NEW INNOVATIONS IN POLISHED RODS, POLISHED ROD LINERS AND THEIR IMPACT ON COST AND THE ENVIRONMENT

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Introduction:

Polished rods have been used for more than 100 years and are the main component of sucker rod pumping world wide. Only in the last five (5) years have manufacturers, supply companies, and oil companies put their efforts into preventing premature polished rod failures.

Even though information about polished rods was not very plentiful or available, information about polished rod liners was nonexistent. The history of polished rod liners goes back to at least 1916 where they were offered for sale by Oilwell Supply Co. The liner is designed to separate the stress from the wear on the polished rod.

The polished rod liner has been completely ignored by the whole academic world. The first time a petroleum engineer learns about polished rod liners is when he goes to work in the oilfield.

Almost half of the United States oil-producing areas have never understood the economical benefits of using polished rod liners and, therefore, do not use them. Hopefully, liners will be viewed with new interest when safety and environmental features are added to their money saving benefits.

I. Innovations Old and New:

A major innovation for polished rods and polished rod liners came out of the Korean War in the 1950's. Metalizing flame spray technology was used to improve the service and wear of jet aircraft parts. This technology, commonly called "Hard Facing," resulted in increased run times for polished rods and liners, as well as many other products. These improvements were due to the excellent resistance to both abrasion and corrosion of the hard faced surface.

A. Polished Rods

1. Piston Steel and Alloys

The most used polished rods are made of ASTM 1045 steel, commonly called Piston Steel, with a maximum ultimate tensil strength of 120,000 psi. The second most popular material used for polished rods is ASTM 4140 Chrome Molly with a maximum tensile strength of 160,000 psi. This type rod is mainly used in California, parts of Europe and South America.

Figure 1 shows a comparison of both the chemical and physical properties of ASTM 1045 and 4140. The third most commonly used polished rod is the hard faced rod. This rod is the best for abrasion and corrosion resistance, but must be handled with more care in installation or serious problems can develop.

2. Polished Rod Problems

a. **Most polished rod failures occur at the carrier bar**. Amoco Productions Levelland Unit conducted an extensive study of polished rod breaks in 1993 (Reference 1). The first focus was on the Levelland unit which had 540 wells with an average depth of 4,800 feet. Their records indicated in 1991 they had 46 polished rod breaks and in 1992 had 47 breaks. Of the breaks recorded, 77% had occurred at the carrier bar. This study went on to include the Slaughter, Wasson, Prentice and Levelland units with a combined total of 305 polished rod breaks during 1991 and 1992. The overall average percentage of breaks at the carrier bar was 58%. After many years of investigating polished rod problems, we would estimate the percentage of breaks close to the carrier bar to be 80% or higher.

A study of polished rod failures entitled "How to Minimize Polished Rod Breaks," (Ref. 2) concluded that most rods break at the bottom of the polished rod clamp and that almost all of these breaks are fatigue failures.

b. **The practice of putting a clamp on the hard faced surface must be eliminated**. When using a hard faced polished rod, never clamp on the spray metal either at the carrier bar or while spacing out the well. Either way, the rod has been cracked and that will cause stress concentrations and premature failures. Figure 2a, 2b, and 2c show magnified pictures of polished rod clamp indentations after they were applied to the hard faced polished rod section. The cracks are a result of the hard faced coating being crushed.

Any of these cracks can cause the rod to fail because in just one week, at 10 strokes per minute, the rod will have cycled and flexed more than 100,000 times.

c. **The most common problem in the oil patch is easy to solve**. Most polished rod pins that fail do so because a sucker rod coupling is installed on the pin. Using a polished rod coupling will eliminate the most common problem in the oilfield and save literally thousands of dollars in potential equipment damage.

The polished rod pin has a 9.0 degree taper between the straight thread section and the shoulder. Figure 3 illustrates the difference between polished rod couplings and sucker rod couplings (Reference 3). Three things can happen when sucker rod couplings are installed on polished rod pins: 1. The coupling can split. 2. The polished rod thread can be damaged and weakened where the 9.0 degree taper begins, causing it to break. 3. Nothing bad happens. Figure 4 is a trouble-shooting guide which features the problem, reasons for the problem, and possible solutions.

For the last forty (40) years, polished rods have remained the same until now. Stimulated by the oil companies and oilfield supply stores desire to reduce costs, reduce inventories, and always have polished rods when needed, a simple idea was developed. The Twin Pin Polished Rod features a different A.P.I. thread on each end. This feature, combined with a color code system to help identify inventory at-a-glance, has changed the conventional way of thinking about polished rods. These features save time, labor, confusion, costs and warehouse space. See Figure 5 for standard pin sizes and color code.

B. Polished Rod Liners:

Polished rod liners separate the stress from the wear surface. The polished rod holds the weight of the rod string while the liner takes the wear. There are many reasons to use polished rod liners with polished rods. Some of the advantages of liner use are:

1. Hard faced polished rod liners save stuffing box packing and energy.
   a. The low coefficient of friction determines the amount of wear to stuffing box packing and will reduce the power required to stroke the well.
   b. A polished rod liner is a tube having a larger circumference permitting fluid between the rod and the liner tube. The liner tube dissipates the heat faster allowing the liner to run cooler which helps to extend the life of the stuffing box packing.
   c. A hard faced polished rod liner is surfaced with a nickel chromium alloy which resists the corrosion and abrasion which cause pitting and excessive wear in piston rods.

2. Polished rod liners allow the use of full strength polished rods.
   a. Core hardness on hard faced polished rods can lose up to 40% of their yield strength.
   b. Downtime due to frequent new polished rod replacements can be eliminated.

3. Liners require less hard faced footage than hard faced polished rods because the liner can be moved to accommodate the stroke area. This is an immediate cost savings.

4. The use of polished rod liners saves money and resources.
   a. Liners save steel, rubber, lost production, labor costs as well as reducing environmental clean up.
   b. Liners allow the re-use of old polished rods that have become worn, scored or pitted by corrosion.

5. Liners are easier to warehouse and to handle than polished rods and save shipping costs. Figure 6 presents recommendations for shipping, warehousing, and handling of polished rod liners.

C. Types of Polished Rod Liners:

The most popular coating for polished rod liners is the hard faced material. A Bronze Alloy polished rod liner is also available and is used in areas where electrolysis or certain types of corrosion are encountered. The Bronze liners are flexible and will help compensate for alignment problems. These liners are hard drawn brass which makes them more resistant to abrasion than commercial brass. Figure 7 is a troubleshooting guide for polished rod liners.

D. New Product Extends Life of Polished Rods and Liners:

The new patented Safety Shock Absorber, Lubricator/Wiper has three different assets.

1. Protects the tops of the stuffing box from both impact and from rain and other elements which collect on top or inside of the stuffing box.
2. Lubricates the polished rod or liner with grease either manually or automatically.
3. Wipes off excess oil on the polished rod or liner on the upstroke. The 3 built-in wipers wipe off abrasive material which sticks to the wet surface of the polished rod or liner on the downstroke. (Figure 8) By reducing friction and abrasion, polished rods, liners and packing will last longer.

E. Protect the Environment and Save Money

A new patent has recently been issued for an Environmental Safety Seal Liner. Its purpose is to help prevent excessive damage to the well string and the environment if a polished rod breaks or slips out of the polished rod clamp. Also, it helps prevent an open hole in the event the rod falls through the stuffing box. There is a one time charge because the Safety Seal top is reusable. The oil companies can reduce their risk by using the Environmental Safety Seal Liner.

The only safety device that can stop damage downhole and save fishing costs has to be built into a liner that rides up and down with the polished rod. The Safety Seal Liner saves money on polished rod use, packing, lost production, and environmental clean up costs. Figure 9 shows the Environmental Safety Seal Liner.

This is a win-win situation for the oil companies. The alternative is to keep doing what everyone has always done for the last 80 years.

There are no risk-free solutions in the oil patch. But it is time to start managing certain risks and stop waiting until something breaks before taking action. The idea, "If it ain't broke, don't fix it," is too expensive for today's budget.

POLISHED ROD SPECIFICATIONS

		Piston Steel	Chrome Molly
Raw Material:		C1045 Carbon	A4140
Chemical Analysis:			
CARBON	C	.41 -.49	.41
MANGANESE	Mn	.60 -.87	.80
PHOSPHOROUS	P	.04 MAX	.014
SULFUR	S	.05 MAX	.025
CHROMIUM	Cr	------	.96
SILICON	Si	------	.22
IRON	Fe	-----	-----
BORON	B	-----	-----
COBALT	Co	-----	-----
NICKEL	Ni	-----	-----
COPPER	Cu	-----	.27
NITROGEN	N	-----	-----
MOLYBDENUM	Mo	-----	.20
TENSILE:		90K-120K	120K-150K
YIELD:		85K-110K	90K-120K
ELONGATION:		9-12%	10% - 20%
HARDNESS:		Rc 19-28	Rc 25-33

Figure 1 - Chemical and Physical Properties of 1045 and 4140

Figure 2A

Figure 2B

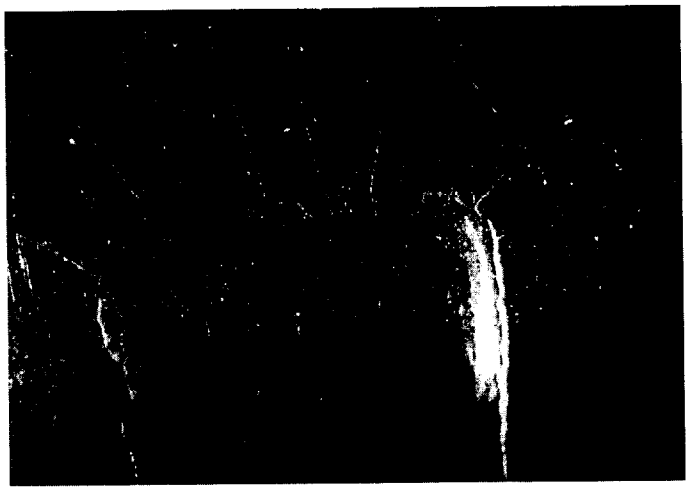
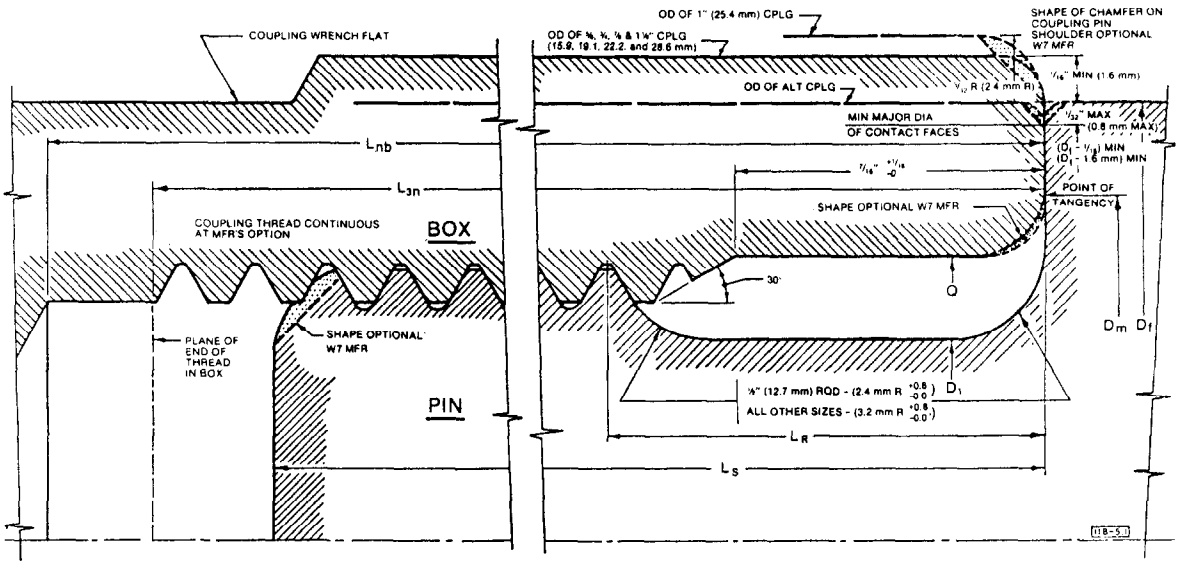


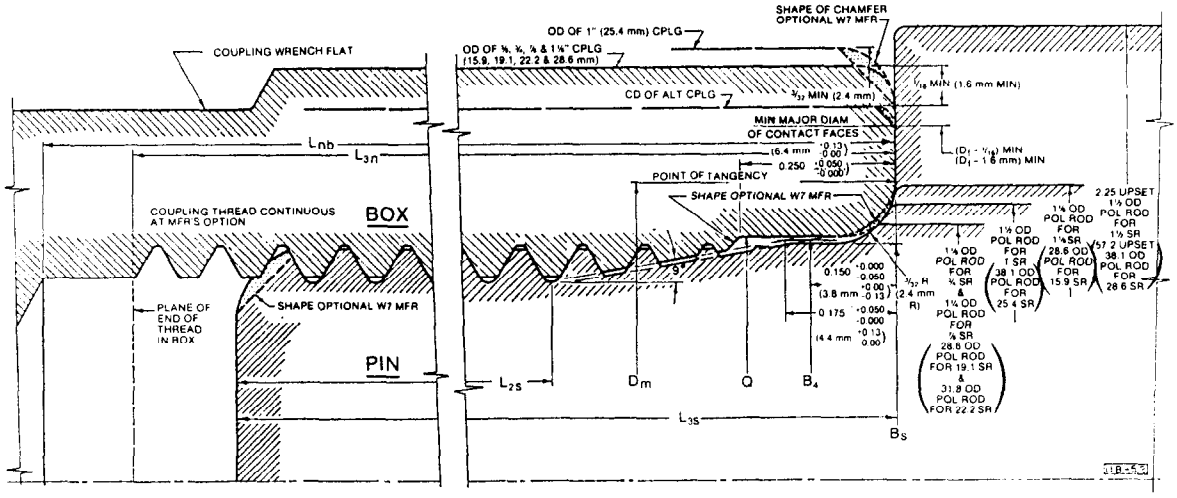
Figure 2C

Magnified Pictures of Polished Rod Clamp
Indentations on Hard Faced Surface



NOTE: *Undercut area with dimension L_R shall be free from surface imperfections which would impair successful rod operation.*

SUCKER ROD CONNECTION



POLISHED ROD CONNECTION

Figure 3 - Drawing of Polished Rod Coupling and Sucker Rod Coupling

TROUBLESHOOTING GUIDE FOR POLISHED RODS

PROBLEM	REASONS	SOLUTIONS
Polished rod pin breaks	Using a sucker rod coupling. A polished rod pin should be connected with a polished rod coupling because a polished rod thread has a 9.0 degree taper.	Install a polished rod coupling.
Polished rod breaks just above or in the stroke area.	Fatigue caused by bending due to misalignment between the pumping unit and the stuffing box.	Align unit and stuffing box by hanging a plumb bob from the carrier bar to the stuffing box.
	A polished rod clamp may have been placed on the hard surface area of the polished rod, which will cause the thin layer of coating to crack resulting in fatigue failure.	Never install the polished rod clamp on the hard surface of a hard faced polished rod.*
	Hard surface area of polished rod may have been damaged when delivered to well location causing the thin layer of coating to crack resulting in fatigue failure.	When transporting polished rods to the well site, the same procedures used in transporting sucker rods should apply.
	Pumping unit may not be level causing unwanted bending or flexing of the polished rod.	Level pumping unit and maintain a level pumping unit foundation.
*Polished rod manufacturers can furnish hard faced polished rods with lengths of uncoated surface at one end for clamping.		
Polished rod breaks between or below clamp or carrier bar.	Fatigue break caused by uneven segments of the polished rod clamp, also bent hinges or bolts could cause unwanted bending or stress.	Replace polished rod clamp. (Make sure to check for uneven segments).
	Carrier bar has worn top surface.	Replace or recondition carrier bar.

Figure 4 - Troubleshooting Guide for Polished Rods

Polished rod breaks between or below clamp or carrier bar.	Carrier bar is out-of-level due to the bridle not being centered over the horses head.	Center bridle over horses head by placing a torpedo level on the carrier bar.
	Pumping unit may not be level causing unwanted bending or flexing of the polished rod.	Level pumping unit and maintain a level pumping unit foundation.
	Clamp was not properly installed on the polished rod.	Clamp bolts should be tightened to the manufacturers recommended torque. Do not over tighten polished rod clamp.
Hard surface flaking off polished rod.	Pinholes started from electrolysis which will undermine hard surface.	Use lubricator with grease to help insulate polished rod.
	Polished rod may be worn out allowing corrosion to attack the base material.	Replace polished rod.
Hard surface worn only on one side of the polished rod.	Hard surface of polished rod rubbing against stuffing box when stroking.	Re-alignment of pumping unit required.
Hard surface of polished rod grooving vertically.	Excessive wear from packing being to tight.	Use lubricator with grease to reduce friction.
	Polished rod stroking against stuffing box.	Re-alignment of pumping unit required.
	Foreign abrasive material imbedded in stuffing box packing.	Remove foreign object or replace stuffing box packing.
Not satisfied with length of polished rod run.	Stuffing box packing too tight, causing friction and excessive wear (abrasive material in fluids).	Use lubricator with grease to reduce friction and pressure on stuffing box packing.
	Blowing dirt, salt or sand sticking to polished rod and the stuffing box.	Use lubricator/wiper to seal stuffing box from environment.

Figure 4 Continued

Not satisfied with length of polished rod run.	Excessive strokes per minute.	Slow down strokes per minute.

Manufacturers recommend that the linear speed of a polished rod should not be more than 1400 inches per minute. The formula to calculate linear speed is:

STROKE LENGTH X STROKES PER MINUTE = LINEAR SPEED

Figure 4 Continued

HASCO® Color Code for A.P.I. Polished Rods		Twin Pin Sizes
1-1/8" Rod	Red Label	.5/8" x 3/4"
1-1/4" Rod	Green Label	.3/4" x 7/8"
1-1/2" Rod	Blue Label	.7/8" x 1"

The Use of HASCO® Polished Rod Liners will eliminate trouble caused by corrosion or abrasion. See pages 3, 4 & 5 for complete information on HASCO® Liners.

HASCO® Color Code for A.P.I. Polished Rods		A.P.I. Pin Sizes
5/8" Sucker Rod	Red	.15/16"
3/4" Sucker Rod	Yellow	.1-1/16"
7/8" Sucker Rod	Orange	.1-3/16"
1" Sucker Rod	Blue	.1-3/8"

Prices for Polished Rods are found on page 6.
Please specify old or TWIN PIN style.

Figure 5 - Twin Pin D-65 and Color Code

POLISHED ROD LINER SHIPPING, WAREHOUSING, AND HANDLING RECOMMENDATIONS

Packaging and Shipping:

The quality of the finished liner should be free of any dents or cracks. They should be encased in cardboard tubes as close to the size of the liner as possible so the cardboard tube will not be damaged in shipping and handling. All liners must be shipped in cardboard or wooden shipping boxes with no more than 8 liners in cardboard containers. This will facilitate handling and reduce the chance of damage caused by overloading boxes and causing fork lifts to be employed or boxes broken.

All dents or damage to shipping containers should be inspected as well as any damage to the liner cardboard tubes. Any physical damage to the outer carton could cause cracking or dents on the surface of Hard Faced liners. This should be done at supply store locations and at the well site.

All liners should be clearly labeled and color coded for identification purposes.

Warehousing and Storage:

All liners should be removed from shipping containers as soon as possible to inspect for freight damage.

Polished rod liners should be stored in a vertical position. This position eliminates the possibility of other materials being placed on top of the liners or other liners being stacked on top of each other.

If the liners must be stored in a horizontal position, care should be taken to support the liner every 3 feet to keep the liner from bending. Each liner should be stamped with the date manufactured for quality control purposes. Liners should be labeled and/or color coded for easy identification.

Handling and Delivery:

The handling of the liner is as important as the manufacturing process. The Hasco-Loy Hard Faced Liner is coated with a nickel chromium alloy which is metalized to the substrate. This process puts a hard coating on a soft steel substrate and at the surface of the steel, the nickel

Figure 6 - Recommendation for Shipping, Warehousing, and Handling of Liners

chromium co-mingles with the steel. This is significant because when the surface of the hard faced liner is dented or cracked, the tube itself is cracked. This is one main difference between a metalized and a plated surface where the coating may be cracked, but not the substrate.

A liner should **not** be removed from the cardboard tube until it is delivered to the well site for installation.

Always support a liner and only use bungee-type cords or straps, or ropes to secure the liner while being transferred to the well site.

1. Never use chains or boom down the liner so as to cause dents or bend the liner which could crack the hard faced coating.
2. Never drop or throw a liner.
3. Never use pipe wrenches or clamps on the liner surface.
4. Never use a hammer to drive the liner over a crooked or bent polished rod. If the liner won't slide over the polished rod without driving it, the polished rod should be sanded or replaced. A crooked polished rod can cause a liner to crack due to the excessive flexing on each stroke.
5. Using a "suitcase" or "knock out" to "jar" the string or pump can cause damage to the liner.
6. Do not over tighten the stuffing box packing. Liners have actually been swaged down due to over tightening, which also causes excessive wear to the packing.
7. Make sure the liner is long enough and positioned correctly so the liner will not pull through the stuffing box on the first stroke. This could bend and/or crack the liner.
8. Make sure the blow-out preventor is not over tightened, causing the liner to be crushed.

Unlike the polished rod, which has all the stress, the liner has nothing but the stuffing box packing and its resistance. There is no weight pulling on the polished rod liner. The stress and wear have been separated. Therefore, when a liner breaks or cracks, we can assume either a shipping, handling, flexing or mechanical problem has been the cause.

Figure 6 Continued

TROUBLESHOOTING FOR POLISHED ROD LINER

PROBLEMS	REASONS	SOLUTIONS
Hard surface flaking off liner	Pinholes started from electrolysis which will undermine hard surface.	Use lubricator with grease to help insulate liner.
		Use Bronze Alloy Liner.
	Wrench or clamp used on liner, causing cracking or flaking.	Always use clamp above liner on polished rod (use knock-off block or suitcase if necessary.)
		Always use wrench flats on liner head, never grip on liner surface.
	Liner may be worn out allowing corrosion to attack steel tube.	Replace liner.
Hard surface worn on one side of liner only.	Metal surface of stuffing box rubbing against liner when stroking.	Re-alignment of pumping unit required.
Liner surface breaking horizontally.	Liner flexing in area where break occurs.	Re-alignment of pumping unit required.
	Liner installed over crooked polished rod causing excessive bending.	Replace polished rod.
	Blow out preventer too tight causing fractures on surface.	Do not over tighten blow- out preventer.
Liner surface breaking vertically or grooving.	Excessive wear from packing being too tight.	Use lubricator with grease to reduce friction.
	Liner stroking against stuffing box.	Re-alignment of pumping unit required.
Liner surface breaking vertically or grooving.	Liner installed over burrs on polished rod caused by set screws.	Check for burrs before replacing liner. (File off or replace polish rod.)

Figure 7 - Troubleshooting Guide for Polished Rod Liners

Liner surface breaking vertically or grooving.	Foreign abrasive material in stuffing box packing.	Remove foreign object or replace packing.
Liner accidentally stroking through stuffing box.	Liner is too short.	Longer liner needed.
	Set screws loosened, allowing liner to slide up the polish rod.	Place liner back in stroke area and tighten set screws.
Not satisfied with length of liner run.	Stuffing box packing too tight, causing friction and excessive wear (abrasive material in fluids).	Use lubricator with grease to reduce friction.
	Blowing dirt, salt or sand sticking to liner and in the stuffing box.	Use lubricator with grease to protect liner surface.
	Excessive strokes per minute.	Slow down strokes per minute.
Liner head leaking oil.	Liner head packing too loose.	Tighten top on liner head to compress packing.
	Liner head packing worn out.	Replace packing in liner head.
Liner head damaged or cracked head.	Damaged from hammering on top, causing fatigue to the weld.	Replace liner.
	Liner positioned too close to stuffing box and damaged on impact.	Position liner using painted guide lines or at least 9" above stuffing box on bottom of stroke.

Figure 7 Continued

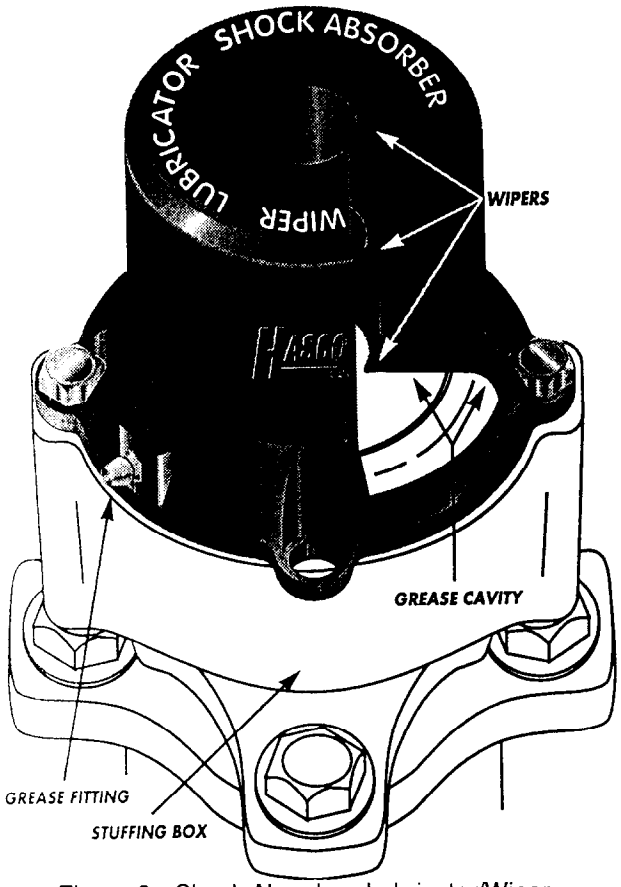


Figure 8 - Shock Absorber, Lubricator/Wiper

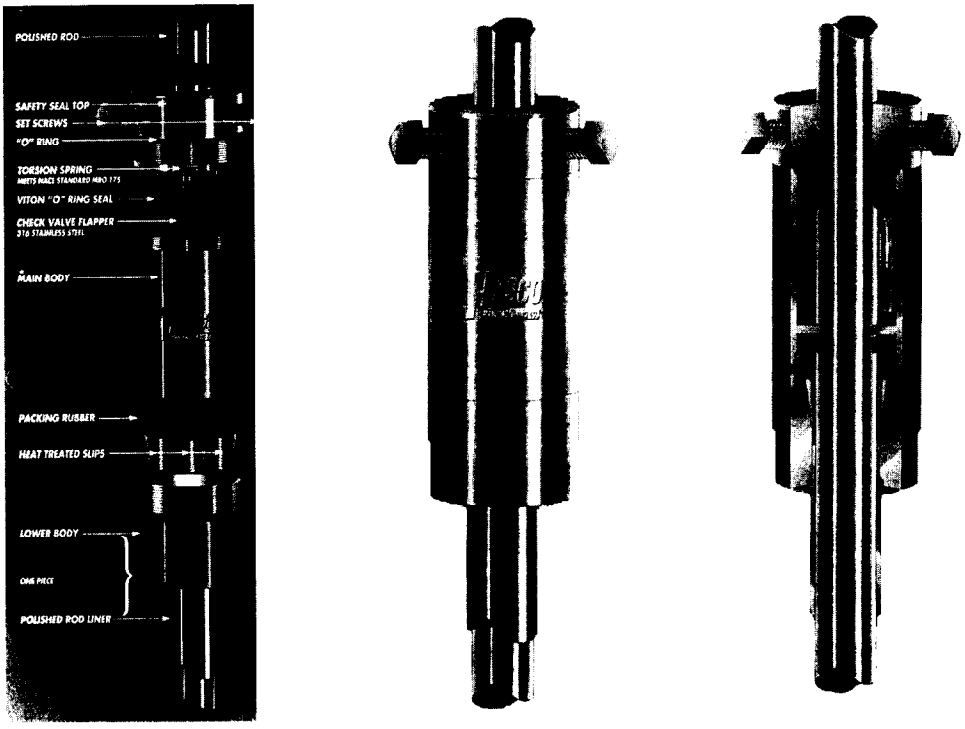


Figure 9 - Environmental Safety Seal Liner