, diaphragms, expansion joints and membranes constructed of Dyneon™ Fluoroelastomers exhibit improved chemical and heat resistance as well as long-term durability in the presence of corrosive materials.

Applications

Valve seats/liners, pipe gaskets, packings, pump seals, tank liners, expansion joints

What's important for optimum performance?

- Chemical resistance
- Adhesion to metal substrates
- Durability
- Durometer of the part

Oil, Gas & Mineral Extraction

From down-hole drilling to pipeline distribution systems, Dyneon™ Fluoroelastomers offer process equipment designers and manufacturers a variety of sealing and containment solutions for aggressive environments such as sour oil and gas, amine corrosion inhibitors, acids and steam.

Applications

Down-hole packers – permanent or retrievable, safety valves, plugs, sliding sleeves, v-packing, T-seals, molded seals

What's important for optimum performance?

- Chemical resistance to production fluids, injection fluids, etc.
- Resistance to produced gases — H_2S, CO_2, etc.
- Volume swell and property changes over time and temperature range
- Resistance to explosive decompression
- Adhesion to metal substrates

DID YOU KNOW...

- **Dyneon™ FG Elastomers for seals, pump linings, etc., comply with US Food and Drug Administration (FDA) regulation 21 C.F.R. 177.2600 (c)(4)(i).**
- **Solvent coatings can be screen printed, roll coated, spray coated or dip coated. These coatings are thin, flexible and offer excellent chemical and heat resistance.**
- **Increasing the crosslink density of the fluoroelastomer can increase the resistance to explosive decompression.**

Specialty Applications

Dyneon offers over 50 grades of fluoroelastomers with varying monomer composition, mooney viscosity and fluorine content. This broad offering combined with Dyneon's expertise in application and product development translates into greater design flexibility. From coatings to calendared sheets, tubing to molded goods, Dyneon has a solution for your specialty application. Please contact us directly to discuss your needs.

What is the Manufacturing Process?

Processing Considerations

The type of manufacturing process you plan to use to produce your part will have an impact on the fluoroelastomer you choose.

Dyneon™ Bisphenol-cured Fluoroelastomers are considered by many to be the best-processing fluoroelastomers on the market today. We offer a large selection of incorporated cure gums to help you develop the most robust compound for your process.

What's important for optimum performance?

- Mooney viscosity
- Cure speed
- Scorch safety
- Flow rates
- Demoldability

Manufacturing Processes

Injection Molding

Choose a low to medium viscosity (20 to 60 MV) gum with excellent scorch safety and a fast cure. (See Multifunctional Improved Productivity (MIP) Products section below.)

Transfer Molding

Choose a low to medium viscosity (20 to 60 MV) gum with good scorch safety to avoid curing in the transfer pot.

Compression Molding

Choose a medium to high viscosity (50 to 90 MV) gum with a fast cure cycle.

Extrusion

Choose a low viscosity (20 to 40 MV) gum with good scorch safety. Many times process aids can be used to improve flow and surface smoothness, but are not always necessary.

Coating

Solution viscosity is determined by the solvent used and filler level. Solution stability (pot life) is of key concern. (See MIP products section below.)

Post Curing

To achieve the maximum in physical properties, post curing of fluoroelastomer parts is recommended. A typical post cure cycle is 16 hours at 232°C (450°F). However, the post cure time and temperature can be varied to optimize finished part properties, manufacturing process flow targets and cost. For some applications, a post cure may not be necessary.

Additional Information

For additional information on processing Dyneon™ Fluoroelastomers, see the following publications (also available at **www.dyneon.com**).

Compounding Dyneon™ Fluoroelastomers

Processing Dyneon™ Fluoroelastomers

Sources of Food Grade Acid Acceptors and Fillers

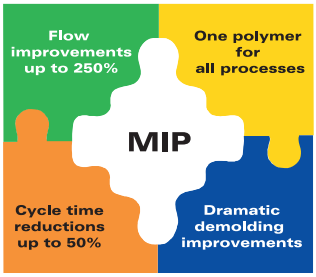
DID YOU KNOW...

- **Post cure is critical for optimum performance and optimum compression set.**
- **Fluoroelastomers can be calendared to <0.25 mm thickness.**
- **Fluoroelastomers offer excellent resistance to weathering, including UV resistance.**

Multifunctional Improved Productivity (MIP) Products

Dyneon™ MIP Fluoroelastomers include a proprietary cure technology that dramatically opens the processing window. Using this technology, Dyneon can customize a polymer to meet your needs. Dyneon™ MIP technology offers many advantages as shown in the graphic.

Advantages of Dyneon™ MIP Fluoroelastomers



We can tailor MIP fluoroelastomers for your process needs.

What is the Part Profile?

Key Considerations for Molded Shapes

Molded goods fall into two main categories: Complex shapes and bonded seals.

When molding complex shapes, the following parameters should be considered:

- What is your manufacturing process?
- What is the geometry of the part – are there undercuts?
- Mold release
- Hot tear strength
- Chemical and heat resistance
- Low temperature performance

Additional considerations for bonded seals are:

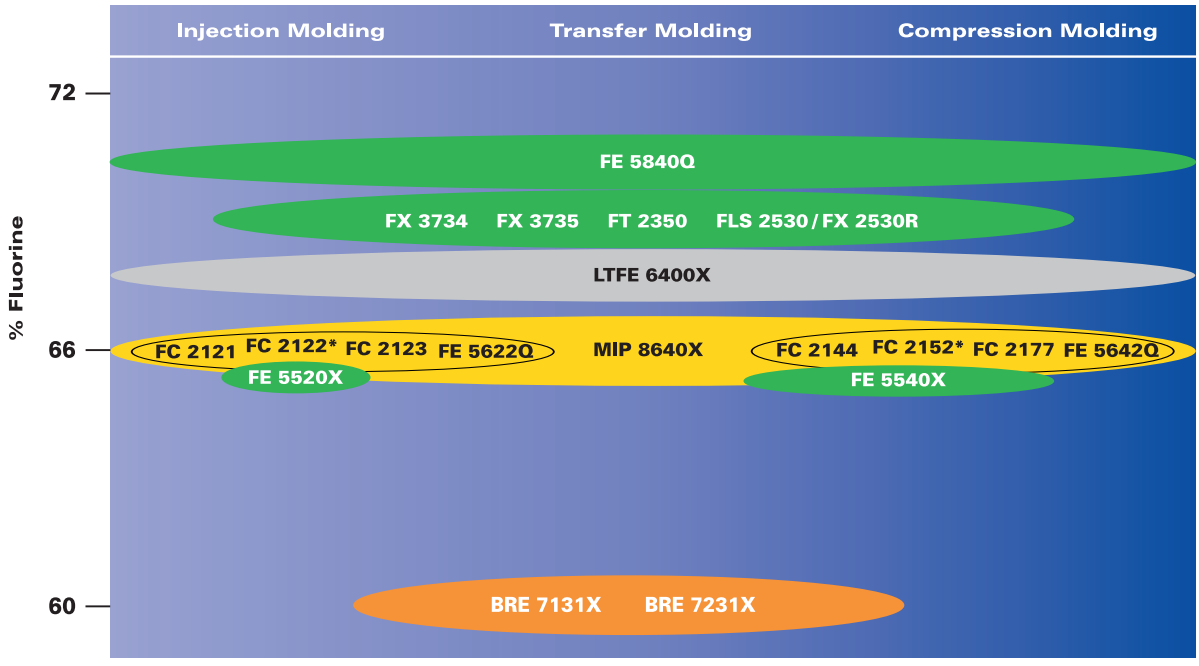
- Adhesion (to the substrate) requirements
- Post cure conditions

Choosing Dyneon™ Fluoroelastomers for molded shapes by key properties

	Injection Molding	Transfer and Compression Molding
Best compression set	FE 5622	FC 2144
Fastest cure speed (Cure temp. must be >190°C)	FE 5622	FE 5642
Best hot tear strength	FC 2122*	FC 2152*

*Not recommended for bonded seal applications

Choosing Dyneon™ Fluoroelastomers for molded shapes by processing method



*Not recommended for bonded seal applications

- FKM Terpolymers
- FKM Dipolymers
- Low Temp FKM
- Base Resistant Elastomers (BREs)

DID YOU KNOW...

- **Fluoroelastomers can be formulated to offer a compression set of less than 10%.**

Key Considerations for O-rings

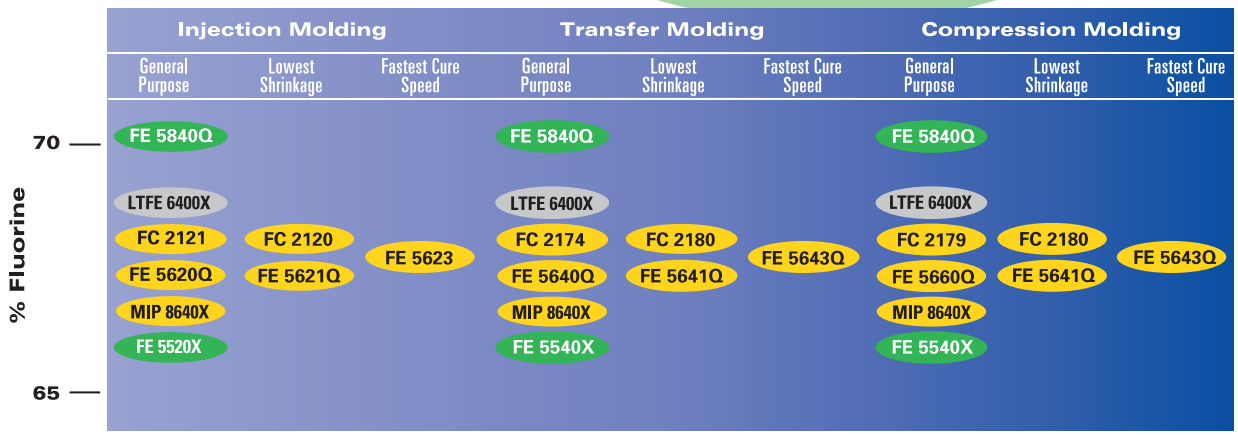
The most important consideration for an o-ring application is usually the compression set. As a general rule, the higher the viscosity of the fluoroelastomer, the lower the compression set.

Viscosity can be an important consideration when choosing Dyneon™ Fluoroelastomer grades that will be injection molded.

FE 5620Q and FE 5621 are suitable for injection molding and offer excellent compression set resistance.

The following chart shows the available Dyneon™ Fluoroelastomers with their respective fluorine contents and applicability to various processing techniques.

Choosing Dyneon™ Fluoroelastomers for o-rings by processing method*



*For additional base resistance, we recommend BRE 7131X and BRE 7231X

1FKM Terpolymers 1FKM Dipolymers
1Low Temp FKM

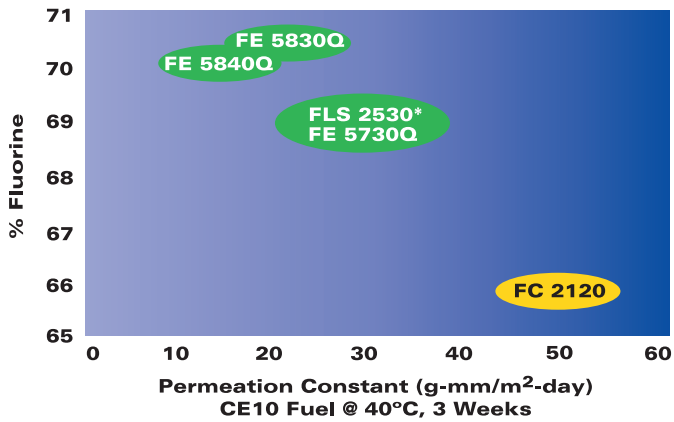
Key Considerations for Extruded Shapes

Fluoroelastomer hose is used in a variety of applications – from automotive fuel line and turbocharger hose to extruded o-ring cord.

What's important for optimum performance?

- Flexibility
- Chemical resistance, in particular permeation resistance
- Fluid pressure
- Material and surface hardness
- Sealability at the hose ends
- Performance over service temperature range
- Extrudate surface requirements

Choosing Dyneon™ Fluoroelastomers for extruded shapes by permeation



*Equivalent to FX 2530R

DID YOU KNOW...

- **For hose applications, consider using FE 5830Q. This product offers excellent processing as well as low permeation and volume swell.**

Typical Physical Properties (Data not for specification purposes)

INCORPORATED CURE FLUOROELASTOMERS										Applications						Product Distinctions
Product	Test Compound (75+/-5 Duro)	%F	S.G.	Mooney Viscosity (ML1 + 10 @ 121°C)	TR10 (°C)	Tensile psi (MPa)	Elong %	100% Modulus psi (MPa)	Compression Set ASTM D395 Method B (70 hrs @ 200°C)	O-rings	Bonded Seals	Molded Shapes	Hoses/ Extrusions	Coatings	Composites/ Sheet Goods	
FC 2110Q	I	65.9	1.80	17[1]	-18	2010 (13.8)	170	950 (6.5)	19					•		Very low viscosity dipolymer for blending and viscosity modification. Suggested alternative: FE 5610.
FC 2120	I	65.9	1.80	23	-18	2140 (14.7)	200	850 (5.9)	16				•		•	Low viscosity dipolymer designed for extrusion and calendaring applications.
FC 2121	I	65.9	1.80	24	-18	2375 (16.4)	180	1025 (7.1)	14	•						Low viscosity dipolymer for o-rings. Suggested alternative is FE 5620.
FC 2122	I	65.9	1.80	25	-18	1900 (13.1)	310	520 (3.6)	25			•				Low viscosity dipolymer for complex custom shapes. Suggested alternative: FE 5622.
FC 2123	I	65.9	1.80	25	-18	2350 (16.2)	270	530 (3.7)	20		•	•				Low viscosity dipolymer for bonded seals. Suggested alternative: FE 5622.
FC 2144	I	65.9	1.80	41	-18	2540 (17.5)	260	550 (3.8)	17		•	•				Intermediate viscosity dipolymer for bonded seals. Intermediate viscosity version of FC-2123. Suggested alternative: FE 5642.
FC 2146X	I	65.9	1.80	46	-18	2500 (17.2)	280	550 (3.8)	15		•	•				Lower shrinkage version of FC-2144.
FC 2152	I	65.9	1.80	51	-18	2100 (14.5)	305	550 (3.8)	22			•				Intermediate viscosity dipolymer for custom shapes. Intermediate viscosity version of FC-2122. Suggested alternative: FE 5622.
FC 2174	I	65.9	1.90	40	-18	2450 (16.9)	180	1050 (7.2)	12	•						Intermediate viscosity dipolymer for o-rings. Suggested alternative: FE 5640.
FC 2176	I	65.9	1.80	30	-18	2175 (15.0)	240	600 (4.1)	22			•				Intermediate viscosity dipolymer for general purpose use. Well suited for autoclave curing.
FC 2177	I[2]	65.9	1.80	33	-18	1865 (12.8)	240	700 (4.8)	21		•	•				Intermediate viscosity dipolymer for bonded seals. Slower cure and excellent tear strength.
FC 2179	I	65.9	1.80	80	-18	2475 (17.1)	180	1100 (7.6)	10	•						High viscosity dipolymer for o-rings. Suggested alternative: FE 5660.
FC 2180	I	65.9	1.80	40	-18	2370 (16.3)	180	1025 (7.1)	12	•						Lower shrinkage version of FC 2174. Suggested alternative: FE 5621.
FC 2181	I	65.9	1.80	44	-18	2560 (17.6)	240	690 (4.8)	13	•		•				Intermediate viscosity version dipolymer with excellent compression set. Suggested alternative: FE 5642.
FE 5520X	I	65.5	1.80	26	-19	2000 (13.8)	175	900 (6.2)	20	•		•				Low viscosity, low fluorine (65.5%) terpolymer for improved low temperature flexibility.
FE 5540X	I	65.5	1.80	40	-19	2100 (14.5)	180	1050 (7.2)	18	•		•				Intermediate viscosity, low fluorine (65.5%) incorporated cure terpolymer for improved low temperature flexibility.
FE 5610	I	65.9	1.80	17[1]	-18	1930 (13.3)	210	800 (5.5)	21					•		Very low viscosity dipolymer for blending and viscosity modification.
FE 5620Q	I	65.9	1.80	23	-18	2240 (15.4)	195	950 (6.5)	13	•						Low viscosity dipolymer for o-rings.
FE 5621	I	65.9	1.80	23	-18	2240 (15.4)	195	950 (6.5)	13	•						Low shrinkage version of FE 5620.
FE 5622Q	I	65.9	1.80	22	-18	2350 (16.2)	250	700 (4.8)	18		•	•				Low viscosity dipolymer for custom shapes and bonded seals.
FE 5623	I	65.9	1.80	24	-18	2300 (15.8)	180	1030 (7.1)	13	•						Faster curing version of FE 5620 and FE 5621.
FE 5640Q	I	65.9	1.80	40	-18	2370 (16.3)	200	1050 (7.2)	11	•						Intermediate viscosity dipolymer for o-rings.
FE 5641Q	I	65.9	1.80	40	-18	2340 (16.1)	185	970 (6.7)	11	•						Low shrinkage version of FE 5640.
FE 5642	I	65.9	1.80	42	-18	2530 (17.4)	230	710 (4.9)	17		•	•				Intermediate viscosity version of FE 5622. Use for custom shapes and bonded seals.
FE 5643Q	I	65.9	1.80	40	-18	2400 (16.5)	180	1120 (7.7)	11	•						Faster curing version of FE 5640 and FE 5641.
FE 5660Q	I	65.9	1.80	60	-18	2400 (16.5)	200	1150 (7.9)	9	•						High viscosity dipolymer for o-rings.
FE 5730	I	69.2	1.87	36	-12	1460 (10.5)	300	375 (2.6)	45				•			Low viscosity terpolymer for extrusion applications. No process aid required when properly compounded.
FE 5830Q	I	70.5	1.90	33	-7	1600 (11.0)	250	640 (4.4)	44				•			Low viscosity terpolymer for extrusion applications. Superior fuel resistance. No process aid required when properly compounded.
FE 5840Q	I[3]	70.1	1.89	37	-7	2000 (13.8)	210	980 (6.8)	26	•		•				Intermediate viscosity high fluorine terpolymer for o-rings and custom shapes.
FG 5630Q	I	65.9	1.80	30	-18	2140 (14.7)	210	810 (5.6)	13	•		•			•	Low viscosity, incorporated cure dipolymer for food grade applications. Excellent compression set resistance.
FG 5661X	I	65.9	1.80	60	-18	2223 (15.3)	193	1008 (6.9)	14	•		•			•	Intermediate viscosity, incorporated cure dipolymer for food grade applications. Excellent compression set resistance.
FG 5690Q	I	65.9	1.80	97	-18	2360 (16.3)	200	1030 (6.9)	10	•		•			•	High viscosity, incorporated cure dipolymer for food grade applications. Excellent compression set resistance.
FLS 2530	I	69.0	1.85	39	-8	2200 (15.2)	255	700 (4.8)	19			•				Intermediate viscosity dipolymer for general purpose.
FT 2320	I	69.0	1.86	23	-12	2000 (13.8)	230	750 (5.2)	39				•		•	Low viscosity terpolymer designed for extrusion and calendaring applications.
FT 2340Q	I	68.6	1.86	49	-14	2030 (14.0)	300	508 (3.5)	33							Intermediate viscosity terpolymer.
FT 2350	I	68.6	1.86	56	-14	2210 (15.2)	310	540 (3.7)	36				•		•	Intermediate viscosity terpolymer. Intermediate viscosity version of FT 2320.
FX 2530R	I	69.0	1.85	39	-8	2200 (15.2)	255	700 (4.8)	19			•				Intermediate viscosity dipolymer for general purpose.
FX 3734	I	68.6	1.86	42	-13	2300 (16.0)	260	650 (4.5)	23		•					Intermediate viscosity terpolymer designed for bonded seals.
FX 3735	I	68.6	1.86	42	-13	2150 (15.0)	310	520 (3.6)	36		•					Intermediate viscosity terpolymer designed for bonded seals.
FX 9194	I	68.6	1.86	45	-13	2450 (17.0)	270	850 (6.0)	20							High viscosity terpolymer. Blend to increase viscosity and green strength.
FX 11818	I	68.6	1.86	28	-14	1800 (12.4)	290	490 (3.4)	34				•		•	Low viscosity version of FT 2350.

Footnotes to product tables

[1] Mooney viscosity at 100°C (212°F)
[2] MgO at 9 phr
[3] Durometer equals 84
[4] Raw Gum
[5] Incorporated Cure
[6] Peroxide Cure

See page 13 for additional footnotes and Test Compounds Charts.

Typical Physical Properties (Data not for specification purposes)

BASE RESISTANT ELASTOMERS

Product	Test Compound (75+/-5 Duro)	%F	S.G.	Mooney Viscosity (ML1 + 10 @ 121°C)	TR10 (°C)	Tensile psi (MPa)	Elong %	100% Modulus psi (MPa)	Compression Set ASTM D395 - Method B (70 hrs @ 200°C)	Applications: O-rings	Bonded Seals	Molded Shapes	Hoses/ Extrusions	Coatings	Composites/ Sheet Goods	Product Distinctions
BRE 7131X[5]	I	60.0	1.60	34	-1	1800 (12.4)	200	800 (5.5)	34		•	•				Incorporated cure terpolymer for bonded seals and complex shapes. Better base resistance than BRE 7231X.
BRE 7132X[5]	I	60.0	1.60	34	-1	2000 (13.8)	170	1200 (8.9)	34	•		•				Incorporated cure terpolymer for o-rings and other shapes. Better base resistance than BRE 7231X.
BRE 7231X[5]	I	60.0	1.60	34	-9	1900 (13.1)	200	800 (5.5)	34		•	•				Incorporated cure terpolymer for bonded seals and complex shapes. Better low temperature flexibility than BRE 7100 series products.

DYNEON™ FLUOROELASTOMER RAW GUMS

Product	Test Compound (75+/-5 Duro)	%F	S.G.	Mooney Viscosity (ML1 + 10 @ 121°C)	TR10 (°C)	Tensile psi (MPa)	Elong %	100% Modulus psi (MPa)	Compression Set ASTM D395 - Method B (70 hrs @ 200°C)	Applications: O-rings	Bonded Seals	Molded Shapes	Hoses/ Extrusions	Coatings	Composites/ Sheet Goods	Product Distinctions
FC 2145	II	65.9	1.80	28	-18	1765 (12.2)	184	805 (5.5)	16							Low viscosity dipolymer for blending to improve flow and in coatings.
FC 2178	II	65.9	1.80	100	-18	2275 (15.7)	177	1065 (7.3)	10							Very high viscosity dipolymer used for increasing viscosity and green strength.
FC 2210X		66.0	1.80	200 Poise at 105°C, spindle #27, 18.7 g, 5 rpm												Extremely low viscosity dipolymer for viscosity modification.
FC 2211	II	65.9	1.80	20[1]	-18	1870 (12.9)	180	600 (4.1)	17							Very low viscosity dipolymer for blending and coatings.
FC 2230	II	65.9	1.80	38	-18	1995 (13.7)	165	972 (6.7)	15							Intermediate viscosity dipolymer used for property modification.
FC 2260[6]	III	65.9	1.80	60	-18	2345 (16.2)	225	745 (5.1)	25							High viscosity peroxide-curable dipolymer. Could be used for co-vulcanizable blends with other elastomers.
FC 2261Q	II	65.9	1.80	63	-18	1870 (12.9)	240	630 (4.3)	14							High viscosity dipolymer used for increasing viscosity and green strength.
FE 5522X	I	65.5	1.8	29	-19	2000 (13.8)	175	950 (6.5)	20							Low viscosity, low fluorine (65.5%) terpolymer for improved low temperature flexibility. Use with other FE 5500 series products
FE 5542X	I	65.5	1.8	42	-19	2100 (14.5)	180	1000 (6.9)	18							Intermediate viscosity, low fluorine (65.5%) terpolymer for improved low temperature flexibility. Use with other FE 5500 series products.
FLS 2640Q	III	70.1	1.89	48						Raw gums can be compounded to meet all of these applications.						High fluorine, intermediate viscosity terpolymer.
FLS 2650[6]	III	70.3	1.89	50	-7	2600 (18.0)	230	780 (5.3)	28							High viscosity peroxide curable terpolymer.
FT 2430	II	68.6	1.86	31	-14	1950 (13.4)	255	340 (2.3)	38							Intermediate viscosity terpolymer. Blend to improve flow or use for coatings.
FT 2481	II	68.6	1.86	75	-14	2200 (15.2)	220	799 (5.5)	24							High viscosity terpolymer. Blend to increase viscosity and green strength..

MIP PRODUCTS

Product	Test Compound (75+/-5 Duro)	%F	S.G.	Mooney Viscosity (ML1 + 10 @ 121°C)	TR10 (°C)	Tensile psi (MPa)	Elong %	100% Modulus psi (MPa)	Compression Set ASTM D395 - Method B (70 hrs @ 200°C)	Applications: O-rings	Bonded Seals	Molded Shapes	Hoses/ Extrusions	Coatings	Composites/ Sheet Goods	Product Distinctions
MIP 8640X	I	65.9	1.80	43	-18	2177 (15)	175	1016 (7)	16	•	•	•				Medium viscosity dipolymer with best overall flow properties.

LOW TEMPERATURE FLUOROELASTOMERS

Product	Test Compound (75+/-5 Duro)	%F	S.G.	Mooney Viscosity (ML1 + 10 @ 121°C)	TR10 (°C)	Tensile psi (MPa)	Elong %	100% Modulus psi (MPa)	Compression Set ASTM D395 - Method B (70 hrs @ 200°C)	Applications: O-rings	Bonded Seals	Molded Shapes	Hoses/ Extrusions	Coatings	Composites/ Sheet Goods	Product Distinctions
LTFE 6400X[6]	V	67.1	1.86	85	-40	1965 (13.7)	180	775 (5.4)	26	LTFE 6400X can be compounded to meet all of these applications.						Excellent low temperature sealing capability, excellent fuel and oil resistance and good compression set resistance.

Footnotes to product tables

[1] Mooney viscosity at 100°C (212°F)
[2] MgO at 9 phr
[3] Durometer equals 84
[4] Raw Gum
[5] Incorporated Cure
[6] Peroxide Cure

Data not for specification purposes. All test compounds are based on mill-mixed batches.

Fluoroelastomer compounds press cured 7 minutes @ 177°C; postcured 24hrs @ 250°C.

Base resistant elastomer compounds press cured 10 minutes @ 177°C; postcured 16hrs @ 200°C.

Raw gums not cured unless noted.

Test Compounds	I	II	III	IV	V
Polymer	100	100	100	100	100
Phosphonium Accelerator		0.5			
Dihydroxy Crosslinker		2			
MT Black (N990)	30	30	30	25	50
MgO	3	3			
$Ca(OH)_2$	6	6	3		
Varox™ DBPH-50 Peroxide			2.5		2.5
Triallyl isocyanurate (TAIC)			2.5	5	1.8
Percadox 14				1	
Sodium sterate				1	
Zinc Oxide					5

Enabling Technologies

Over the years, our Application and Product Development professionals have developed a variety of "enabling technologies" that enhance the use of our fluoroelastomers and help make your operations more productive.

Dynamar™ Elastomer Processing Additive (FC 2171) is designed to enhance the processing of bisphenol-cured fluoroelastomers by offering reduced mill sticking, improved mold release (levels < 5 phr) and faster extrusion rates (at levels > 10 phr).

Dynamar™ Rubber Curatives (FC 5157, FX 5166 and RC 5251Q) are designed as a currative package to be added to ECO, NBR or NBR/PVC to enhance bonding of these materials to bisphenol-cured FKMs without the need for external bonding agents. This package, when added to non-lead containing ECO compounds, allows the processors to eliminate lead from their formulations, yet maintain excellent heat-age properties.

Bonding Technology

Dyneon has a wide array of bonding technologies that allow processors to bond fluoroelastomers and fluoroplastics to a wide variety of metal and non-metal substrates (i.e. VMQ, ECO, NBR, NBR/PVC, HNBR, FP, etc.). This technology is well demonstrated in current commercial hose constructions but is also applicable to other composite structure needs.

Dyneon also offers primerless technology that can enable bonding to various steel substrates without the need for external priming or bonding agents. This can offer significant processing savings. This technology is particularly attractive for Multi-Layered Steel (MLS) cylinder head gasket constructions.

Material Characterization

We recognize that our ability to provide information about how our fluoroelastomers will perform in certain applications is key to our success as a fluoropolymer supplier. For this reason, Dyneon has invested considerable time and effort in the areas of Permeation testing and Compression Stress Relaxation (CSR) testing.

Permeation Testing

With the advent of new global regulations restricting the amount of evaporative emissions allowed by automobiles it is becoming increasingly important to understand and develop permeation measurement techniques that allow for accurate characterization of a polymer or part. Dyneon is recognized in the automotive industry for its expertise and developments in permeation test methodologies that yield results that are accurate, reproducible and scaleable to commercial constructions. Please see SAE Technical Papers 2000-01-1096 and 2001-01-1126 for additional information.

Permeation test jig

Compression Stress Relaxtion (CSR)

Dyneon recognizes the value of CSR as a tool for the design engineer to make an informed decision about the best fluoroelastomer for the application as well as the predictive information it provides about long-term performance. Dyneon has designed a low-cost test fixture which is small, easy to use and most importantly, yields accurate and reproducible results. Please see SAE Technical Papers 2000-01-0752, 2001-01-0742 and 2003-01-0946 for additional information.

CSR test jigs

In summary, we welcome the opportunity to work with you to review your operations and have our experts suggest ways (from optimized post cure to polymer handling) that could improve your polymer processing.

Glossary of Terms

BRE Grades – Dyneon's line of Base Resistant Elastomers based on combinations of tetrafluoroethylene, propylene and vinylidene fluoride monomers. These products typically contain cure packages that are unique to Dyneon and yield products that process similar to our standard FKM's. They typically offer enhanced chemical resistance to aggressive lubricants.

Brittle Point* – The highest temperature at which a cured rubber part will fracture under sudden impact and specified test conditions.

CE10 – A mixture of 90% RFC and 10% Ethanol.

CM15 – A mixture of 85% RFC and 15% Methanol.

Compound* – An intimate mixture of a polymer(s) with all the ingredients necessary for the finished article. Sometimes call stock.

Compression Set* – The residual deformation of material after removal of the compressive stress. Generally obtained after stress was applied for a given length of time at a specified temperature.

Compression Stress Relaxation (CSR) – The measurement of a material's ability to be compressed and maintain the resultant sealing force over a range of environmental conditions.

Cross Linking* – When chemical bonds set up between molecular chains, the material is said to be cross linked. Once cross linked, materials cannot be reprocessed. A form of curing.

Curing Agent* – A chemical that will cause cross linking to occur.

Durometer* – An instrument for measuring the hardness of rubber and plastics. "A" Durometer is used for flexible materials the "D" for rigid materials.

Durometer Hardness* – An arbitrary numbering scale that indicates the resistance to indentation of the indentor point of the Durometer. High values indicate harder materials. The value may be taken immediately (highest point) or after a very short specified time.

Elastomer* – A polymeric material which, at room temperature, is capable of recovering substantially in shape and size after removal of a deforming force. This generally refers to a synthetic polymer as opposed to rubber, which preferably indicates the natural product.

Elongation* – Extension produced by tensile stress, usually expressed as a percent of original unit length.

Elongation, Ultimate* – The elongation at time of rupture.

FC Grades - Dyneon's line of dipolymer products based on combinations of vinylidene fluoride and hexafluoropropylene monomers. Some of these products contain incorporated cure packages. Many of these products have alternative counterparts in our FE or MIP product lines that may offer improved processibility.

FE Grades - Dyneon's line of dipolymer or terpolymer products based on combinations of vinylidene fluoride, hexafluoropropylene and tetrafluoroethylene monomers. This family of products was designed to offer improved processing characteristics over our FC grades. They are based on cure systems and modified polymers designed to yield improved scorch safety, mold release characteristics and improved processing in fabrication processes such as injection molding and extrusion.

FG Grades – Dyneon's line of incorporated cure, dipolymer products based on vinylidene fluoride and hexafluoropropylene that comply with US Food and Drug Administration (FDA) regulation C.F.R. 177.2600 (c)(4)(i). The cure system incorporated into these products, offers excellent moldability including scorch safety and mold release characteristics.

FLS Grades - Dyneon's line of high fluorine content terpolymers based primarily on vinylidene fluoride, hexafluoropropylene and tetrafluoroethylene monomers. Due to the higher % fluorine in these products, they typically offer improved chemical resistance over lower fluorine containing terpolymers or dipolymers.

FKM – ASTM designation for fluoroelastomers.

Glass Transition Point* – Temperature at which a material loses its glasslike properties and becomes a semi-liquid.

Heat Aging* – When specimens of vulcanized rubber are given accelerated aging in air or oxygen at elevated temperatures and in some cases, pressure for specified periods of time. The deterioration is generally noted as a percent change from originally measured properties.

LTFE Grades- Dyneon's Low Temperature Fluoroelastomers, offering excellent low temperature sealing capability, excellent fuel and oil resistance, and low compression set resistance in peroxide-cured fluoroelastomers.

Low Temperature Flexibility* – The ability of a rubber product to be flexed, bent or bowed at specified temperatures without loss of serviceability.

MIP Grades – Dyneon's line of Multifunctional Improved Productivity fluoroelastomers offering improved flow properties, faster cure times and excellent processability.

Mold Shrinkage* – The difference in dimensions, expressed in inches per inch, between a molding and the mold cavity in which it was molded, both the mold and the molding being at room temperature when measured.

Mooney Scorch* – A procedure for determining the cure characteristics of a compound using the Mooney Viscometer, generally at specified elevated temperatures. The values versus time are recorded or plotted and the time values reported when the viscosity values have increased 5 and 30 points above the minimum.

Oil Resistance* – The ability to withstand swelling and deterioration by a specified oily liquid for a specified time and temperature.

Peroxide* – A compound containing a bivalent —O—O— group in the molecule. They are strong oxidizing agents and are very reactive (examples: benzoyl peroxide, dicumyl peroxide). Used in polymerization reactions and for cross-linking agents.

Post Cure* – Heat or radiation treatment, or both, to which a cured or partially cured thermosetting plastic or rubber composition is subjected to increase the state of cure or enhance the level of one or more properties.

Press Cure* – Vulcanization in a mold in a press.

Processability* – The relative ease with which raw or compounded rubber can be handled in rubber machinery.

RFC – A mixture of 50% Toluene and 50% IsoOctane.

Strain* – Deformation resulting from a stress.

Stress* – Force per unit of original cross sectional area that is applied to a part or specimen.

Stress Relaxation* – The time dependent decrease in stress for a specimen at constant strain.

Thermogravimetric Analysis (TGA)* – A test procedure used to determine the thermal stability or composition of a material. Tow modes are possible: determining the change of weight of a specimen while changing temperature at a given rate, or the change of weight of a specimen with time at a fixed temperature.

Temperature Retraction (TR) Test* – A method for evaluating the low temperature characteristics of a vulcanized part by measuring the temperature at which retraction over the range of 10 to 70% of original elongation occurs. The test is generally employed to determine the susceptibility of a rubber to crystallize. The specimen is stretched at room temperature, cooled to very low temperature, released and warmed at a uniform rate.

Tensile Strength* – The maximum tensile stress applied during stretching of a specimen to rupture.

***Source:**
The Language of Rubber,
Automotive Elastomers & Design, March 1982

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Imaginative fluoropolymer solutions

At Dyneon, our goal is to provide you with design solutions to make your job easier – helping you with material selection now so that you can avoid problems later.

Whatever your challenge, you can count on Dyneon to respond with dependable, high-performance fluoropolymer products. By working directly with our customers and exploring new technologies, you can be sure that our fluoropolymers will not only meet today's needs, but future design requirements as well.

Our worldwide commitment to quality

Indicative of our commitment, most Dyneon design, development, production and service facilities have achieved a global ISO 9001:2000 quality management certification. One of our Decatur, Alabama sites and all Germany locations, as well as the production facilities at Antwerp, Belgium have also received ISO 14001 certification for their environmental management system. And, our Aston, Pennsylvania PTFE custom compounding facility has A2LA accreditation for its quality control laboratory.

The Dyneon Product Portfolio:

Dyneon™
PTFE, TFM™ PTFE, Custom PTFE Compounds

Dyneon™
PFA, FEP, ETFE, HTE, PVDF, THV™ Fluorothermoplastics

Dyneon™
Fluoroelastomers, Base Resistant Elastomers (BREs), Low Temperature Fluoroelastomers (LTFEs), Perfluoroelastomers, Multifunctional Improved Productivity (MIP) Fluoroelastomers

Dyneon™
Polymer Additives

Dynamar™
Polymer Processing Additives

Dynamar™
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Dyneon™
Monomers

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Dyneon is a 3M company.

Printed in USA. 98-0504-1569-8

Issued: 12/04.

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