



Kalrez® seals for aggressive

wafer processing environments

Improve sealing integrity • Reduce contamination • Increase MTBR

Improve yields • Reduce cost of ownership

 **Kalrez®** perfluoroelastomer parts
A Product of DuPont Dow Elastomers

Kalrez® provides
outstanding resistance
 to chemical and thermal extremes

In sealing applications that involve aggressive media and temperature extremes, Kalrez® perfluoroelastomer parts will outperform and outlast other sealing materials by a wide margin (Figure 1). The polymer's outstanding level of chemical and thermal stability has been proven over a 25-year history of success where seals, O-rings and other components of Kalrez® are known for reliable, long-term service in a wide range of industrial and electronic-grade chemicals.

Using the original invention of fluoropolymer as a base, DuPont Dow Elastomers continues to develop new and improved perfluoroelastomer products for specific semiconductor processes. Formed in 1996, DuPont Dow Elastomers is the only fully integrated manufacturer of both polymers and finished parts. Our commitment to develop new, and innovative solutions stretches across the entire product cycle. Users of Kalrez® have the assurance of quality and traceability of all parts made at the company's ISO 9000 and AS 9000 registered facilities in the USA and Japan. No other high performance seal manufacturer offers this total control over product quality and end-use applications.

Figure 1. How Kalrez® Compares with Other Elastomers for Chemical Resistance

	Ethylene propylene	Silicone	Fluoro-silicone	Fluoro-elastomer	Perfluoro-elastomer
ASTM Code	EPM	VMQ	FVMQ	FKM (Viton®)	FFKM (Kalrez®)
Max. continuous service temp.	135°C	200°C	200°C	200°C	316°C
Hardness durometer (Shore A)	40 to 80	40 to 75	40 to 80	55 to 95	65 to 95
Compression set	G	VG	G	VG	G
Alcohols	E	E	E	E	E
Alkalis	VG	R	R	N	E
Ammonia	G	VG	N	N	E
Chlorine	N	N	VG	E	E
Concentrated acids	R	N	G	VG	E
Fluorinated gases	N	N	G	VG	VG
Halogenated solvents	N	N	VG	VG	VG
Hydrofluoric acid	N	N	R	G	E
Hydrogen bromide	N	N	R	E	E
Ketones	G	N	N	N	E
n-Methyl pyrrolidone	N	N	R	G	E
Oxygen	G	E	G	VG	E
Ozone	VG	E	E	E	E
Piranha	N	N	N	VG	E
Reactive plasmas	N	G	VG	VG	E
Silane	R	G	G	E	E
Standard clean 1	G	R	G	G	E
UPDI water	VG	G	G	VG	E

KEY E = Excellent
 VG = Very Good
 G = Good
 R = Reasonable
 N = Not Recommended

*Data has been drawn from DuPont Dow tests and industry sources. Data is presented for use only as a general guide and should not be the basis of design decisions. Contact DuPont Dow for further information.

A comprehensive table of Kalrez® compatibility ratings in all current semiconductor process chemicals is available from your authorized Kalrez® distributor or our website.



KALREZ® PERFLUOROELASTOMER PARTS MEET THE DEMANDS OF WAFER PROCESSING SYSTEMS

Seals in wafer manufacturing are subject to process conditions that challenge seal performance. Chemical resistance that is nearly universal, coupled with superior high temperature properties, enables Kalrez® parts to withstand virtually any process media—including plasmas—at temperatures as high as 316°C.

ENGINEERED FOR OPTIMUM PERFORMANCE

For over 25 years, DuPont and DuPont Dow Elastomers have been perfecting the art of manufacturing perfluoroelastomer parts. Elastomeric parts typically consist of three main components: a polymer chain (“backbone” of the elastomer), a crosslinking system (which “links” the polymer chains together and is the key to elasticity and sealing performance), and a filler system (used to enhance mechanical properties). Based on its extensive experience, DuPont Dow adjusts these components to optimize seal performance in wafer processing environments. By selecting the Kalrez® compound that is best suited to a specific application, processors can improve seal performance in all wafer-fabricating operations.

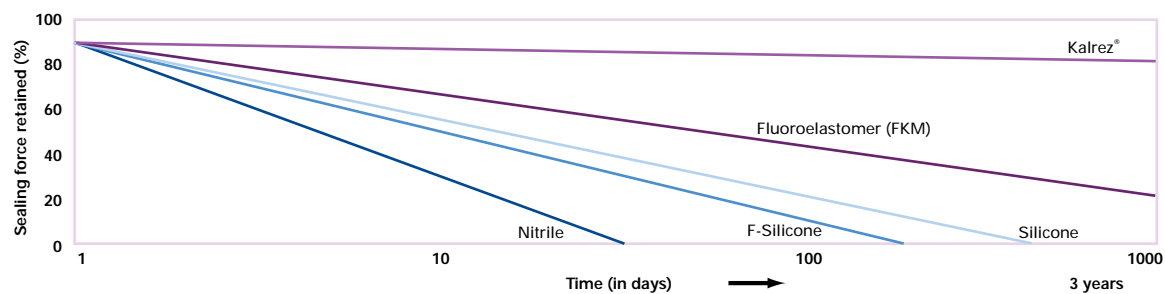
EXCEPTIONAL SEALING PERFORMANCE TO 316°C

Many seals used in wafer processing are required to function at process temperatures ranging from 200 to 300°C. The ability of an elastomer to resist thermal degradation has a significant impact on its ability to function effectively as a seal over time.

As a class of materials, perfluoroelastomers (FFKM) exhibit improved thermal stability compared to fluoroelastomers and silicone. Among these, Kalrez® is in a class by itself: it retains properties like elastic recovery and sealing force far better than other heat-resistant elastomers including alternative perfluoroelastomer types—even after long-term exposure at temperatures as high as 316°C.

Figure 2 compares the seal force retention properties of Kalrez® and alternative seal materials when aged for 3 years at 160°C. This thermal aging stress relaxation test is a direct indication of long-term sealing performance at elevated temperatures over time.

Figure 2. Kalrez® Prolongs Seal Life and Adds Extra Safety at High Temperatures*



*Sealing force retention at 160°C.
 ISO 3384: Stress relaxation in compression (“Lucas Test”).
 AS568A Size 113 O-rings at 25% compression.

chamber lids

slit valve door seals

flanges

gas feedthroughs

exhaust valves

Kalrez® parts for

plasma and gas deposition



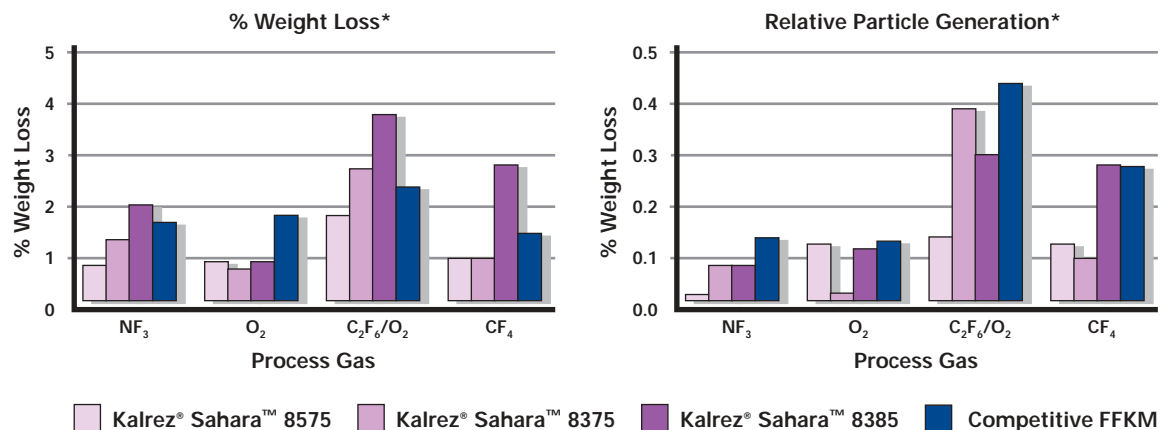
Etching • Ashing • PECVD • HDPCVD • PVD • Metal CVD • Copper

Semiconductor fabricators have found that plasma is a very powerful tool for etching, CVD and stripping because all materials are consumed in plasma. Perfluoroelastomer (FFKM) seals are used in these processes because of their exceptional resistance to aggressive media. Despite this, prolonged exposure to plasmas can degrade their surface resulting in particulate contamination before sealing functionality is lost. The ideal seal for plasma applications, therefore, would resist surface degradation and maintain its functionality.

Kalrez® perfluoroelastomer parts offer excellent chemical resistance to a wide range of process gases used in plasma and gas deposition processes. New proprietary developments in the polymer and crosslinking system have resulted in products that exhibit reduced weight loss, particle generation and outgassing (Figures 3 and 4). This can improve wafer yield, insure process reliability and reduce the frequency of equipment maintenance.

Kalrez® can reduce particle generation, extend seal life, increase equipment reliability and mean time between repair (MTBR). This translates to improved wafer yields and reduced cost of ownership.

Figures 3 and 4. Plasma Performance Comparison



*Sample directly exposed to plasma for 6 hours at 200 watts, 0.5 torr.

mass flow controllers

throttle valves

viewports

lip seals

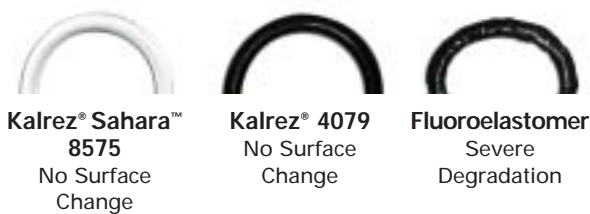
gate valves

isolation valves

Semiconductor manufacturers use a variety of aggressive chemicals for chamber cleaning. These chemicals can cause elastomeric O-rings to excessively swell and degrade, causing permanent seal failure to occur. Figure 5 shows the excellent chemical resistance exhibited by Kalrez® perfluoroelastomer parts to chlorinated gases, i.e., ClF_3 , used for chamber cleaning versus alternative

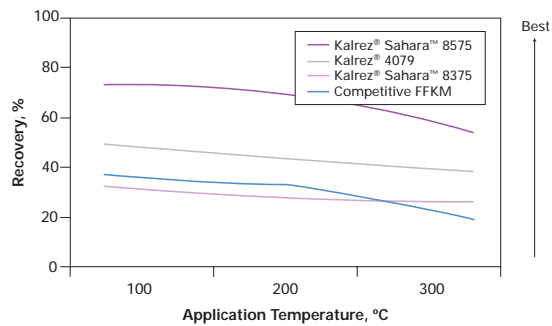
seal materials. New proprietary developments in the polymer and crosslinking system have also resulted in products that exhibit improved elastic recovery properties. Figure 6 illustrates the improved elastic recovery properties of Kalrez® versus competitive perfluoroelastomer sealing materials at elevated temperatures.

Figure 5. ClF_3 Compatibility Evaluation*



*Exposure conditions: ClF_3 at 180°C, 1 atm, 72 hours.

Figure 6. Elastic Recovery Properties*



*Size 214 O-rings under 25% compression for 16 hours.

Kalrez® parts for

thermal applications



LPCVD • Oxidation Diffusion • Lamp Anneal • RTP

High heat and temperature spikes can “cook” elastomeric seals beyond recognition, causing them to become hard and brittle. When this occurs, it means that their crosslinking structure, the key to their elasticity, has become irreversibly damaged. This loss of elasticity makes effective sealing impossible. In addition, elastomers can degrade under high temperatures, causing outgassing to occur, thereby contaminating the process environment. The result is unscheduled downtime, or even worse, product loss. Figure 7 shows the extremely low outgassing properties of Kalrez® Sahara™ 8475 from room temperature up to 400°C.

Specifically, thermal processes, like rapid thermal processing (RTP), LPCVD, diffusion, lamp annealing, etc., need seals that resist not only the process chemicals, but also the extreme temperatures required. Reliable, in service temperature ratings for sealing materials are best defined by long-term (672 hours as opposed to the standard 70-hour) testing for seal force retention. Figure 8 clearly shows the superior seal force retention properties of Kalrez® in long-term service.

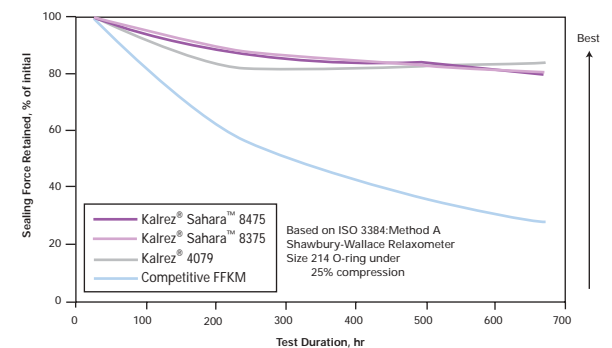
Kalrez® perfluoroelastomer parts retain their sealing force longer and reduce problems caused by sticking and outgassing. They reduce equipment downtime, lengthen MTBR and can help increase yield and process reliability.

Figure 7. Kalrez® Sahara™ 8475 TG-MS Outgassing Analysis* (10°C/min)

Gas Evolved	R.T. to 100°C (ppm)	R.T. to 200°C (ppm)	R.T. to 300°C (ppm)	R.T. to 400°C (ppm)
H ₂ O	2	255	324	345
HF+	0	0	0	1
CF+	0	0	0	12
CO ₂	0	0	2	103
CF ₂	0	0	0	19
CHF+	0	0	0	20
CF ₃ +	0	0	0	119
C ₂ F ₃ +	0	0	0	23
CF ₃ O+	0	0	0	0
C ₂ F ₄ +	0	0	0	9
C ₂ F ₅ +	0	0	0	1
C ₃ F ₅ +	0	0	0	31
Total Outgas, %	0.00	0.03	0.03	0.07
Weight Loss, %	0.00	0.00	0.01	0.07

* Data provided by independent testing laboratory.

Figure 8. Long-Term Seal Force Retention at 204°C



Kalrez® parts for

wet chemical applications



Etching • Cleaning • Stripping • Copper Plating

To transform raw semiconducting materials into a useful device requires hundreds of chemical processing steps. A significant number of these steps involve aggressive acids, solvents (including amines), and bases used to clean, rinse, etch or strip unwanted materials and contaminants from the wafer surface. These chemicals can attack elastomeric seals causing them to swell and degrade or to leach undesirable metallic and ionic extractables that affect integrated circuit functionality.

DuPont Dow Elastomers has developed a number of Kalrez® compounds for use in wafer cleaning, wet etching, photolithography and copper plating that feature low metallic, ionic and total oxidizable carbon (TOC) extractables as well as outstanding chemical resistance. They provide superior contamination performance compared to competitive sealing materials (Figures 9 and 10). Our proprietary Kalrez® UltraPure™ cleaning method further helps to keep extractables in wet media to an absolute minimum.

Figure 9. Total Metallic Extratables by ICP-MS

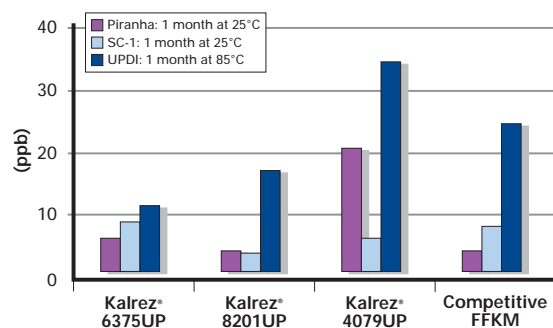
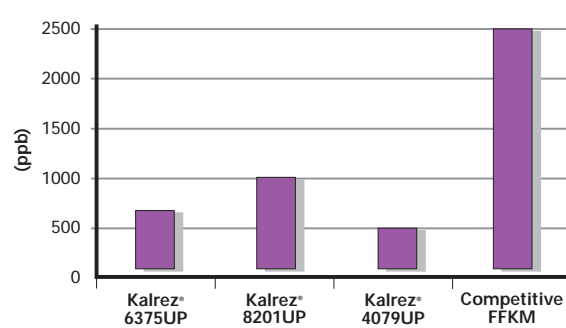


Figure 10. Total Oxidizable Carbon (TOC)*



*One month at 85°C in UPDI water.

Kalrez® perfluoroelastomer parts are specifically designed to reduce extractables in the harshest chemicals. Because Kalrez® seals last longer and produce fewer contaminants than other “off-the-shelf” products, Kalrez® is your best choice to improve wafer yield in wet processing.



Kalrez® reduces cost of ownership for chip manufacturers

The success of Kalrez® perfluoroelastomer parts in industrial applications has been field proven in the manufacture of semiconductors, where processing steps can involve extremes of both chemical and thermal exposure. Since purity is critical to high wafer yield, reducing contamination from particulates, outgassing and extractables caused by seal deterioration is a major goal of semiconductor fabricators. Whether it's in plasma, gas deposition, thermal or wet environments, manufacturers gain seal integrity and process purity that is backed by more than a quarter century of success with Kalrez®.

You can obtain the outstanding heat and fluid resistance of Kalrez® perfluoroelastomer parts in a wide variety of finished product forms—from conventional seal shapes to custom geometries. Various Kalrez® compounds are available with properties that can meet the performance demands of specific equipment and processing applications.

FIELD PROVEN IN ALL SEMICONDUCTOR PROCESSES

- Over 50,000 wafers processed in a high-energy oxygen plasma asher without a slit valve seal change
- Over 400 wafer batches (6 months) in a 250°C nitride LPCVD tube furnace
- 4x improvement in seal life and reduced seal sticking vs. silicone in a 300°C nitride process
- Doubled seal life in a metal etch process compared to other perfluoroelastomers
- Seal life improved 10x over silicone in a plasma asher door seal at 130°C
- Lower ionic extractables in a 100°C wet chemical pump application
- Over 6 months seal life in a large slit valve for Liquid Crystal Display processing etcher
- Over 3 months seal life in a 280°C diffusion furnace application
- 8 months seal life (35% more than competitive custom slit valve seal) for Kalrez® TriLobe™ in a TEOS PE-CVD process
- Doubled seal life with a Kalrez® seal in a plasma asher
- 8x to 14x improvement in seal life (over 3 months) compared to a competitive perfluoroelastomer in plasma asher showerhead seals
- Doubled seal life compared to a competitive perfluoroelastomer in a PECVD slit valve application
- Best overall performance in LPCVD using ClF_3 cleaning gas (lower outgassing and particle generation)

The right Kalrez® part to meet any wafer processing need

STANDARD AND NONSTANDARD O-RINGS

O-rings made from standard compounds are available from stock in standard AS568A, metric and JIS sizes. Many AS568A, metric and JIS O-ring sizes in commercial compounds may be available for immediate shipment from your local authorized Kalrez® distributor. In addition, DuPont Dow Elastomers maintains inventories of AS568A, metric and JIS O-ring sizes.

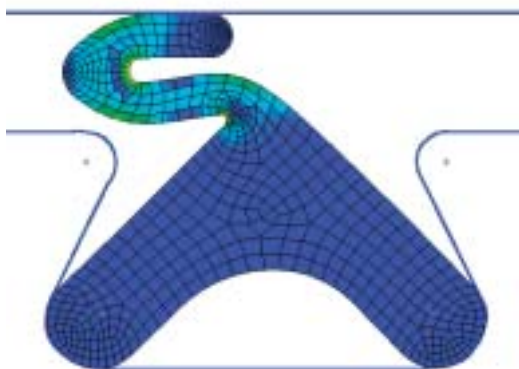
CUSTOM SHAPES

Custom parts and components with unusual geometries can be designed and molded to meet the needs of specific sealing applications. Examples include special profiles and rectangular-shaped seals for slit valves and windows; metal-bonded parts, profiled quartz tubes, diaphragms, lip seals, hollow O-rings, tubing and other specialized components.

Advanced Finite Element Analysis (FEA) capabilities are available to help design new seal shapes by calculating stress patterns, optimizing compound selection and groove geometry, and accurately modeling part performance in service. Use of FEA can significantly shorten development lead times and produce innovative solutions for long-term sealing performance.

KALREZ® ULTRAPURE™ PACKAGING

Kalrez® parts for semiconductor processes are specially cleaned and double packaged at Class 100 workstations. This care results in part cleanliness significantly superior to those available from other perfluoroelastomer part suppliers as shown by independent laboratory tests. Results clearly show that the ultrapure post-cleaning and packaging process significantly reduces particle and surface contamination. For more information contact DuPont Dow Elastomers.



Kalrez® provides technical support

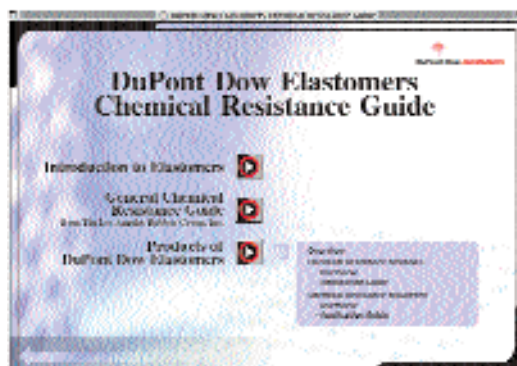
Comprehensive technical service is available globally from DuPont Dow Elastomers. Our laboratories in the US, Europe and Japan are equipped to run a variety of performance and analytical tests for product development, seal design or failure analysis. Capabilities include plasma exposure tests, FTIR, ESCA, SIMS, EDX and other analytical tests, long-term seal force retention and compression set, outgassing, vacuum and permeability, and polymer identification.

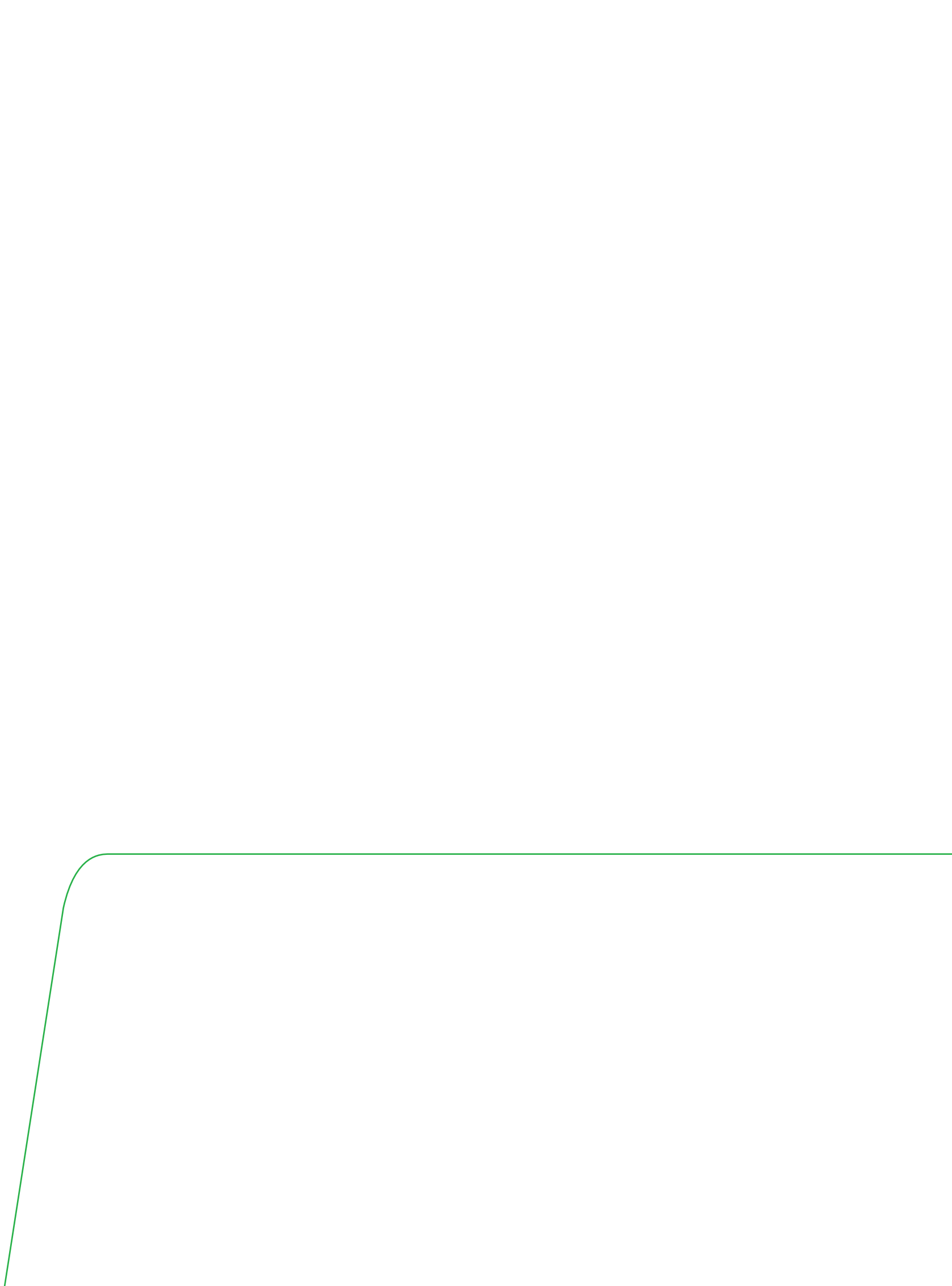
To assist in product selection and seal design, DuPont Dow Elastomers has developed two easy-to-use tools. The DuPont Dow Elastomers Chemical Resistance Guide (CRG) rates general elastomer performance in a variety of

chemicals and provides additional information about DuPont Dow products including Viton® and Kalrez®. This tool is readily available at www.dupont-dow.com/crg. For more specific information about Kalrez®, an interactive software program called the Kalrez® Application Guide is also available from DuPont Dow.

On-site seminars can be held at your facility to allow design, maintenance and process engineers to learn more about elastomeric materials and discuss specific sealing problems that may occur in wafer processing equipment. Contact DuPont Dow about potential seminars.

DuPont Dow Elastomers Chemical Resistance Guide at www.dupont-dow.com/crg





Visit www.dupont-dow.com/kalrez

Requests for further information from countries or regions not listed below should be sent to the respective headquarters.

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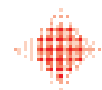
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