Seals for CO_2 Refrigeration

No. 5729-USA

Greenhouse gas makes for a cooler world.

Carbon dioxide, long considered a "greenhouse gas" for its potential to contribute to global warming, now finds a possible future in replacing halogenated refrigerants in air conditioning and refrigeration systems. High-pressure CO_2 offers interesting and unique design challenges for HVAC system development, particularly in the selection of seal materials.

Temperature

The extreme temperature range involved in the transcritical CO_2 refrigeration cycle (-40° to +160°C) limits the choice of seal materials. Fluorocarbon (FKM), Hydrogenated Nitrile (HNBR), and Ethylene-Propylene (EP) compounds exhibit the most suitable thermal stability.

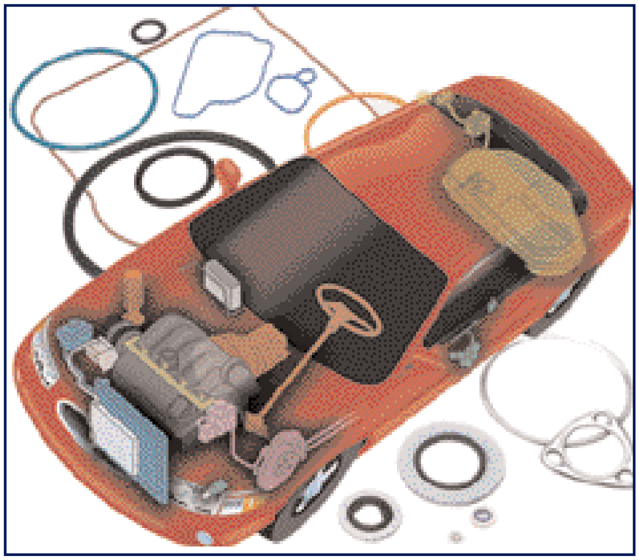
Chemical compatibility

When evaluating the chemical compatibility between carbon dioxide, compressor oils and rubber sealing components, it is necessary to consider several important issues that can directly affect system performance. The polarity of the carbon dioxide molecule results in lower potential for swell, permeation, and explosive decompression with EP seals than with fluorocarbon or HNBR materials.

Some Polyalpha olefin (PAO) compressor oils can cause swelling of EP compounds, but are generally compatible with fluorocarbon and HNBR. Polyalkylene glycol (PAG) and polyol ester (POE) oils are generally compatible with all three seal materials. But because rubber compounds and commercially-available PAGs and POEs vary widely, compatibility testing with specific compressor oils and seal materials should be performed to ensure acceptable seal performance.

COMPARISON OF REFRIGERANTS

	UL Minimum Design Pressures		Critical Point Data			
Refrigerant	Low side (psia)	High side (psia)	Temperature (°F)	Pressure (psia)	Density (lb/ft^3)	Normal boiling point (°F)
CO_2	955	1058	87.76	1070.00	29.20	-109.00
R134a	88	135	213.70	588.75	32.00	-14.90
R407c	167	243	188.10	669.95	32.90	-46.40
R410a	238	344	161.80	714.50	30.50	-51.53
R507	180	262	159.60	550.00	N/A	-52.10
R22	144	211	205.00	723.70	32.70	-41.50



Figures 1-3 (see reverse) document the effect of various compressor oil technologies on representative rubber compounds. Figure 4 (see reverse) demonstrates the differences in performance of compounds from within the same polymer family – the exact compound used in application is critical to success.

Pressure

Carbon dioxide refrigeration cycles must operate at significantly higher pressures than those of conventional refrigerants. Pressure-related seal failure can be caused by extrusion (gas pressure forcing the seal material into a clearance gap) permeation (pressure loss) and by explosive decompression (blisters and splits caused by expansion of gas trapped within the seal material).

Figure 5 (see reverse) displays the relationship between maximum attainable fluid pressure before extrusion occurs, the clearance gap on the low-pressure side of the rubber seal, and the hardness of a rubber seal material.

Explosive Decompression can be roughly predicted, but specific compounds should be evaluated for permeation and explosive decompression in actual operating conditions whenever possible.

Parker Hannifin Corporation
O-Ring Division
2360 Palumbo Drive, Lexington, KY 40509
Phone: (859) 269-2351 Fax: (859) 335-5128
www.parkerorings.com

Figure 1

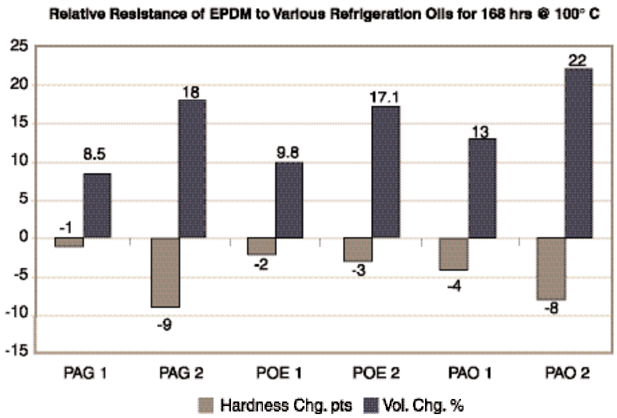


Figure 2

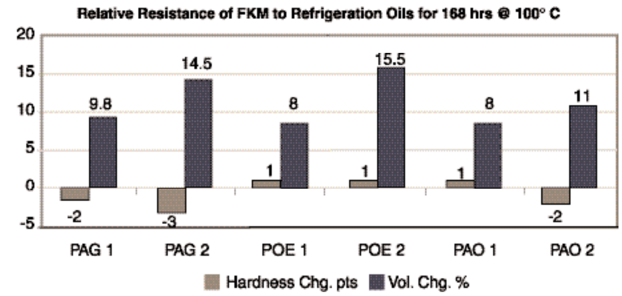


Figure 3

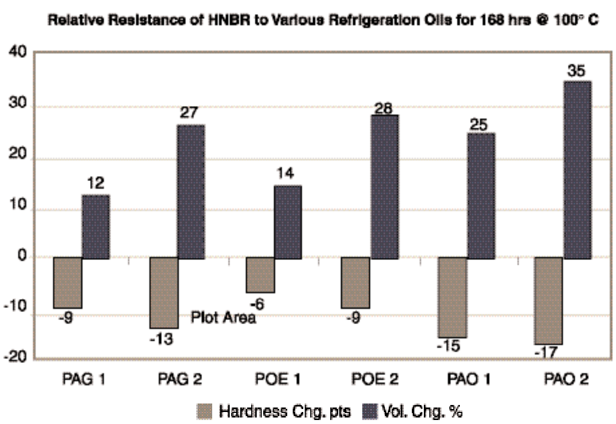


Figure 4

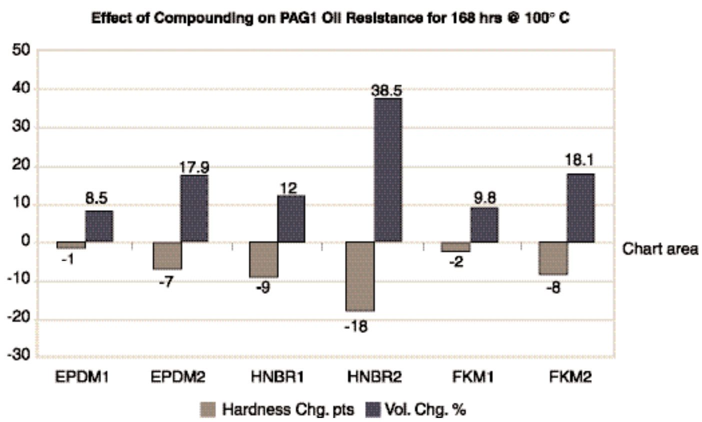
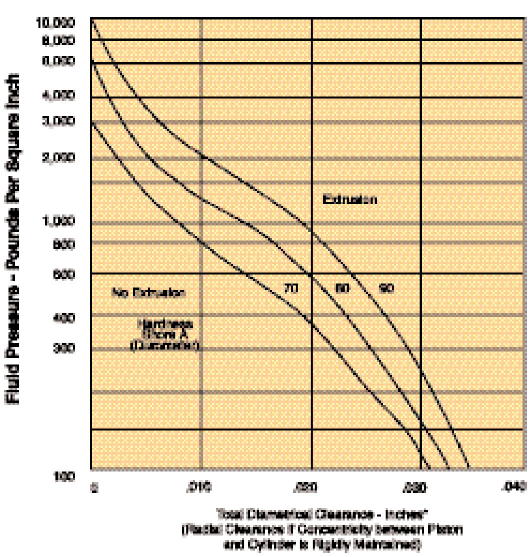


Figure 5



Extrusion-Pressure/ Hardness/Clearance-gap Relationships

PHYSICAL PROPERTIES OF CARBON DIOXIDE		
Molecular weight	44.010	AMU
Vapor pressure @ 70° F	844.700	psia
Specific volume @ 70° F, 1 atm	8.760	ft^3/1b
Triple point temperature	-69.900	°F
Triple point pressure	75.100	psia
Specific gravity @ 32° F, 1 atm	1.521	(air=1)
Latent heat of vap @ triple point	149.600	BTU/lb
Latent heat of vap @ 32° F	101.030	BTU/lb
Solubility in water @ 32° F, 1 atm	0.759	vol/vol water

Unless otherwise noted, these are test values from a limited number of samples and should not be used for establishing specific limitations.

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