INTER-OFFICE MEMO **TENNECO CHEMICALS, INC.**

TO E. V. Schenke AT Burlington DATE April 4, 1977

FROM I. A. Rumberg AT Burlington COPY TO W. Fogelsanger
N. Quist
J. Sandstedt
P. Scarito
J. Sweeney
C. Thompson

SUBJECT DEI-603-604 DOUBLE MECHANICAL SEALS
BURLINGTON/FLEMINGTON

Herewith attached is the Design Study and Test Results of our Double Mechanical Seal Program to meet EPA requirements.

I. A. Rumberg

IAR/ib
Attachments

ENGINEERING DESIGN STUDY

The Design Study was done by means of a 5 step investigation.

1) Establish what pumps are presently installed on VCM service.

2) Research the original specifications and data sheets of the existing VCM service pumps.

3) Evaluate the feasibility of installing double mechanical seals on our VCM service pumps.

4) If the above is concluded as a viable solution to our problem, then prepare a preliminary project scope and estimate, for installation of double mechanical seals on VCM service pumps.

5) Begin a test program to evaluate the best manufactured seal for our use.

DEI - 604 DOUBLE MECHANICAL SEALS FLEMINGTON

DEI - 603 DOUBLE MECHANICAL SEALS BURLINGTON

NO	DESCRIPTION	# OF	1 MAKE	2 MODEL	3 PUMP FLUID	4 STUFFING BOX PRESS.	5 TEMP.	6 LOC.	7 SIZE	8 RPM	9 HP	10
G-3103	VAPORIZER		GOULDS	3195	V. C.	75 - C	70°F.	OUTSIDE	1 X 2 - 6	3500	5	
G-3101	VCM TRANSFER		DURCO	HA-1	V. C.	85 - C	70°F.	OUTSIDE	1 X 1 - 7	3500	7½	
G-3102	VCM TRANSFER		DURCO	HA-1	V. C.	80 - C	70°F.	OUTSIDE	1 X 1 - 7	3500	7½	
G-3201	PURE VCM CHARGE		GOULDS	3196	V. C.	85 - C	100°F.	OUTSIDE	2 X 3 - 10	3500	50	
G-3202	REC'D MONOMER CHARGE		GOULDS	3196	V. C.	85 - C	100°F.	OUTSIDE	2 X 3 - 10	3500	50	
G-4203	REC'D MONOMER RECIRC		DURCO	MK#2 GRP#2	V. C.	85 - C	100°F.	OUTSIDE	3 X 2 - 7	3500	7½	
G-4301A	REACTOR CHARGE		DURCO	MK#2 GRP#2	V. C.	80 - C	100°F.	OUTSIDE	4 X 3 - 10	3500	75	
G-4301B	REACTOR CHARGE		DURCO	MK#2 GRP#2	V. C.	80 - C	100°F.	OUTSIDE	4 X 3 - 10	3500	75	
G-3327	SLURRY TRANSFER		GOULDS	3175	SLURRY	40 - C	130°F.	INSIDE	3 X 6 - 14	1750	60	
G-4304	SLURRY TRANSFER		GOULDS	3175	SLURRY	40 - C	130°F.	INSIDE	3 X 6 - 14	1750	60	FLEMINGTON
41202	MONOMER TRANSFER		GOULDS	3195	V. C.	85 - G	127-10°F.	OUTSIDE	1½ X 3 - 8	3500	20	BURLINGTON
41206	MONOMER TRANSFER		GOULDS	3195	V. C.	85 - G	127-10°F.	OUTSIDE	1½ X 3 - 8	3500	20	
41205	VAPORIZER FEED		PEERLES		V. C.	85 - C	127-10°F.	OUTSIDE	2½ X 3 - 10½	3500	30	
41207	VAPORIZER FEED		GOULDS	3196	V. C.	85 - G	127-10°F.	OUTSIDE	1 X 2 - 6	3500	5	
*41306	COPLY REACTOR CHARGE	2	GOULDS	3906	V. C.	85 - G	127-10°F.	INDOORS	2 X 3 - 9	3500	50	
41340	COPLY RECOV'D MONOMER RECIRC		GOULDS	3196	V. C.	85 - G	100°F.	OUTDOORS	1 X 2 - 8	3500	7½	
41103	COPLY REC'D MONOMER CHARGE		GOULDS	3195	V. C.	85 - G	100°F.	OUTDOORS	1 X 2 - 8	3500	15	
41335	PVC REC'D MONOMER CHARGE		GOULDS	3196	V. C.	85 - G	100°F.	OUTDOORS	1 X 2 - 8	3500	7½	
41323	PLASTISOL REC'D MONOMER CHARGE		GOULDS	3195	V. C.	85 - G	100°F.	OUTDOORS	1 X 2 - 8	3500	15	
41329	PVC MONOMER CHARGE		GOULDS	3196	V. C.	85 - G	127-10°F.	INDOORS	1½ X 3 - 10	3500	40	
*41326	PLASTISOL "A" FUME SCRUBBER		GOULDS	3196	SLURRY	85 - G	100°F.	INDOORS	1 X 2 - 8	3500	7½	
*41828	PLASTISOL "B" FUME SCRUBBER		GOULDS	3196	SLURRY	85 - G	100°F.	INDOORS	1 X 2 - 8	3500	10	
41804	HOMOGENIZATION FEED "A"		GOULDS	3196	V. C.	85 - G	90°F.	INDOORS	2 X 3 - 10	1750	7½	
41805	HOMOGENIZING "A"	3	S1-H1	AEHE-4108	V. C.	500*	90°F.	INDOORS		1750	25	
41825	HOMOGENIZATION FEED "B"		GOULDS	3196	V. C.	85 - G	90°F.	INDOORS	2 X 3 - 13	1750	15	
41826	HOMOGENIZING "B"	3	S1-H1	AEHE-4108	V. C.	500*	85°F.	INDOORS		1750	100	

C - CALCULATED

G - GAGE

* - Specially designed seal will have to be supplied.

COLORITE 018303

PRELIMINARY PROJECT SCOPE

DEI - 603/604 DOUBLE MECHANICAL SEALS BURLINGTON/FLEMINGTON

The intent of this project is to reduce personnel exposure to VCM by the installation of double mechanical seals on monomer service pumps.

Double Mechanical Seals - the seals are to be installed on all monomer service pumps.

See Attached Sheet.

Pressure Pots - to provide the sealing media of glycerin and water with a pressure of 15-20 LBS above that of the stuffing box @ 85 LBS a seal pot must be provided on each of the above installations. The pressurization is to come from the existing plant nitrogen system and provide a minimum pressure of 125 LBS.

Instrumentation - in order that we may prevent damage to the seal body or pump from loss of pressure or sealing media we will install pressure sensing instrumentation, capable of shutting down the pump.

Electrical - The pressure switches mentioned above are to be wired into the pump control circuitry to prevent starting and running of the pump under a low pressure condition.

Approx. Cost $2500 per installation

Burlington	21 pumps	$53,000
Flemington	10 pumps	$25,000

On April 7, 1976 a Design Parameter meeting was held with Manufacturing representatives from both Burlington and Flemington. The following standards for double mechanical seal implementation were specified.

1) Seals are to be capable of being pressurized to 125 psi.

2) Assembly to be of the cartridge type.

3) Standardized on 1¼" X 1 3/4" seal diameters.

4) Maximum allowable temp to be generated by seal of 120°F.

5) Maximum of 2-3 cc/hr of glycerin to leak into dump cavity.

6) Seal manufacturers representative to be on site during installation of test seals.

The following seal manufacturers were contacted and were requested to participate in the test seal program.

1) Crane

2) Durametallic

3) Chempro (Sealol)

4) Chesterton

Arrangements were made with the Burlington site to enable the seal installations to be put on our worst service pumps that being copolymer.

After numerous delays we began this program. Our initial tests with Buna n and Viton "O" rings ended in failure whereby we began using Kalrez "O" rings which enabled us to keep the seal running. The only exception to this was the Chempro seal which because of its Bellows construction did not experience the "O" ring failure. After our preliminary go around, the second generation of seals were tested with the following findings.

1) Durametallic Seal was ruled out after second test because of high temperature generation in the seal.

2) Crane Seal was ruled out after second test because of high temperature generation in the seal.

3) Chempro Seal has been in test for approximately four (4) months with only one excursion above 10 ppm, once the "O" ring swelled the system has maintained a maximum of 3-5 ppm leakage.

4) Chesterton Seal has been in test for approximately four (4) months and has maintained a 0-3 ppm leakage.

In conclusion this department feels, that the Chesterton 241 Seal should be installed on all future seal installations, in order for Tenneco to meet the EPA requirements.

It should be noted that we have choosen the Chesterton Seal over the Chempro although both have performed satisfactorily. The reasoning behind this decision is that the Chempro Seal is constructed with metal Bellows which have always been plagued with fatigue problems caused during cavitation or startup torques. This was not experienced during our testing but could occur over long periods of running.

COMPARISON TABLE

	CHEMPRO (676)	CHESTERTON (241)
COST	$750.00	$713.00
MAX PRESS	300 PSIG	400 PSIG
TEMP.	LIMIT OF "O" RING	LIMIT OF "O" RING
A) BUNA N	-40 F to 225 F	-40 F to 225 F
B) VITON	0 F to 400 F	0 F to 400 F
C) KALREZ	-40 F to 600 F	-40 F to 600 F
EXCHANGE PROGRAM	NO	YES
CAN BE REPAIRED IN HOUSE	YES	YES
FRETTING	NONE	NONE
REACTION TO HARMONIC FATIGUE	AVG	GOOD
RESPONSE TO TORQUE	AVG	GOOD
PRODUCT BUILDUP	IN BELLOWS DURING SHUTDOWN	MIN
CARTRIDGE TYPE	YES	YES
GUARANTEE AGAINST DAMAGE TO PUMP	NO	YES
REACTION TO SHOCK IN CAVITATION	AVG	GOOD
SELF ALIGNING CAPABILITIES	AVG	EXCELLENT

DU PONT

Kalrez PERFLUOROELASTOMER PARTS

I. RUMBERG
F.Y.I.

December 27, 1976

PRICE CHANGE - "KALREZ" PERFLUOROELASTOMER PARTS

Prices for KALREZ (formerly ECD-006) perfluoroelastomer parts are going to increase, effective January 31, 1977. During our first three years of commercial business, we had been able to resist inflationary pressures. Now, however, we must make some upward adjustments but did want to give you as much notice as possible. More quantity differentials have been added to provide additional price reductions for orders for larger quantities. Conversely, premiums for very small quantity orders have been increased. All orders placed by January 31, 1977, will be honored at present prices.

We will be pleased to send you copies of our new price lists if you will just indicate your interest and return the attached request card or call us if you have an immediate need. We are also updating our mailing list so please fill out the balance of the card so that we keep your name in these records. This will help us get pertinent information in your hands now and as it develops.

Great things are happening with KALREZ. Daily we hear from someone who has used a KALREZ part to solve a particularly difficult temperature or chemical resistance problem. They are truly becoming "the elastomer parts to use when nothing else works."

We do appreciate your interest and if we can help at any time, don't hesitate to get in touch.

John B. Knox

John B. Knox
Product Sales Manager

Att.

E. I. DU PONT DE NEMOURS & COMPANY (INC.) • ELASTOMER CHEMICALS DEPARTMENT • E353312 • WILMINGTON, DE 19898
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Chemical Resistance Guide for DU PONT Kalrez*

PERFLUOROELASTOMER PARTS

DU PONT

STEVEN M. OGINTZ
KALREZ* Perfluoroelastomer Parts

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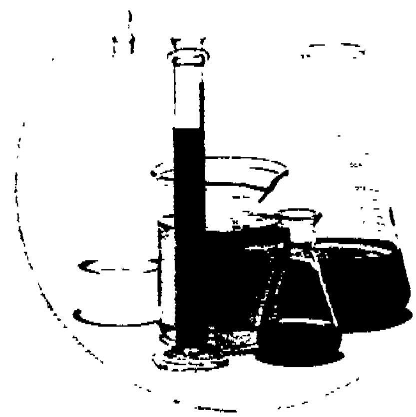
*Du Pont trademark



DU PONT

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Chemical Resistance Guide for DU PONT KALREZ*

PERFLUOROELASTOMER PARTS

Chemical Resistance—General

Du Pont KALREZ perfluoroelastomer (formerly designated ECD-006) is an outgrowth of the chemistry that yielded VITON** fluoroelastomer and TEFLON** fluorocarbon resins. KALREZ combines many of the elastomeric properties of VITON with the chemical and heat resistance of TEFLON and provides certain advantages over both. Because of the difficult compounding and processing necessary in fabricating parts of KALREZ, Du Pont alone manufactures and sells finished parts. This bulletin has been prepared to provide assistance to the design engineer in determining the suitability of KALREZ parts for service in chemical environments.

KALREZ perfluoroelastomer parts possess outstanding chemical resistance. When using appropriately formulated compositions, almost all classes of chemicals, with the exception of fluorinated solvents, exhibit little or no measurable effect on KALREZ parts. Exposure to fluorinated solvents will induce moderate swelling and slight loss of physical properties (even so, KALREZ parts may provide better service than other elastomers). Because of their excellent resistance to swelling by most chemicals, KALREZ parts resist permeation by these same materials. In addition, KALREZ maintains its chemical resistance at operating temperatures far above those of other elastomers. KALREZ parts can function continuously at 500-550°F (260-288°C) and intermittently to 600°F (316°C). This combination of chemical and thermal resistance makes KALREZ especially suitable for service in hot, corrosive environments including:

- Polar solvents (ketones, esters, ethers)
- Strong organic solvents (benzene, dimethyl formamide, *Perclene*[1], tetrahydrofuran "THF")
- Inorganic and organic acids (hydrochloric, nitric, sulfuric, trichloroacetic) and bases (hot caustic soda)
- Strong oxidizing agents (dinitrogen tetroxide, fuming nitric acid)
- Metal halogen compounds (titanium tetrachloride, diethylaluminum chloride)
- Hot mercury/caustic soda
- Chlorine, wet and dry
- Inorganic salt solutions
- Fuels (ASTM Reference Fuel C, JP-5 Jet Fuel, aviation gas, kerosene)
- Hydraulic fluids (*Skydrol 500 A*[2], *Pydraul 312*[2], *Anderol L-774*[3], and transmission fluids)
- Heat transfer fluids *(Dowtherm A)*[4]
- Oil well sour gas (methane/hydrogen sulfide/carbon dioxide/steam)
- Steam

Chemical Resistance Tables

Information on the resistance of KALREZ to specific chemical reagents is provided in Table I and to proprietary fluids and blends in Table II. The ratings in these tables are based on the best composition of KALREZ for the given chemical exposure. We emphasize that the table should be used as a guide only and suggest that careful consideration be given to the following factors:

- For the great majority of products listed, the ratings are based upon results of complete immersion tests, and, therefore, are conservative. In actual service only one-side or limited-edge exposure to fluids is normally experienced.
- KALREZ exhibits exceptional thermal stability and is serviceable at continuous temperatures to 500-550°F (260-288°C) and intermittent temperatures up to 600°F (316°C). Because of laboratory constraints, many of the tests reported in the attached tables were conducted at temperatures far below the maximum service temperature for KALREZ. Therefore, test results should not be construed to indicate either the maximum service temperature or maximum duration at which KALREZ will remain serviceable in a given environment.
- In laboratory tests, many elastomeric materials show excellent chemical resistance to pure reagents. However, they may fail in actual service because of chemical attack by additives and/or impurities in plant process streams. KALREZ perfluoroelastomer, with its near universal chemical resistance, provides extra insurance against these potentially unknown corrosive influences.

Design Considerations

As with all elastomers, specific compounding of KALREZ is needed to achieve the most suitable material. Factors considered in the selection of the optimum compound include chemical environment, service temperatures, operating pressures and essential physical properties.

In many cases, part design has been found to be as critical as inherent chemical resistance in achieving a functional and economical part.

Du Pont engineers will carefully consider all of the parameters in designing finished parts for your specific applications. It is normally advisable to subject prototype parts to either simulated or actual service testing to verify chemical resistance and functionality of design.

*Trademark
**Reg. U.S. Trademark of Du Pont

[1] U.S. Trademark of Diamond Shamrock Chemical Co.
[2] U.S. Trademark of Monsanto Co.
[3] U.S. Trademark of Tenneco Chemicals
[4] U.S. Trademark of Dow Chemical Co

RATING SYSTEM

A—Shows little or no effect after exposure to the specified reagent as listed. Slight swelling (less than 10%) or loss of properties may occur under severe conditions but this should not affect performance.

B—May be affected by the specified reagent after exposure as listed, as evidenced by slight visible swelling and/or loss of physical properties. KALREZ* perfluoroelastomer can be expected to perform adequately in such service for some time period. Oftentimes, KALREZ will operate in such environments long after other elastomers would have failed. Please consult Du Pont for advice in specifying KALREZ for these environments.

X—KALREZ is unsuitable for service in the environment as specified.

( )—The bracket has been used around a rating letter, exposure temperature and exposure time where no data are presently available on the effect of the reagent on KALREZ. Based on similarities of the test chemicals and our long-term experiences with both KALREZ and VITON, Du Pont chemists would expect KALREZ to exhibit chemical resistance as indicated by the bracketed letter and test conditions.

TABLE I—CHEMICAL REAGENTS

Chemical	Exposure Temperature °F	Exposure Temperature °C	Exposure Time Days	Rating
Acetaldehyde				(B)
Acetamide	(400)	(204)	(3)	(A)
Acetic Acid, 10%	122	50	100	A
Acetic Acid, Glacial	75	24	28	A
Acetic Acid, Glacial	428	220	60	B
Acetic Anhydride	113	45	100	A
Acetone	113	45	100	A
Acetonitrile	113	45	100	A
Acetylene				(A)
Acetylene Tetrabromide	(75)	(24)	(28)	(A)
Acrylonitrile	75	24	8	A
Ammonia, Anhydrous	75	24	240	A
Ammonium Hydroxide, 35%	113	45	100	A
Amyl Acetate	(75)	(24)	(7)	(A)
Amyl Alcohol	(212)	(100)	(5)	(A)
Aniline	(300)	(149)	(7)	(A)
Benzaldehyde	(75)	(24)	(3)	(A)
Benzene	113	45	100	A
Benzene	(158)	(70)	(28)	(A)
Benzoic Acid				(A)
Benzophenone	(212)	(100)	(7)	(A)
Benzoyl Chloride				(A)
Benzoyl Peroxide				(A)
Boric Acid, 10%	104	40	30	A
Boric Acid, 10%	212	100	4	A
Butanol	113	45	100	A
Butanol	(250)	(121)	(4)	(A)
Butyl Acetate	113	45	100	A
Butyl Carbitol	113	45	100	A
Butyl Carbitol	(250)	(121)	(4)	(A)
Butyl Cellosolve	113	45	100	A
Butyraldehyde	104	40	30	B
Butyric Acid				(B)
Carbon Disulfide	(75)	(24)	(28)	(A)
Carbon Tetrachloride	113	45	100	B
Chlorine, Liquid, Dry	140	60	7	A
Chlorine, Liquid, Dry	(212)	(100)	(5)	(A)
Chlorine, Gaseous, Dry	75	24	150	A
Chloroacetic Acid, 10%	104	40	30	A
Chloroform	75	24	28	A
Chlorosulfonic Acid	(75)	(24)	(7)	(A)
Chromic Acid, 10-50%				(A)
Cyclohexane	75	24	600	A
Cyclohexanone	(75)	(24)	(5)	(A)
Dibenzyl Ether				(A)
o-Dichlorobenzene	(300)	(149)	(28)	(A)
Diethylaluminum Chloride				(A)
Diethylamine	75	24	28	A
Diethylene Glycol				(A)
Diisobutyl Ketone	(75)	(24)	(10)	(A)
Diisopropyl Ketone				(A)
Dimethyl Formamide	75	24	28	A
Dimethyl Sulfoxide	75	24	28	A
Dinitrogen Tetroxide	160	71	8	A
Dioctyl Phthalate	113	45	100	A
Dioxane	(75)	(24)	(3)	(A)
Ethanol	113	45	100	A
Ethanol Amine	113	45	100	A
Ethyl Acetate	75	24	28	A
Ethyl Acetoacetate	113	45	100	A

Chemical	Exposure Temperature °F	Exposure Temperature °C	Exposure Time Days	Rating
Ethyl Ether				(A)
Ethylene Chlorohydrin	113	45	100	B
Ethylene Diamine	104	40	30	A
Ethylene Dichloride	113	45	100	A
Ethylene Glycol	113	45	100	A
Ethylene Glycol	(250)	(121)	(5)	(A)
Ethylene Oxide	(158)	(70)	(5)	(A)
2-Ethyl Hexanoic Acid	113	45	100	A
Fluorine Gas				(B)
Fluoboric Acid				(A)
Formaldehyde	104	40	30	A
Formic Acid, 12%	212	100	7	B
FREON** fluorocarbon products (partially halogenated e.g. F-22, F-23)	(75)	(24)	(7)	(B)
FREON** fluorocarbon products (fully halogenated e.g F-11, F-12, F-13, F-113, F-114)	75	24	10	X
Furfural	(158)	(70)	(28)	(A)
Glycerine	(250)	(121)	(5)	(A)
Glycolic Acid				(A)
Glyoxal, 40%	113	45	100	A
n-Heptane				(A)
Hexafluoroisopropanol	75	24	4	A
Hexamethylphosphoramide	75	24	28	A
Hexane	(75)	(24)	(21)	(A)
Hexanol	113	45	100	A
Hexanol	(158)	(70)	(7)	(A)
Hydrazine Hydrate	75	24	10	A
Hydrazine, Unsymmetrical Dimethyl	75	24	336	A
Hydrobromic Acid	104	40	30	A
Hydrochloric Acid, 10%	113	45	100	A
Hydrochloric Acid, 20%	(230)	(110)	(14)	(A)
Hydrochloric Acid, 37%	75	24	28	A
Hydrochloric Acid, 37%	(158)	(70)	(7)	(A)
Hydrofluoric Acid, 75%	(212)	(100)	(5)	(A)
Hydrogen Peroxide, 90%	(270)	(132)	(1)	(A)
Hydrogen Sulfide (see also sour gas)	(270)	(132)	(7)	(A)
Hydroxyacetic Acid				(B)
Isophorone	113	45	100	A
Isophorone	(158)	(70)	(7)	(A)
Isopropyl Acetate	(75)	(24)	(7)	(A)
Isopropyl Alcohol	(75)	(24)	(21)	(A)
Kerosene	113	45	100	A
Kerosene	(400)	(204)	(40)	(A)
Lactic Acid	(158)	(70)	(7)	(A)
Mercury/Caustic	200	93	360	A
Methanol, 50%	104	40	30	A
Methanol, 100%	113	45	100	A
Methyl Butyl Ketone				(A)
Methyl Cellosolve				(A)
Methyl Chloride				(A)
Methyl Ethyl Ketone	113	45	100	A
Methyl Isobutyl Ketone	(175)	(79)	(8)	(A)
Methylene Chloride	150	66	70	A
Monochlorobenzene	(75)	(24)	(30)	(A)
Naphtha	(158)	(70)	(28)	(A)

*Trademark **Reg. U.S. Trademark of Du Pont

Chemical	Exposure Temperature °F	Exposure Temperature °C	Exposure Time Days	Rating
Nitric Acid, 70%	104	40	30	A
Nitric Acid, 70%	158	70	7	A
Nitric Acid, 70%	212	100	4	B
Nitric Acid, fuming	75	24	123	A
p-Nitroaniline				(A)
Nitrobenzene	75	24	600	A
o-Nitrochlorobenzene	436	225	5	A
Oxalic Acid, Dilute				(A)
Oxalic Acid, Conc.				(B)
Perchloroethylene (*Perclene*[1])	75	24	28	A
Perchloroethylene (*Perclene*[1])	(212)	(100)	(28)	(A)
Phenol	113	45	100	A
Phenol	(300)	(149)	(28)	(A)
Phenylene Diamine	450	232	60	A
Phosphoric Acid, 60%	(212)	(100)	(28)	(A)
Phosphorus Pentachloride				(A)
Phthalic Anhydride	(400)	(204)	(1)	(A)
Propionaldehyde	75	24	28	A
Propylene Glycol	104	40	30	A
Pyridine	75	24	28	A
Sodium Hydroxide, 10%	113	45	100	A
Sodium Hydroxide, 46%	75	24	7	A
Sodium Hydroxide, 46%	(158)	(70)	(7)	(A)
Steam	212	100	28	A
Steam	390	199	28	A
Steam	450	232	28	A
Steam	509	265	365	A
Sulfuric Acid, 50%	75	24	28	A
Sulfuric Acid, 60%	(250)	(121)	(28)	(A)
Sulfuric Acid, Conc.	113	45	100	A
Sulfuric Acid, 30% Oleum	122	50	270	A
Tetrachloroethane	(75)	(24)	(21)	(A)
Tetrahydrofuran	75	24	600	A
Titanium Tetrachloride	75	24	2	A
Toluene	75	24	600	A
Trichloroacetic Acid, 10%	104	40	30	A
Trichloroacetyl Chloride	75	24	28	A
Trichloroethane	(212)	(100)	(28)	(A)
Trichloroethylene	104	40	30	B
Trichloroethylene	(158)	(70)	(28)	(B)
Triethanolamine				(A)
Trifluoroacetic Acid	165	74	6 hrs.	B
Vinyl Acetate	113	45	100	A
Water (also see steam)	194	90	100	A
Xylene	(158)	(70)	(28)	(A)

1 U.S. Trademark of Diamond Shamrock Chemical Co
2 U.S. Trademark of Tenneco Chemicals
3 U.S. Trademark of Mobil Oil Corp.
4 U.S. Trademark of Dow Chemical Co.
5 U.S. Trademark of Monsanto
6 U.S. Trademark of Stauffer Chemical Co.

TABLE II—PROPRIETARY FLUIDS & BLENDS

Automatic Trans Fluid	302	150	70	A
Anderol L-774[2]	400	204	7	A
ASTM Ref. Fuel B	75	24	7	A
ASTM Ref. Fuel C	(75)	(24)	(7)	(A)
Avrex 256[3]	212	100	28	A
Aviation Gas	113	45	100	A
Dowtherm 209[4]	212	100	28	A
Dowtherm A[4]	500	260	180	A
Gasoline, unleaded				(A)
Jet Fuel Type II	600	316	3	A
Jet Fuel JP-5	75	24	7	A
	392	200	42	B
Jet Oil II	212	100	28	A
Kerosene	113	45	100	A
Kerosene	(400)	(204)	(40)	(A)
Pydraul 312C[5]	212	100	28	A
Skydrol 500A[5]	212	100	28	A
Sour Gas (methane/ hydrogen sulfide/ carbon dioxide/steam) 600 psi	450	232	6	B
Stauffer #2 Oil[6]	212	100	28	A

RATING KEY
A—Little or no effect.
B—Should be suitable depending on service conditions.
X—Unsatisfactory.
( )—Estimated to belong in noted category.

Du Pont—Problem Solver on Finished Parts

Due to the difficult compounding and processing necessary to fabricate this unique elastomer, Du Pont has assembled a special laboratory and engineering staff to work directly with potential end-users in an attempt to fill their needs for high-performance elastomeric parts.

We believe, that for most new applications, prototype testing is the best way to go. To this end, Du Pont is ready to work with you in determining whether a KALREZ* part will solve your problem. Obviously, there must be a special need to justify the cost for KALREZ. But that is where KALREZ stands out—because there are many jobs that just can't be done satisfactorily with any other material.

You are invited to submit drawings and/or specifications for price quotations. For further information, please call or write:

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DU PONT

Kalrez* PERFLUOROELASTOMER PARTS

Technical Bulletin

KALREZ (formerly ECD-006)—The elastomeric analogue of TEFLON[1] fluorocarbon resin provides exceptional fluid and high temperature resistance and extends the use of elastomers beyond current application limits. KALREZ parts, standard and custom fabricated, are available from Du Pont.

F atures

- Exceptionally inert—virtually unaffected by most chemicals—an elastomeric TEFLON.
- Thermally stable—usable at temperatures 100-200°F (38-93°C) above those for VITON[1] fluoroelastomer, silicone, fluorosilicone, acrylates.
- Durability—suitable for long-term service at 500-550°F (260-288°C) and intermittent service to 600°F (316°C).
- Du Pont—Problem Solver on Finished Parts—Special design team assistance from concept to finished part.

Benefits

- Reduced downtime
- Reduced maintenance
- Simplified design
- Increased service life

Description

Du Pont KALREZ perfluoroelastomer is an outgrowth of the chemistry that produced VITON fluoroelastomer and TEFLON fluorocarbon resins. KALREZ combines many of the elastomeric properties of VITON and the chemical and heat resistance of TEFLON with certain advantages over both. KALREZ provides the end-user with elastomeric parts that are serviceable continuously at temperatures in excess of 500°F (260°C) and intermittently to 600°F (316°C). It is virtually unaffected by almost all chemical agents. KALREZ is synthesized from monomers which are very costly to produce. Its compounding is complex. Consequently, the base price is many-fold more expensive than for VITON. Because of the chemical inertness of KALREZ, both the base polymer and the compounded stock are extremely difficult to manufacture and fabricate into useful finished parts. As a result, Du Pont alone designs, produces, and sells KALREZ parts, both standard and custom fabricated.

G n ral Physical Properties

Table 1 provides a brief summary of physical properties for some of the more commonly used compositions of KALREZ. Compounds 1050 and 3018 are widely used, general purpose compositions suitable for most mechanical parts. Compound 1064 is a plasticized version of 1050 and offers improved elongation properties. Compound 3065 is a more highly reinforced version of Compound 3018 offering improved tensile properties, at some sacrifice of extensibility, under both ambient and elevated temperatures. Table 2 lists typical miscellaneous engineering properties of interest to design engineers. Similar to other fluorinated and perfluorinated polymers, KALREZ possesses excellent resistance to the adverse effects of the environment, including sunlight, ozone and weather.

*Trademark [1]Reg U S Trademark of Du Pont

TABLE 1

General Physical Properties

COMPOUND	1064	1050	3018	3065
Hardness, Durometer A	70	80	90	95
100% Modulus[1], psi	900	1,400	1,900	–
MPa	6.20	9.65	13.10	–
Tensile Strength[1], psi	2,100	1,900	2,660	2,600
MPa	14.48	13.10	18.34	17.92
Elongation at Break[1], %	170	130	120	60
Compression Set, ASTM D 395B Pellets 70 hr				
@ 400°F (204°C), %	45	38	36	50
@ 550°F (288°C), %	N.A.[2]	53	47	N.A.[2]
Brittle Point ASTM D746, °F	−42	−35	−35	−20
°C	−41	−37	−37	−29

[1]ASTM D412, 10"/min.
[2]Not applicable

TABLE 2

Miscellaneous Engineering Properties
(Compounds 1050 and 3018)

Specific Gravity 2.02

Linear Coefficient of Thermal Expansion

Over the range of 77-482°F (25-250°C) using the equation:

$L = L_o(1 + \propto\Delta T)$ $\propto = 1.78 \times 10^{-4}/°F$
$\propto = 3.2 \times 10^{-4}/°C$

Specific Heat (by DSC)

Cp, 122°F (50°C) = 0.226 cal/g
Cp, 212°F (100°C) = 0.233 cal/g
Cp, 302°F (150°C) = 0.252 cal/g

Electrical Properties

Dielectric Constant (ε) at 1,000 Hz	4.9
Dissipation Factor (D) at 1,000 Hz	5×10^{-3}
D. C. Resistivity (ρ)	5×10^{-17} ohm-cm
Dielectric Strength (Breakdown potential)	>450 volts/mil

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Thermal Stability

KALREZ* perfluoroelastomer possesses excellent thermal stability. Table 3 presents data for samples of KALREZ 3018 that were aged in hot air for up to 504 days at 450°F (232°C) and 7 days at 600°F (316°C) as well as intermediate conditions.

As shown by both laboratory and field testing, various compositions of KALREZ provide excellent long-term sealing capability at elevated temperatures. Figure 1 shows the retained sealing force of KALREZ O-rings as a function of time at elevated temperatures. KALREZ O-rings retain sealing capabilities in excess of 700 days at 450°F (232°C) and up to 60 days at 500°F (260°C) in air.

Compression set data for pellets are shown in Table 1. Although these high temperature test results are good, compression set testing (Method B, ASTM D395, 25% deflection) is not a reliable predictor of the sealing properties of KALREZ at elevated temperatures because of the product's unique thermal stability and its exceptionally high coefficient of thermal expansion. Sealing force test methods (Figure 1) are preferred.

TABLE 3

Long Term Heat Aging—Compound 3018

Property	Original	504 Days 450°F (232°C)	112 Days 500°F (260°C)	28 Days 550°F (288°C)	7 Days 600°F (316°C)
100% Modulus,[1]					
psi	1,900	950	980	900	1,010
MPa	13.10	6.55	6.76	6.20	6 96
Tensile Strength,[1]					
psi	2,660	2,450	2,440	1,630	2,030
MPa	18.34	16.84	16.82	11.24	13 99
Elongation[1] At Break	120	220	240	320	230
Hardness, Durometer A	90	86	87	86	87

[1]ASTM D412, 10"/min.

Chemical Resistance

KALREZ exhibits exceptional resistance to nearly all classes of chemicals with the exception of some fluorinated materials. Some of the more difficult to handle chemicals and their effect on KALREZ are listed in Table 4. Of special note is the outstanding resistance to oil field sour gas, polar solvents (ketones, ethers, and esters), commercial solvents (tetrahydrofuran, dimethyl formamide), oxidizing and reducing agents, fuels, hydraulic fluids, heat transfer fluids, and steam. Figure 2 shows how little the physical properties of a composition of KALREZ have been effected after extended exposure in a difficult chemical service. More details can be found in the more extensive "KALREZ Chemical Resistance Guide".

*Trademark

TABLE 4

Resistance of KALREZ to Selected Chemicals

Chemical	Temp. °F	Temp. °C	Time, Days	Rating'
Acetic Acid, glacial	75	24	28	A
Acetic Anhydride	113	45	100	A
Acetone	113	45	100	A
Ammonia, Anhydrous	75	24	240	A
Benzene	113	45	100	A
Boric Acid, 10%	212	100	4	A
Butyraldehyde	104	40	30	B
Carbon Tetrachloride	113	45	100	B
Chlorine, Gaseous, dry	75	24	150	A
Chloroacetic Acid, 10%	104	40	30	A
Dimethyl Formamide	75	24	28	A
Dimethyl Sulfoxide	75	24	28	A
Dinitrogen Tetroxide	160	71	8	A
Dowtherm A[1]	500	260	180	A
Ethyl Acetoacetate	113	45	100	A
Ethylene Dichloride	113	45	100	A
Formic Acid, 12%	212	100	7	B
Freon[2], fluorocarbon products fully halogenated	75	24	10	X
Hexamethylphosphoramide	75	24	28	A
Hydrazine	75	24	336	A
Hydrochloric Acid, 10%	113	45	100	A
Isophorone	113	45	100	A
Jet Fuel, JP-5	392	200	42	B
Mercury/Caustic Soda	200	93	360	A
Methanol, 100%	113	45	100	A
Methyl ethyl ketone	113	45	100	A
Nitric Acid, 70%	158	70	7	A
Nitrobenzene	75	24	600	A
Skydrol 500A[3]	212	100	28	A
Sodium Hydroxide, 10%	113	45	100	A
Sour Gas[4]	450	232	6	B
Steam	390	199	28	A
Steam	509	265	365	A
Sulfuric Acid, 30% Oleum	122	50	270	A
Tetrahydrofuran	75	24	600	A

RATING KEY
A—Little or no effect
B—Should be suitable depending on service conditions
X—Unsuitable

[1]U.S Trademark—Dow Chemical
[2]Reg U S Trademark—Du Pont Co
[3]U S Trademark—Monsanto
[4]Mixture of methane/hydrogen sulfide/carbon dioxide/steam at 600 psi

FIGURE 1

Effect of Service Temperature on O-Ring Seal Durability
Method ISO/DIS 3384

AS-568A-113 O-Rings, 25% Compression

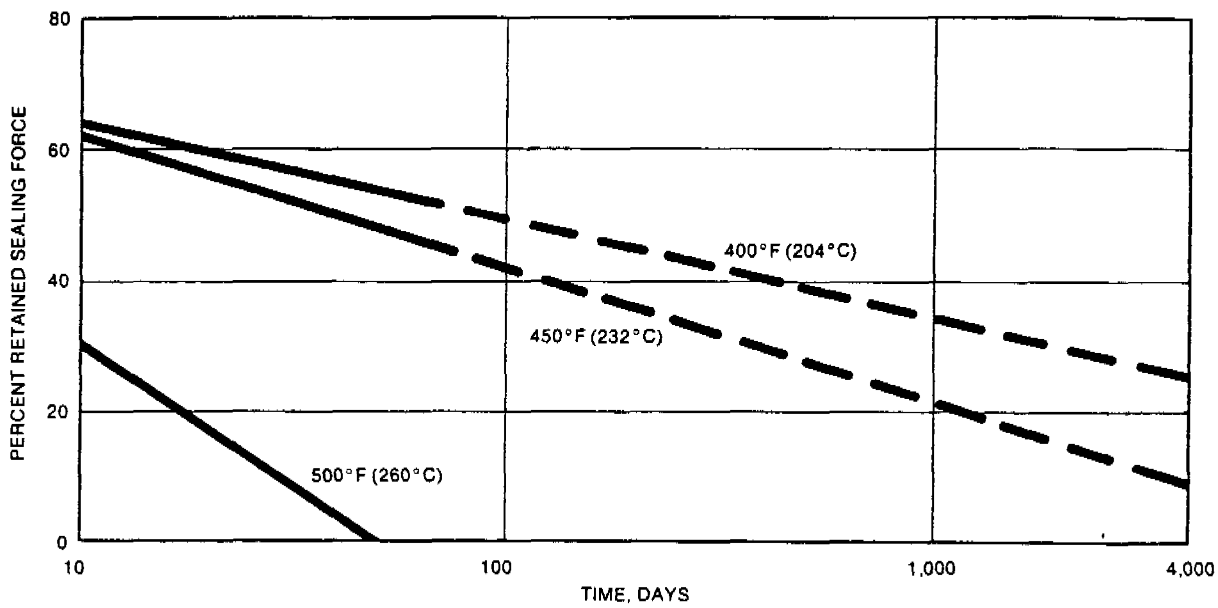
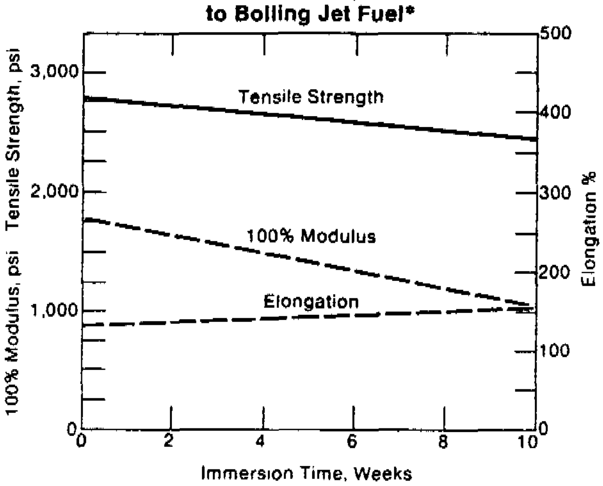


FIGURE 2

Resistance of Compound 3018 to Boiling Jet Fuel*



*JP-5 Fuel at 390-400°F (199-204°C)

Compositions and Design Considerations

As with all elastomers, specific compounding of KALREZ is needed to achieve the most suitable balance of properties for a specific application. While this bulletin provides data on only a few of the more commonly used compositions of KALREZ, many additional compositions are available to achieve desired end-use performance. It is the purpose of this review to make users aware that KALREZ* parts are available in various compositions to meet differing needs. However, this is not to suggest that the user specify a particular composition—nor are the physical property data to be interpreted as a specification. Du Pont is best equipped to select compositions when complete specifications on the application have been provided. The Du Pont design team of engineers and chemists will select the most appropriate composition for the intended service based on a complete evaluation of critical design parameters including chemical environment, service temperatures, operating pressures and essential physical properties.

*Trademark

Parts Availability

Both standard and custom parts, molded, calendered, extruded or otherwise processed, are available.

- Standard Parts, made to tight tolerances include:

Sheeting	Tubing
O-Rings	Septa
Slabs	Reinforced Sheeting
Rodding	Reinforced Slabs

- Custom-Made Parts, with physical properties tailored to meet specific end-user requirements include:

Electrical Connectors	Pump Diaphragms
Fluid-Sealing Components	Pump Liners
Flange Seals	Roll Covers
Gasket Stock	Valve Seals & Seats
Liners	Wire Coverings
Pipe-Coupling Seals	

Du Pont—Problem Solver on Finished Parts

Due to the difficult compounding and processing necessary to fabricate this unique elastomer, Du Pont has assembled a special laboratory and engineering staff to work directly with potential end-users in an attempt to fill their needs for finished elastomeric parts. (Information on applications for KALREZ* parts is available in a separate report, E07259.)

We believe that for most new applications prototype testing is the best way to go. To this end, Du Pont is ready to work with you in determining whether a KALREZ part will solve your problem. Obviously, there must be a special need to justify the cost for KALREZ. But that is where KALREZ stands out—because there are many jobs that just can't be done satisfactorily with any other material.

You are invited to submit drawings and/or specifications, including full details on chemical environment, service temperatures, operating pressures, and essential physical properties, for price quotations by the Du Pont KALREZ design team.

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DU PONT

Kalrez* PERFLUOROELASTOMER PARTS*

Product Profile

Du Pont KALREZ perfluoroelastomer (formerly ECD-006) is composed primarily of fluorine and carbon. It combines many of the properties of a fluoroelastomer (i.e. Du Pont VITON fluoroelastomer) with those of a perfluorinated plastic (i.e. Du Pont TEFLON** fluorocarbon resins). It provides certain advantages over both.**

KALREZ is synthesized from monomers which are very costly to produce. Its compounding is complex. Consequently, the base price is manyfold that of VITON fluoroelastomer. And, because conversion into finished parts involves unusual processing, Du Pont alone designs, produces and sells KALREZ parts, both standard and custom fabricated.

Features of KALREZ Perfluoroelastomer Parts...

- KALREZ parts have mechanical properties similar to other fluorinated elastomers but exhibit greater heat resistance and chemical inertness.
- KALREZ parts have thermal, chemical resistance and electrical properties similar to TEFLON fluorocarbon resins but, made from a true elastomer, possess excellent resistance to creep and set.
- Generally, KALREZ parts are capable of providing continuous service at temperatures of 500-550°F (260-288°C) and can operate at 600°F (316°C) for shorter periods.
- Their chemical resistance is outstanding. When using specially formulated compositions, little or no measurable effect is found in almost all chemicals, excepting fluorinated solvents which induce moderate swelling. The parts have excellent resistance to permeation by most chemicals.
- Resistance to attack is especially advantageous in exceptionally hot, corrosive environments such as:
    - Polar solvents (ketones, esters, ethers).
    - Strong commercial solvents (tetrahydrofuran, dimethyl formamide, *Perclene*[1], benzene).
    - Inorganic and organic acids (hydrochloric, nitric, sulfuric, trichloroacetic) and bases (hot caustic soda).
    - Strong oxidizing agents (dinitrogen tetroxide, fuming nitric acid).
    - Metal halogen compounds (titanium tetrachloride, diethylaluminum chloride).
    - Hot mercury/caustic soda.
    - Chlorine, wet and dry.
    - Inorganic salt solutions.
    - Fuels (aviation gas, kerosene, JP-5 Jet Fuel, ASTM Reference Fuel C).
    - Hydraulic fluids (*Skydrol*[2] 500A, *Pydraul*[2] 312, *Anderol*[3] L-774, and transmission fluids).
    - Heat transfer fluids (*Dowtherm* A[4]).
    - Oil well sour gas (methane/hydrogen sulfide/carbon dioxide/steam).
    - Steam.

1 U S Trademark of Diamond Shamrock Chemical Co.
2 U S Trademark of Monsanto Co
3 U S Trademark of Tenneco Chemicals
4 U S Trademark of Dow Chemical Co

*Trademark **Reg. U S Trademark of Du Pont

Benefits of Use of KALREZ Parts...

- **Increased Service Life** The useful life of a part can often be increased manyfold by making it from KALREZ.
- **Reduced Downtime** Replacing less durable materials with KALREZ is buying long term protection against part failures that result in shutdowns, ruined equipment or unsafe operations. KALREZ provides extra protection at extreme service temperatures that degrade lesser polymers. KALREZ parts are ideal for those maintenance situations where shutdown costs are large in relation to the parts cost involved.
- **When Nothing Else Works** Often, in highly critical situations, when no other material would function, a KALREZ part has met the need.
- **New Design Possibilities** KALREZ parts, with their unique properties, often open new design possibilities and opportunities for system simplification that can reduce overall costs.

  However, a direct shape substitution of KALREZ for a part made from plastic, metal or another elastomer may not always be satisfactory. Rather, a cooperative study must sometimes be made with the design engineer to tailor the shape of the part to the requirements. In many cases, this results in more desirable engineering design, with one KALREZ part replacing a more complicated part or several component parts.
- **KALREZ parts should be considered to** increase parts reliability and increase safety. This can result in important benefits such as reduced maintenance costs, extended equipment life, reduction of production interruptions and reduction of weak links in systems.

Industries Served...

Since the start of test marketing KALREZ parts in mid-1972, many different types of parts problems have been studied. Economic factors have ruled out KALREZ for some applications while many others are under development. The rest comprise a rapidly growing list of successful commercial uses of KALREZ.

- **Oil Fields** KALREZ parts are providing improved components for equipment used in oil wells previously considered impractical to recover. Such wells are plagued with highly corrosive hydrogen sulfide under unusually heavy pressures and high temperatures. One application, specialty boots for electronic logging, was the first commercial usage of KALREZ. Among other oil field applications now commercial or being developed are: insulation sleeves for electric connectors, O-rings, chevron packings, shaft seals, packings and insulated wire for downhole use.
- **Aerospace** The mechanical properties of KALREZ parts, combined with their resistance to jet fuels, kerosene, benzene, isooctane, and such oxidizing agents as dinitrogen tetroxide and fuming nitric acid have stimulated considerable developmental and commercial activity in O-rings, bladders, and miscellaneous seals.

• **Analytical and Process Instruments** One of the most demanding applications for KALREZ* is as injection port septa for liquid chromatographs. The near universal chemical resistance of KALREZ allows the liquid chromatograph user to easily switch from one to another solvent stream without changing septa. KALREZ resists most common solvents, including acetic acid, alcohols, aromatic organics, hexane, ketones and tetrahydrofuran, while maintaining self-sealing properties after repeated punctures by hypodermic needles.

In gas chromatography, the thermal stability of KALREZ septa to temperatures in excess of 300°C (572°F) provides outstanding resistance to septa bleed (the evolution of volatiles from the septa, which interferes with sample analysis) and out-gassing under high vacuum.

The combination of thermal stability, chemical resistance and out-gassing resistance has led to the expanding use of KALREZ parts (diaphragms, gaskets, O-rings, and seals) in process instruments and valves in severe services, such as ammonia, chlorine, hydrochloric acid, sulfuric acid and tetrahydrofuran.

• **Chemical Process and General Industry** KALREZ perfluoroelastomer is particularly useful in industry for maintenance parts that must withstand the effects of high heat and/or harsh chemicals. KALREZ parts are being used in equipment operating in chemical and thermal environments which quickly degrade other elastomers...or where TEFLON has been used previously for chemical and thermal stability but where elastomeric sealing characteristics are more desirable.

Some of the more severe environments in which KALREZ has solved difficult sealing problems include: heat transfer fluids at 500°F (260°C), nitrochlorobenzene at 440°F (227°C), hot polyesters at 500°F (260°C), and caustic/chlorine at 200°F (93°C). In one instance, switching to large KALREZ O-rings in heavy duty compressors has dramatically reduced downtime which costs the user about $100,000 a day in lost production.

• **Electrical/Electronic** Due to their excellent dielectric strength, KALREZ parts offer great potential as electrical insulators and connectors for oil-field equipment and sophisticated electrical appliances operating in hostile environments.

Printed electronic circuit boards have been successfully produced using rolls covered with KALREZ, submerged in a 550°F (288°C) oil-solder bath to squeeze off molten solder.

Availability of Parts...

Both standard and custom parts, molded, calendered, extruded, or otherwise processed, are now commercially available from Du Pont.

• Standard Parts, made to tight tolerances include:

Sheeting	Tubing
O-Rings	Septa
Slabs	Reinforced Sheeting
Rodding	Reinforced Slabs

• Custom-Made Parts, with physical properties tailored to meet specific end-use requirements, can be compounded with a variety of fillers, and include:

Electrical Connectors	Pump Diaphragms
Fluid-Sealing Components	Pump Liners
Flange Seals	Roll Covers
Gasket Stock	Valve Seals & Seats
Liners	Wire Coverings
Pipe-Coupling Seals	

A Departure...

Rarely does a raw polymer manufacturer assemble a special laboratory and engineering staff to work directly with potential end users in an attempt to fill their immediate needs for finished elastomeric parts. Due to the difficult compounding and processing necessary to fabricate this unique elastomer, Du Pont, in this instance, is making such an individualized service available.

We invite you...

We believe that for most new applications, prototype testing is the best way to determine the suitability of a KALREZ part. To this end, Du Pont is ready to work with you in determining whether a KALREZ part will solve your problem. Our special research and application team of chemists and engineers will study your problem.

You are invited to submit drawings and/or specifications for price quotations. To receive other information or for an answer to a question related to your specific needs, please call or write:

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DU PONT

Kalrez® PERFLUOROELASTOMER PARTS

"KALREZ" PARTS IN CHEMICAL SERVICE

Chemical Service	Conditions	Parts
Acrylonitrile	RT[1], >14 Days	O-Rings[2]
Air	316°C (600°F), 1,000 hrs.	Spark Plug Boots
Ammonia, Anhydrous	RT[1], >4 mos.	O-Rings
Ammonia, Liquid, Dry	RT[1], 240 Days	O-Rings
CO_2	249°C (480°F), 450 psi >360 Days	O-Rings
Chlorine, Gas, Wet	RT[1], 180 Days	Diaphragms, O-Rings
Chlorine, Liquid	RT[1], 150 Days	O-Rings
Chlorine, Gas, Dry	RT[1], 240 Days	O-Rings
Chloro-Acetyl Chloride	70°C (158°F), 90 Days	O-Rings
3,4-Dichloro Aniline	130°C (266°F), 30 Days	O-Rings
Fuming HCL	RT[1], 180 Days	O-Rings
Heat Transfer Fluids	260°C (500°F), >180 Days	O-Rings
Mercury/Caustic	RT[1], 270 Days	Diaphragms, O-Rings
Methyl Methacrylate	RT[1], >90 Days	O-Rings[2]
Methylene Chloride	66°C (150°F), >10 Weeks	O-Rings
Mixed Liquids (Hydrazine, Ammonia, Sulfides)	66-93°C (150-200°F) >12 Weeks	O-Rings[2]
Mixed Liquids (MIBK, Organics, HCL)	66-93°C (150-200°F) >12 Weeks	O-Rings[2]
NaOH, H_2O, Chlorate	93°C (200°F), >3,000 hrs.	O-Rings
Nitric Acid, 90%	RT[1], >123 Days	O-Rings
Nitrochlorobenzene	225°C (437°F), >115 hrs.	Pump Seal
m-Phenylene Diamine	230°C (446°F), >2 mos.	O-Rings[2]
Polyester Polymerization	288°-316°C (550°-600°F) >5 mos.	O-Rings
Process Steam	265°C (509°F), >1 yr.	O-Rings[2]
Sour Gas (H_2S, CO_2, H_2O, etc.)	260°C (500°F), 20,000 psi	Electrical Connectors, O-Rings
Styrene	RT[1], >3 mos.	O-Rings[2]
Sulfuric Acid, 30% Oleum	50°C (122°F), >9 mos.	O-Rings[2]
Sulfuric Acid, 10-20%	82°C (180°F), 180 Days	Diaphragms, O-Rings[2]
Sulfur Trioxide	50°C (122°F), >9 mos.	O-Rings[2]
THF	Boiling	Valve Seats
Toluene/MEK/$MeCl_2$	RT[1], >100 hrs.	O-Rings[2]
Xylene	121°C (250°F), >3 mos.	O-Rings[2]

The above listing summarizes some of the successful applications using KALREZ parts in severe chemical environments. In almost all cases indicated by an indeterminate duration (e.g., >360 days), the KALREZ parts were still functioning at the end of the time period and maximum service life has not y t been established. In many cases, maximum service life of the system is now being determined by limitations other than the life of the rubber seal.

[1]RT – Room Temperature
[2]No Other Elastomer Works

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DU PONT

Kalrez PERFLUOROELASTOMER PARTS

HOW "KALREZ" PERFLUOROELASTOMER PARTS CAN SAVE YOU MONEY ON YOUR SEALING NEEDS

Elastomeric parts such as O-rings and other seals made from KALREZ perfluoroelastomer, the "rubbery" TEFLON®, offer many opportunities to reduce the total operating cost of equipment used in the chemical process industry (CPI). KALREZ parts are higher priced than similar parts made from other elastomers. However, where the need exists, they can be the lowest cost in service.

Savings from the use of KALREZ parts can normally be achieved by: 1) reduced maintenance costs as a result of the greater service life attainable through the use of KALREZ; 2) reduction of downtime caused by equipment outages; 3) reduced initial cost due to greater design freedom; and 4) greater safety.

SOME CASE HISTORIES WHERE "KALREZ" PARTS ARE HELPING TO SAVE MONEY

Investment of $300 Results in Savings of $2,000.00

A chemical plant has eight pumps used for Dowtherm A[1] at 246°C (475°F), pumping 5,000 gallons per minute. Mechanical seals using O-rings for the secondary seal were failing on the average every two months. Maintenance costs ran about $1,000 for each failure. An investment of $300 for KALREZ O-rings has resulted in more than tripling of service life between overhauls, and a resultant seven-fold payback. No pumps have failed to date because cf the KALREZ O-rings.

Equipment Operation Extended from 3 Weeks to Over 5 Months

A polyester film plant uses a mechanical seal on a mixer operating at 280°-316°C (536°-600°F). O-rings on the seal failed on the average every 3 weeks. KALREZ O-rings have been in service for over 5 months without failure.

Operating Where Lost Production C uld Cost $100,000.00/Day

A carbon dioxide compressor operates at 244°C (470°F) and 100 psig. Silicone O-rings were failing in a short time and lost production could run as much as $100,000/day. KALREZ O-rings hav now been in service for over a year and a half and are still functioning.

Saving $1,000 Per Seal

A pump handling para-nitrochlorobenzene at 150°C (302°F) required a metal bellows seal that cost nearly $2,400. This has been replaced with a conventional seal, using KALREZ O-rings, which cost only $1,400, a significant savings.

Eliminating a Fire Hazard

A pump handling heat transfer oil at 220°-240°C (428°-464°F) used a conventional stuffing box which allowed leakage. A fire occurred which damaged the pump and other equipment. The pump was replaced with one using a mechanical seal with KALREZ O-rings thus eliminating the leakage and potential fire hazard.

Extending Instrument Life Over 35 Times

Instruments in a sulfuric acid plant exposed to sulfur trioxide at 50°C (122°F) and 30% oleum at 50°C (122°F) needed replacing on a weekly basis because of O-ring failure. Instruments fitted with KALREZ O-rings have been in service for mor than nine months without replacement.

[1]U.S. Trademark of Dow Chemical Co.

Call or write us at the address below to find out how KALREZ parts can help you save money.

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Select O-rings carefully

Seldom visible O-rings are often present in process machinery sealing applications. Observe these guidelines to make them work for you, not against you

Malc lm G. Murray Jr., Murray & Garig Tool Works, Baytown, Texas

In HYDROCARBON PROCESSING plants, mechanical seals for pumps and compressors, tube fittings and pipe flanges often use O-rings to prevent fluid flow or leakage. According to application, O-rings can be categorized as static (seal between flange facings) and dynamic (subjected to movement or wobble). See Fig. 1. Table 1 lists the commonly available O-ring materials and their characteristics.

Chemical compatibility of O-rings with a process fluid and temperature limits will define the method of O-ring production, using full-circle molding, ambient adhesive bonding and hot bonding or vulcanizing. Having no joint, hence no weak point, reliable in operation, full-circle, molded O-rings are the most common. Available in a wide range of stock sizes and materials, O-rings of this type also can be custom-molded. Ambient adhesive bonded O-rings of any diameter can be quickly and easily made, using cord stock of most materials except silicone rubber. A simple jig used for cutting square ends and aligning them for bonding gives a smooth joint, which can sometimes be made in place without machine disassembly. Vulcanizing is considered to be an intermediate method in terms of nonstock O-ring delivery, chemical and temperature resistance. Thermal and chemical resistance of the hot, bonded O-rings are superior to the adhesive-bonded but inferior to the molded.

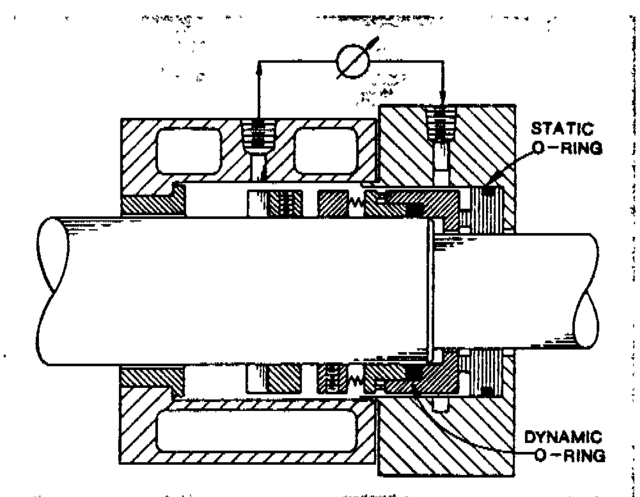

Fig. 1—Mechanical seal installation with static and dynamic O-rings.

O-ring failure analysis can be instructive to prevent machine failure. I will now discuss several common causes of O-ring failure.

Deterioration in storage. Some synthetic rubbers such as neoprene and buna N are sensitive to ultraviolet radiation, others to heat and ozone. Storage in a cool, dark environment, away from electrical equipment, is therefore recommended.

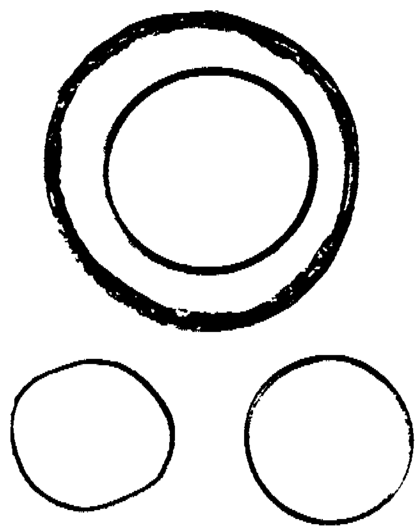

Fig. 2—Failed O-rings.

Temperature. Exceeding an allowable temperature is a common cause of O-ring failure (see Fig. 2). The largest O-ring failed from overheating because of blockage of seal flush. The inner one did not recover from compression set at high temperature, remaining "flattened out" as shown. The two lower rings failed because of overheating or chemical attack. Table 1 lists temperature limits for common O-ring materials. These limits can often be exceeded for short periods. Process fluid temperature may not be equal to O-ring temperature. A cool flush may reduce O-ring temperature, as may heat dissipation through a barrier structure. On the other hand, localized frictional heating may increase the O-ring temperature. If high or low temperatures are suspected as causing failure, it may be practical to change the environmental temperature or the O-ring material. In extreme cases, an all-metal bellows seal may permit elimination of O-rings.

Mechanical damage. Tearing, pinching, foreign matter embedment, dry rubbing and various other mechanical

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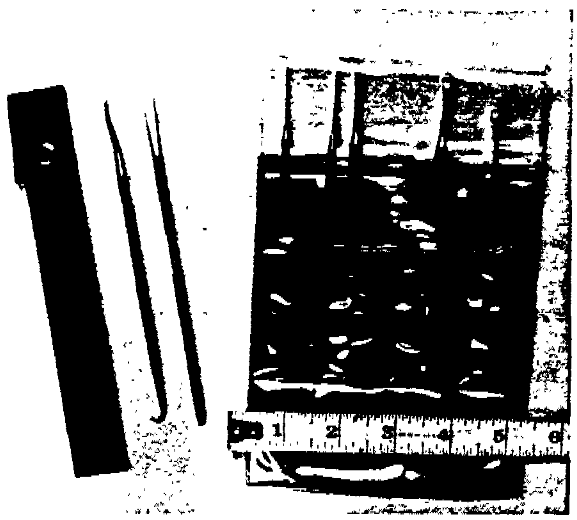

Fig. 3—O-ring tool kits.

damage can occur during installation, operation and removal. A sharp steel tool used for O-ring removal can scratch the groove or sealing surface and cause leakage. Brass, wood or plastic tools can be used without risk of scratching. Fig. 3 shows two O-ring tool kits. The two-piece kit on the left is made of brass, the five-piece kit on the right, having rounded tips and edges, is made of stainless steel.

Chemical attack. Table 1 is useful in selecting O-ring materials compatible with various fluids. Experimental verification is sometimes worthwhile. Complications may occur because of different properties of supposedly identical O-rings produced by various manufacturers. Also, a loss of identification in storage and handling is possible. To minimize unpleasant surprises for critical service such as hot xylene, we routinely discard new O-rings which come with new and rebuilt seal assemblies, and replace them with O-rings of known material from a single manufacturer considered reliable. To check whether an unknown, used O-ring is Viton or something else, we use the carbon tetrachloride test described in Table 1.

Ab ut the author

MALCOLM G. MURRAY, JR., is owner of Murray & Garig Tool Works, Baytown, Texas. He designs and manufactures machinery alignment, grouting, tank inspection and rescue signaling equipment for oil refineries, chemical plants and marine applications. Mr. Murray holds a B.S. degree in mechanical engineering from Duke University and an M.S. in mechanical engineering from Stanford. He was a machinery test engineer in the U.S. Army Corps of Engineers, Ft. Belvoir, Va. He was then a construction project engineer and a machinery maintenance and procurement engineer with a major overseas oil refinery before forming his own firm. He is a member of ASME and is a registered professional engineer in the District of Columbia and Texas. He has several patents on machinery alignment devices and plastic sunlight reflectors. ■

TABLE 1—O-Ring material

Property \ Material	Neoprene	Buna N	Fluorocarbon du Pont Viton	Ethylene propylene EPDM	Polyacrylate	Silicone	Urethane	Perfluoroelastomer du Pont Kalrez (formerly ECD-006)	Composite — Synthetic rubber inside, du Pont Teflon outside	Fluorosilicone
Service temperature limits, °F	−65 to +300	−60 to +300	−10 to +450 for continuous, dynamic service. Intermittent service to 600. Static service to −50	−60 to +350	−20 to +350	−178 to +450 (to +700 for short periods)	−65 to +240	−36 to +550 continuous To +600 intermittent	To +400	−90 to +400
Specific gravity	1.25	0.98	1.8 — 1.9	0.86	1.09	1.1 — 1.6	1.25	2.01	...	1.4
Chemical resistance	Good for common refrigerants and lube oils	Good for most petroleum oils.	Good for broad range of hydrocarbons and acids. Not recommended for ammonia or amines	Good for phosphate ester base hydraulic fluids. Not recommended for petroleum oils	Used extensively for auto transmissions and power steering	Good for dry heat in static applications.	Good for hydrocarbons. Poor in acids, ketones, chlorinated hydrocarbons	Excellent over-all fuel and chemical resistance, similar to Teflon	Inert to most chemicals	Good for dry heat plus exposure to hydrocarbons
Sunlight resistance	Poor	Poor	Good			Good	Good	Good	Good	Good
Compression set resistance	...	Good	Good to excellent	...	Fair	Good	Fair to good	Fair to good. Good below 500 °F	Superior to Teflon used alone. This is its main selling point.	
Abrasion resistance	Fair to good	Fair to good	Fair to good	...	...	Poor	Excellent	Fair to good	Fair	Fair
Remarks	...	Poor ozone resistance	The best general purpose O-ring material for refineries and chemical plants. Has largely displaced neoprene and buna N for such plants. O-rings made from du Pont E60C Viton provide major improvement in high temperature compression set resistance over the older Vitons.*	...	...	Can often be identified by red color, or failure to bond with cyanoacrylate adhesive.	High tensile strength and extrusion resistance. Some types of ants like to eat some types of urethane rubber, so best to provide ant-proof storage.	A comparatively new material. O-rings made from it are available only from du Pont. When its unique properties are required, however, it can easily be worth its price.	Has chemical resistance of Teflon with better compression set resistance. Not recommended for certain applications—consult manufacturer. For the future, it appears possible that this type of O-ring may become obsolete, as the Kalrez O-rings come into more common use.	

*To identify Viton, drop the material into carbon tetrachloride. If it sinks, it is probably Viton. If it floats, it is not. Kalrez perfluoroelastomer would also sink, but this material is uncommon and seldom unidentified by other means.

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John Crane

SEAL SITTER MARK II

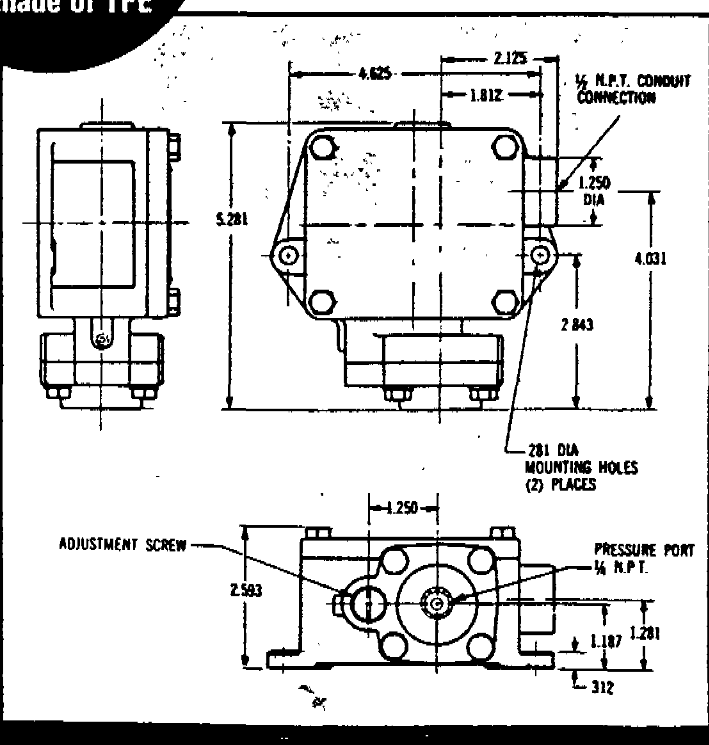
FEATURES:
Explosion-Proof Construction
•
All Wet End Parts are made of TFE

Pressure Sensitive Switching Device For Protecting Mechanical Seals

The John Crane Seal-Sitter Mark II automatically protects mechanical seals, impellers and other sensitive pump components against damage as the result of dry running conditions. It can be readily installed in a system so as to instantly shut off operation and/or actuate an audio or visual alarm when a pressure drop occurs.

The Seal-Sitter Mark II pressure switch is adjustable within a range of 6 to 340 PSIG at temperatures from —65° to +160° F. Enclosure is explosion- and tamper-proof. All wetted parts contacting the fluid are made of TFE to permit the handling of practically any chemical or corrosive.

The Seal-Sitter is especially valuable in systems engaged in batch system transfer cycles, loading or unloading tanks and vessels or similar operations. It also protects against maintenance failure in systems dependent on flow through a filter or where an independent flushing source is used. Other applications are protection of installations using double seals or throttle bushings.



WIRING DIAGRAM ON REVERSE SIDE

ENCLOSURE:

Explosion-proof (NEMA 7,9) designed to the requirements of hazardous locations Class I, Groups C & D and Class II, Groups E, F & G. Tamper-proof external adjustment.

●

ELECTRICAL CHARACTERISTICS:

Underwriters' Laboratories, Inc. listed single pole double throw snap-action switching elements. Electrical rating (continuous inductive) 10 amps 125 or 250 volts AC, 3 amps 480 volts AC, .5 amps 6 volts DC, .5 amps 24 volts DC. Automatically reset by snap-action of switch. Class J switch element with elastomer boot around actuator and sealed to prevent moisture and foreign matter from affecting contacts.

●

ELECTRICAL CONNECTION:

Through ½″ NPT conduit connection to screw terminals on switch.

●

PRESSURE CONNECTION:

¼″ 18 NPT internal thread.

●

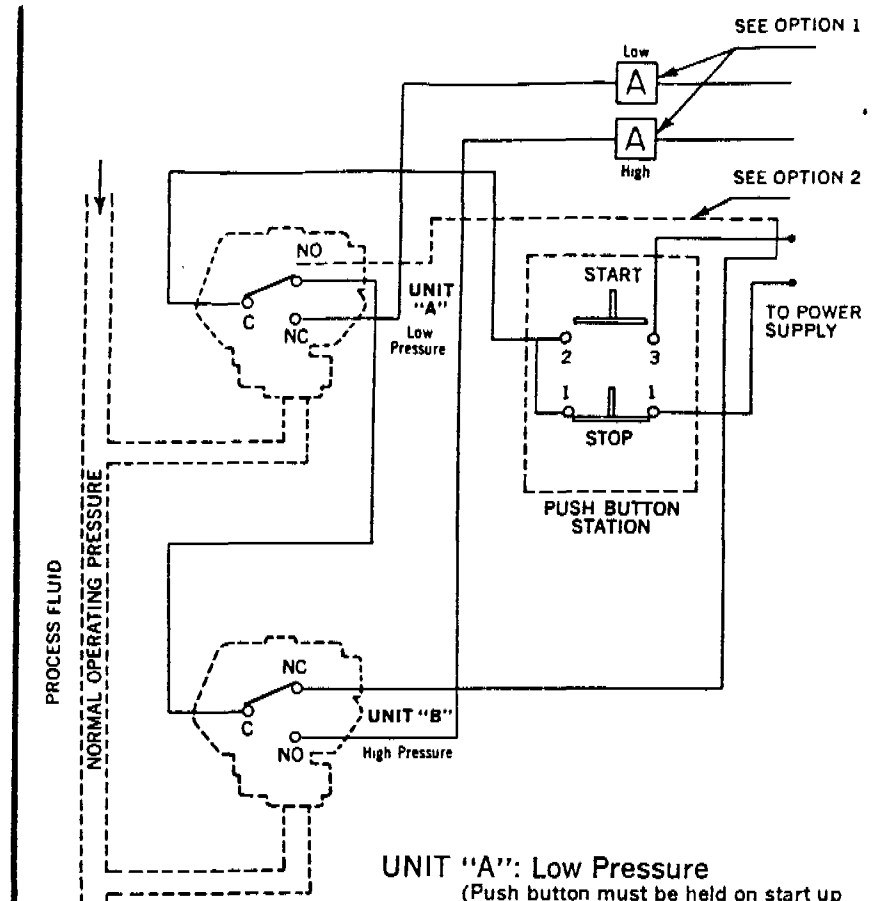
ADJUSTMENT INSTRUCTIONS:

Loosen set screw with a #10 Allen wrench. With screwdriver, turn adjustment screw clockwise to raise and counterclockwise to lower the actuation point. Tighten set screw after desired setting is reached.

●

SHIPPING WEIGHT:

2¾ lbs. (approx.)



UNIT "A": Low Pressure
(Push button must be held on start up until Switch A is closed by Pressure)

UNIT "B": High Pressure

OPTIONS:
1. High or low pressure circuit audio or visual alarm.
2. Low pressure cut out only (install jumper). High and low pressure cut out (remove jumper).

Switches can be used in combination to effect a warning signal on initial pressure decrease, then shut off if pressure drops to critical level.

OPERATING CHARACTERISTICS
All values given in P.S.I. (Gauge)

Proof Press.	Adjustable Range				Approx.* Actuation Value
	Decreasing		Increasing		
	Min.	Max.	Min.	Max.	(Differential)
2000	6.0	331.5	7.0	340.0	1.0 - 8.5

**Fixed at any pressure setting. Varies as shown from lowest to highest setting.*

John Crane

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