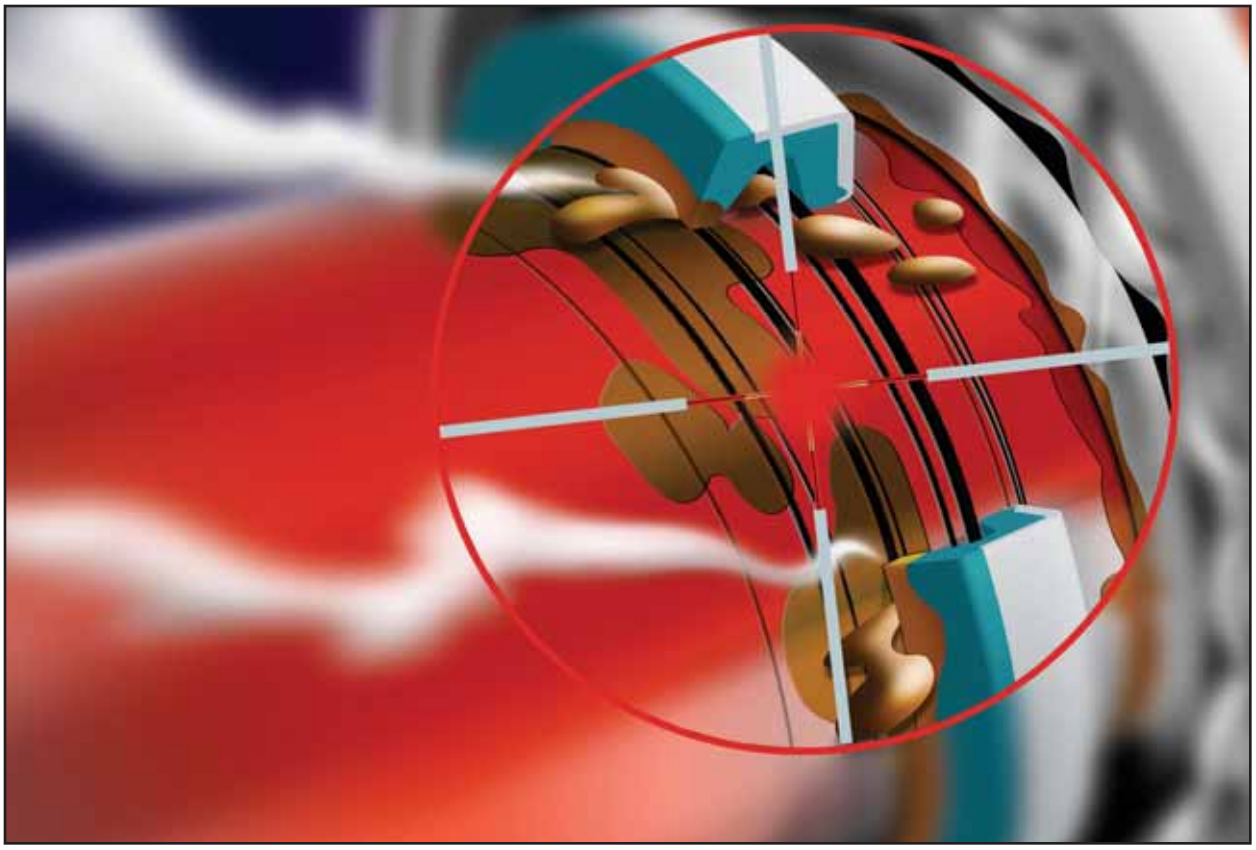

Target: Lip Seals

Thirty-eight million rubber lip seals are produced for industrial use in the United States each year. At least half of them, nineteen million, are probably misapplied and should not be installed in industrial rotating equipment.

According to their manufacturers, even the best lip seals have a median life to failure of only 1,844 hours or 77 days of operation. Half last longer than that and half last less than the mean time hours to leakage. More than 90% of them will quit sealing within the first 3,000 hours of operation.

After that, they either groove the shaft or burn to a crisp at the point of contact with the rotating shaft. Why, then, are they applied to protect rotating equipment that is designed to run uninterrupted for five years and bearings that are rated for much longer than that? **figure 1**

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CIC 7810-192
Exhibit III

NATIONAL HOURS TO FAILURE	MEDIAN RANK (% FAILURE)	CR WAVESEAL® HOURS TO FAILURE	
182	6.7	144	
188	16.32	576	
275	25.94	1343	
300	35.57	1736	
556	45.19	1763	Median
648	54.81	1973	
772	64.43	1979	
902	74.06	2946	
1264	83.68	2982	
1366	93.30	3003	
(57 Days)		(125 Days)	

CIC 7810-192
Exhibit IV
Percent Failure vs. Hours To Leakage

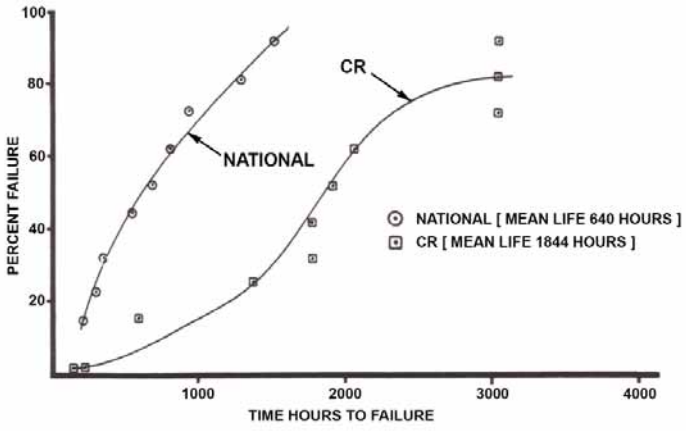


Figure 1

On average, each lip seal consumes 147 watts of power. A plant with 600 pumps, assuming two lip seals per pump, consumes 176.4 KW per hour of operation. Assuming 7.56 cents per KWh, that amounts to $117,041 per year spent just to overcome lip seal drag. The low initial purchase price of lip seals represents only a tiny percentage of their total operating cost. **figure 2** Fortunately, or unfortunately, the run-time will be considerably less than a full year and the energy costs are not as much as they could be unless the lip seals are changed out every time that they quit sealing. The odds of that happening are not great.

When the lip seal quits sealing and loses contact with the shaft, very undesirable things are liable to happen. Lubricant is free to exit the bearing enclosure and as the equipment cycles, moisture in the environment is drawn into the enclosure where it condenses and contaminates the lubricant. Even a minute amount of water in the oil is very detrimental to the bearing fatigue life projection. **figure 3**

CONTACT SEAL POWER CONSUMPTION COST CALCULATION

While they are engaged with a rotating shaft and effectively sealing, contact seals, including lip seals and face seals, consume significant energy. According to industry sources, that rate of power consumption is, on average, 147 watts per seal.

Even though the contact seal's ability to maintain sealing contact and protect the bearing environment may be temporary and of short duration, the costs of shaft repair and seal replacement will continue to accumulate. Catastrophic bearing failure, because of inadequate bearing protection, would add to the associated life cycle costs of the rotating equipment.

NUMBER OF CONTACT SEALS	$/kw **	HRS/YR	COST TO RUN LIP SEALS - WHILE CONTACTING
1,200	0.07569	8766	$117,041

(example: 600 pumps)

TOTAL POWER CONSUMPTION: KW 176.4

** Includes demand charges, state and municipal taxes and utility fees.

Data research by Inpro/Seal® Company

Note: Inpro/Seal bearing isolators do not consume energy.

Figure 2

Figure 3

TABLE 1—THE EFFECT OF WATER ON ROLLING CONTACT FATIGUE LIFE IN LUBRICATING OILS

BASE OIL DESCRIPTION	WATER CONTENT OF WET OIL	FATIGUE LIFE REDUCTION, PERCENT	TEST EQUIPMENT AND HERTZIAN STRESS	AUTHOR(S) (REFERENCE)
Base Mineral Oil Dried	0.002%	48 ✓	Rolling 4-Ball	Grunberg & Scott
Over Sodium	0.014%	54	8.60 GPa	1960
	3.0%	78	(1.25 × 10⁶ psi)	(1)
	6.0%	83		
Squalene	0.01%	32-43	Rolling 4-Ball	Schatzberg & Felsen
0.001% Water			6.34-8.95 GPa	1969
			(0.92-1.30 × 10⁶ psi)	(2)
Dried Mineral Oil	Not stated—moist air environment	80 ✓	Rolling 4-Ball	Ciruna & Szieleit 1972 (3)
Two Formulated Tetraester Oils—0.005% Water	0.05%	29; 73	#204 Bearings 2.48 GPa (0.36 × 10⁶ psi)	Fein 1969 (4)
Emulsifying Hydraulic Fluid Purged with Argon	1% Sea Water	45	Rolling 4-Ball 6.89 GPa (1.00 × 10⁶ psi)	Schatzberg 1971 (5)
Mineral Oil-Based	0.1%	45	Angular Contact Bearing	Felsen, et. al.
Emulsifying Hydraulic Oil—0.02% Water	0.5%	56	2.27 GPa (0.33 × 10⁶ psi)	1972 (6)

Note: Water doesn't have the same viscosity of film strength as lube oil. Even a minute amount that is entrained in the oil will allow metal-to-metal contact within the bearing and start a chain reaction of wear and destruction. 0.002% is approximately one drop in one quart. (Liter)

Sometimes it is nearly impossible to avoid the use of lip seals in industrial equipment. When shafts are flooded with lubricant or the total area for sealing is restricted to one-half inch (12 mm) or less, there is a compelling reason for their use, but care must be taken to cope with their frailty and extremely short life expectancy. Read: "change them out every month or so and thereby avoid leakage in or out of the bearing enclosure."

Advocates of lip seals will theorize that they do not come in contact with the shaft and that they "hydroplane" on a thin film of oil at the sealing point. Another theory is that the lip seal acts as a small pump at the point of contact to maintain lubricant in the bearing enclosure, but also at that point ingests contaminants that are present in the near environment. Both theories may or may not have merit, but in practice shafts are grooved and sealing lips are carbonized by heat.

Lip seals were first introduced for use in the process industries in the 1930s, when they were the only sealing devices conveniently available for general use. Until the present time, they are very inexpensive to purchase and command 99 + % of the industrial rotating equipment sealing market, in sheer numbers. Most process plants have an extensive inventory of lip seals, stacked next to the spare bearings in the stock room. Rotating equipment repair often has a timing function that is necessary for economic operation of the plant and the inventory is deemed necessary.

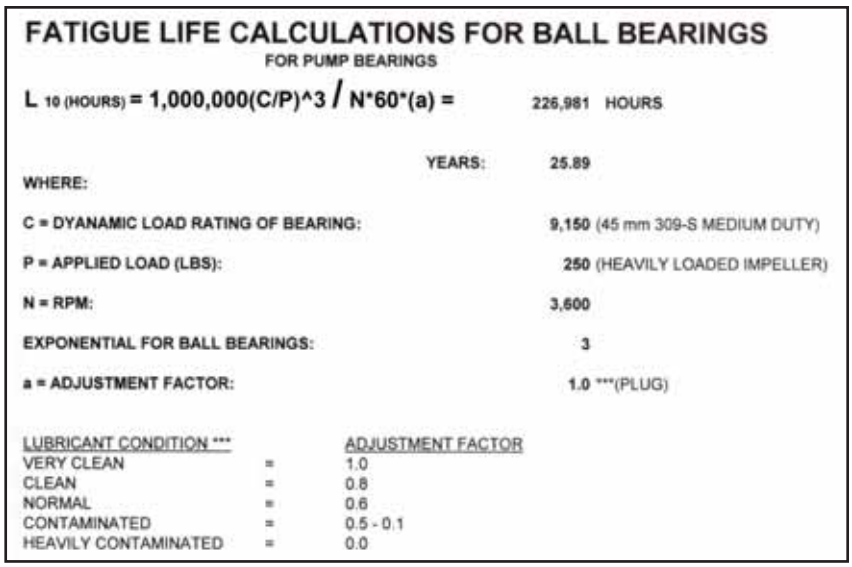
Lip seals have their place in the mechanical universe, but it may not be on industrial rotating equipment. Automobiles have a series of lip seals that are found on the wheel bearings and power train. If they survive for 3,000 hours, you've had a good run. [3,000 hours @ 40 miles (64 km) per hour equals 120,000 miles (193,000 km)] Wash machines, lawn mowers, electric drills, even farm tractors, are adequately served by common rubber lip seals because of their relatively short service life. None of these are continuous duty machines as are pumps, motors and gearboxes in the process industries.

Lip seals are cheap, but not as cheap as they sometimes are perceived to be. The cost of installation is as much as for a bearing isolator. One pump failure after a lip seal burns out will cost as much as dozens of bearing isolators. Lip seals may already be functionally obsolete in the process industries, but hardly anyone realizes it.

It was not until the late 1970s that alternative, permanent, sealing devices for industrial/process rotating equipment were made available with the invention of the Bearing Isolator by what is now the Inpro/Seal Company. Even the term "Bearing Isolator" was invented at Inpro/Seal Company.

Bearing isolators are made to order for the various sizes and shapes of industrial rotating equipment. In order to service the customers as well as the lip seal manufacturers with 25,000 part numbers in their catalogs, bearing isolators must be able to be shipped the same day that they are ordered. Rotating equipment repair, as stated before, usually has a very short-term deadline for completion.

Other contact seals, such as spring or magnetically loaded face seals, have been used for bearing sealing, but with only limited success. Even the highly touted double face magnetic seal is projected to last no more than 18,000 hours and is somehow expected to protect 200,000 hour bearings. All contact seals have a finite life and a 100% failure rate over time. **figure 4**



FATIGUE LIFE CALCULATIONS FOR BALL BEARINGS

FOR PUMP BEARINGS

$L_{10\ (HOURS)} = 1{,}000{,}000(C/P)^3 / N*60*(a) =$ 226,981 HOURS

YEARS: 25.89

WHERE:

C = DYANAMIC LOAD RATING OF BEARING: 9,150 (45 mm 309-S MEDIUM DUTY)

P = APPLIED LOAD (LBS): 250 (HEAVILY LOADED IMPELLER)

N = RPM: 3,600

EXPONENTIAL FOR BALL BEARINGS: 3

a = ADJUSTMENT FACTOR: 1.0 ***(PLUG)

LUBRICANT CONDITION ***		ADJUSTMENT FACTOR
VERY CLEAN	=	1.0
CLEAN	=	0.8
NORMAL	=	0.6
CONTAMINATED	=	0.5 - 0.1
HEAVILY CONTAMINATED	=	0.0

Figure 4

No one will benefit from casual installation of bearing isolators in place of lip seals on a one-at-a-time schedule. In order to maximize results, we must organize a structured program of some magnitude. Two programs that will produce real and quantitative outcomes are:

1) For the first 100 orders in the program, the Inpro/Seal Company will ship product the same day that it is ordered and then pay for the FedEx next day delivery. *(At least 35% of our products are shipped the same day as ordered.)*

2) The Inpro/Seal Company will furnish bearing isolators free of charge and after a period of time, participate in a set percentage of documented savings attributable to the use of said bearing isolators. *(The Inpro/Seal Company has been in the Bearing Isolator business for 28 years and we know how we can benefit our customers.)*

If you have read this far, you may or may not agree with us at Inpro that lip seals are as obsolete as buggy whips and do not have a place in contemporary process industries. The same thing happened to bias-ply tires and carbon steel razor blades. They both faded out when the superior technology of radial tires and stainless blades became available.

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