MISSION™ PRODUCTS
Fluid End Expendables

Application and Troubleshooting Guide

Fluid End Expendables Application and Troubleshooting Guide

NATIONAL OILWELL VARCO

One Company | Unlimited Solutions

About the Author:

Jerry Johnson was introduced to the oilfield in 1979 when he went to work at TRW Mission in Houston, Texas. For the next ten years he was involved in the designing and field testing of expendable parts for positive displacement pumps. He then spent another ten years with a major oilfield firm designing oilfield products and field testing prototype equipment. Jerry is now employed at National Oilwell Varco in the Mission Products Group. In the 25 years Jerry has been in the oilfield, he has always focused on product design, product application, supporting the sales department and customer to better understand the products and their uses.

National Oilwell Varco appreciates the dedication and the passion Jerry has exhibited to put together this document. He provides valuable information allowing the reader to match the proper products to the varying application needs of today's demanding drilling industry. We wish to express our gratitude for the excellent results contained within.

Although some of the material outlined in this guide is basic information, it is hoped that some elements offer some insight into the products, the product application and, where applicable, the product limitations. This guide also attempts to alert the customer to product failure mechanisms and to identify problems so expenses and downtime are reduced. As new products and drilling conditions arise, this guide may be expanded to include those items and any problems that might develop in those conditions.

If there are questions particular to your situation not covered in this guide, please contact your local Mission Sales Representative for assistance.

CONTENTS

INTRODUCTION

This reference information is to aid the end user of triplex pumps so that problems can be identified and corrected. This should allow the end user to reduce pump downtime, increase pump parts life and decrease overall operating costs related to the products discussed. This should be applicable to all triplex single acting pumps used in drilling, well service, mining, slurry and other types of fluid transfer.

The products to be covered:

- Liners (all types)
- Pistons (all types)
- Valves and Seats (all types)
- Backflush Systems
- Liner Retention Systems
- Gaskets (all types)
- Modules (in brief)
- Piston Rods (all types)
- Piston Rod Clamps

In addition to the products discussed, attention will be paid to the more common types of failure mechanisms and the corrective actions to remedy the situation. This will include conditions of higher pressures, temperatures, solids, corrosion and different types of fluid mediums.

LINERS

General Liner Information

Liners should never be struck directly with hammers. If one must hammer to get a liner in, place a piece of wood between the liner and hammer to absorb some shock and eliminate dents in the liner. Dents in the shell material can cause the sleeve or chrome plating to crack.

Always remove any rust preventative in a sleeved liner. The rust preventative chemistry may be harmful to the piston material. Grease the liner and piston prior to assembly. Make sure the liner gasket is lightly greased and properly installed.

While connecting the liner to the pump, tighten the liner clamp or collar to specification. After a certain amount of time, the liner will seat. This may affect the collar or clamp tightness. To avoid extrusion of the gasket and possible washout of the fluid end, retighten the collar or clamp to specification the next time the pump is down. On bolted collar type connections, the fasteners at the bottom of the collar are difficult to get to. Washouts of both the liner and fluid end can sometimes be attributed to improper torque of the bottom fasteners in these cases. Use of proper tools is critical to allow even torquing of all fasteners.

Ceramic Liners

Ceramic liners are currently the premium liner offered today. Ceramic liners have been known to operate well over the 7,000 hour mark. Due to the high hardness of the ceramic surface, they wear substantially less than other liner types. This translates into longer piston operating times. If the correct conditions are present, the cost per operating hour can be much less than that of the other liner types.

The main mode of premature failure of the ceramic liner is caused by the disruption of the ceramic surface in the piston stroke area. This is normally caused by the piston's metal body coming in hard sliding contact with the ceramic surface. This hard sliding contact may be the result of a misaligned pump or a piston left in operation too long after failure begins. The amount of damage done to the surface in a given amount of time would depend on the degree of misalignment or, in the case of the piston failure, the operating pressure, strokes and fluid temperature.

The disruption of the surface is caused by the microscopic fracture of the ceramic material. These fractures are similar to glass fractures and are very abrasive on the mating component (in this case, the piston). The fractured material is also very hard and will remain in place unless the liner is repaired by re-honing the bore, thereby renewing the liner. A liner that has a damaged bore can usually be identified by a discoloration of a section of the bore and the texture of the bore will not be as smooth as the opposing side.

Corrosion, solids content, temperature of the fluid and fluid chemistry have relatively little effect on the ceramic liner. When installing the ceramic liner, care should be taken not to strike the liner with hammers. When installing the piston and rod assembly, care should be taken so that the hanging weight does not cause the piston flange to damage the liner bore. Sometimes, on initial assembly, the ceramic liner bore will be broken in by causing the first piston to wear at a faster rate. After the first piston, the liner is broken in and the piston and liner should provide the end user with a very satisfactory life expectancy.

Photographs of scoring in liner bore disrupting ceramic surface.

Supreme High Chrome Iron Sleeved Liner
The Supreme liner is a premium liner with a sleeve of hardened high chrome iron material installed in an alloy or carbon steel shell. This liner has been a premium liner for many years.

High chrome iron sleeved liners, while resistant to wear, do not have the hardness of the ceramic liner. Some drilled solids, such as quartz, have a higher hardness than the high chrome iron material.

One mode of premature failure is what is referred to as liner streaking. This is caused from the presence of hard drilled solids entrapped between the piston and liner bore. As the piston reciprocates in the liner bore, these solids slowly wear longitudinal grooves in the liner bore. If left unchecked, these grooves will develop to a point where the liner is washcut and destroy the liner.

To retard groove growth and to prolong the liner life, it is recommended that every time the pump is stopped (or once a day) the operator should turn the piston / rod assembly approximately ¼ turn. This will disrupt the current wear pattern and start a new one. In this fashion the groove will never achieve the depth to cause a washcut. Solids content of the fluid has a direct relationship to the high chrome iron liner wear rate and its useful life.

While misalignment and piston failures do contribute to higher wear rates in the high chrome iron sleeved liners, these conditions do not disrupt the surface of the bore as dramatically as the ceramic liner. The wear rate will be higher than the ceramic, but the surface will not be as damaging to the piston. For this reason, the high chrome iron liners do not have to be renewed.

Corrosion, temperature and fluid chemistry normally have little effect on the life of the high chrome iron liner. The high chrome content resists corrosion pitting in most applications where the liners are currently being utilized. Gradual temperature changes have no effect and today's fluid chemical compositions have no measurable effect in the drilling or mining industry. Care should be taken when installing a high chrome iron sleeved liner that the liner is not hammered in any way during installation.

Liner operated with short rod.

Liner operated in acidic or caustic fluid.

Chrome Plated Liners

In some smaller size liners and some liners approaching maximum bore for the pump, liners manufactured with a chrome-plated bore are offered. These liners offer some resistance to abrasion and limited resistance to corrosion.

Hard sliding contact such as pump misalignment and a prolonged piston failure can strip the chrome plating from the base substrate causing flaking of the chrome material. Once flaking of the chrome starts, this will continue until failure. This flaking chrome is very abrasive and piston life will be shortened.

Chrome plating is inherently porous. Corrosive conditions will undermine the plating and rust the substrate, loosening the chrome plate. It is recommended that, when not in use, the chrome plated bore be kept greased to limit the amount of air and moisture that can come in contact with it.

Although chrome plated liners are much better than induction hardened liners in operation, care must be used when operating these liners. Over 90% of the claims sought on chrome plated liners are the result of corrosion or pump misalignment, or due to piston flange drag or failure. Rarely is it defective chrome plating. To avoid damaging the liner, use no hammers on assembly and ensure the hanging weight of the piston / rod assembly does not put stress on the bore.

Induction Hardened Liners
Induction hardened liners are resistant to abrasion but not generally recommended for triplex pump service. These liners have no designed resistance to corrosion. Since triplex pump liners are open to the atmosphere, corrosive conditions exist in all environments in which the liner will be operating. Once the corrosion pitting develops, piston life will diminish at a rapid rate.

Liner Storage Procedures
Liners are packaged and coated with paint and rust preventative for short-term covered warehouse storage. Liners exposed to the outside elements and temperature extremes may deteriorate over time. Liners should be kept in the original unopened container away from ground moisture and elevated above concrete floors. Care should also be taken to eliminate conditions that promote condensation in the original container. Keep the liners away from direct sources of moisture. Some liners are packaged with liner gaskets manufactured with elastomeric compounds. Liners with liner gaskets should be stored away from high heat areas. After gaskets are molded, the gasket starts to age at a linear rate. Heat will increase the rate of aging, cooler temperatures will maintain or reduce the rate of aging. The cooler the temperature at which these gaskets can be stored, the longer the gaskets' useful life. The gaskets should also be stored away from direct sunlight (ultraviolet radiation), aromatic solvents, moisture and electric motors (ozone production).

At times, used liners are stored short term for later use. The proper storage preparations for storage of used liners should include the cleaning of all surfaces of contaminant matter and inspecting for damaged areas that could be detrimental to the function of the product. If no damaged areas are found, the liner should be coated with clean heavy grease over all surfaces to reduce the possibility of corrosion. Corrosion in the bore will abrade the piston, corrosion in the gasket area will reduce gasket life and corrosion on the outside of the liner may swell the surface causing installation difficulties.

PISTONS

General Piston Information
Pistons come in many styles and compositions. Normally a piston of a certain type is designed for a specific purpose. Outside the designed purpose, this piston may not be suitable or economical for use. The brief descriptions below outline some of the designed criteria and limitations of standard piston types.

For the optimum performance of a piston, the pump must be properly supercharged, the pump should not have any misalignment issues, the liner should be in good operational order and the backflush system should be properly designed and in good working order. Fluid temperature, solids content, fluid chemistry, operating pressure and pump speed also have a major impact on piston life, but are not normally as controlled as the other criteria.

The pump supercharger should be designed to operate properly. It is essential that the pump be continuously flooded and at the correct pressure. If the pump is not properly supercharged, the piston can suck air from behind the piston lip and create a water hammer that causes excessive vibration and destroys the piston. A pump that is only marginally supercharged may not have the pressure to energize the piston on the backstroke. An energized piston on the backstroke helps centralize the piston in the liner and eliminates some flange drag on the liner.

The proper supercharging pressure is 80 feet of head at the positive displacement pump. The proper flow of the supercharger would be 1-1/2 times the maximum rated output for the positive displacement pump up to 170 strokes per minute. Over 170 strokes per minute, sizing should be increased to 1-3/4 times the maximum flow of the positive displacement pump. The supercharger should be designed with its own driver to operate at a constant speed regardless of the positive displacement pump speed. Supercharger pumps that are belt driven from the jackshaft of the positive displacement pump do not provide the required pressure at low speeds to fill the cylinders and energize the pistons. This can damage the positive displacement pumps power end and reduce piston life.

Pump alignment is a critical issue and will be a major factor in piston and liner life. The degree of misalignment is directly related to the reduction in life of fluid-end expendables. Misalignment is also a direct source of additional frictional heat build-up in the piston and can elevate the temperature at the surface of the piston to very high levels. These levels can easily exceed the maximum rated temperature ratings for the piston.

On urethane pistons, it can cause the compound to melt and disintegrate. Urethane pistons will have the visual characteristics of a melted candle. Material will be missing and the surrounding areas of the missing material will be very smooth and sometimes discolored.

On black rubber pistons, it can cause the compound to burn on the surface. Once a black rubber piston has reached these elevated temperatures, the rubber will take on a smell of burnt rubber that will remain with that piston.

Self-aligning rods are produced to eliminate some misalignment. These can help if the misalignment is mild to moderate but not if the misalignment is severe. In these cases, the pump should be repaired to OEM specifications to reduce expendable costs.

The pump backflush system is also another very important factor in piston life. The backflush fluid cools the piston; aids in lubrication and flushes particulate matter from the liner bore. For urethane pistons, the recommended minimum flow to each piston is 14 gallons a minute uninterrupted. For black rubber pistons the minimum flow to each piston is 10 gallons a minute uninterrupted.

The backflush nozzle should be attached and positioned so that the entire liner bore is covered as the piston strokes down the liner. This ensures that all areas of the liner bore the piston travels in are cooled, lubricated and flushed. Areas that are not covered will cause high heating of the piston compound. The compound failures will be similar to those outlined in the misaligned pump section above. The cooler and more lubricated the piston is, the longer the piston will operate. Backflush water temperature can also be a factor in piston performance. The cooler the backflush water is, the better the piston performance. To reduce some frictional heat and improve lubricity, some contractors add water-soluble oil to the backflush water mixture. The oil should be water soluble, non-detergent and should be environmentally friendly to the location.

Identifying Urethane Piston Failures

Pistons manufactured using urethane compounds typically fail from one of four different conditions and each can be identified fairly easily. The four conditions are: heat, extrusion, abrasion and chemical attack. Failure can also occur due to multiple conditions.

HEAT: Urethane pistons that fail due to heat have a loss of material and acquire a surface similar to a melted candle. This condition can be a result of high fluid temperature, inadequate backflush supply or frictional heat due to other forces. As the temperature increases, the mechanical properties of the urethane decrease. Standard (not high temperature compounds) urethane pistons have a maximum temperature of approximately 180° F (82° C). This maximum temperature is the sum of the temperature of the fluid being pumped plus the frictional heat generated by the reciprocating piston.

EXTRUSION: Urethane pistons that fail due to extrusion look torn and are very rough in appearance. They also have a loss of material emanating from the piston flange upward. Edges of the urethane surface will be sharp and rough to the touch. Premature piston failure due to extrusion usually indicates that the liner bore to piston flange gap was too great for the pressure operated.

ABRASION: Urethane pistons that fail due to abrasion have loss of material and the surface will be rough but not torn. Longitudinal streaks will normally be observed on these pistons where solids have been entrapped between the urethane compound and the liner and operated for some time.

CHEMICAL ATTACK: Urethane pistons that fail due to chemical attack are not as easily identified visually. The urethane compound will soften and sometimes swell. Normally this type of failure will have a heavy chemical smell of solvents or hydrocarbon compounds when first examined out of the pump. The attacking compounds may dissipate shortly after removal and lose this chemical smell shortly thereafter. A few mud bases and mud additives have chemistries that, when first added to the mud, tend to degrade the elastomers. Most of these bases and additives are less volatile over time and as the fluids circulate tend to become diluted to the point that they do not continue to degrade the elastomers. If new bases or additives are added that have not been utilized before it may not be the fault of the elastomers if some fail earlier than normally expected.

MULTI-CONDITION: Some failures are caused by more than one condition. Under heat failure conditions, the urethane will eventually be lost to a point where the piston will have what seems to be a blowout. The blowout will take on characteristics of extrusion by the rough edges surrounding the failure. Under extrusion conditions, fluid that fills up the void in the extruded area can hydraulically push the piston to the side opposite of the void in the pressure stroke to cause excessive heating of the urethane at that location. Normally, one can discern between the primary cause and secondary result of the failure.

Green Duo Heat Damage

Green Duo Extrusion Damage

White Lightning Heat Damage

White Lightning in High Solids

Blue Lightning Heat Damage

Green Duo in High Solids

Competitor's Piston Age Hardened

Identifying Black Rubber Piston Failures
Black rubber pistons normally fail from one or more of the following conditions: heat, extrusion, abrasion, chemical attack, ID/OD washout or putting rubbers on piston bodies too worn out for the operating pressure. The failures on the black rubber piston are not as easily identified visually as those of the urethane type but can be determined by the following and other identifying characteristics.

HEAT: Once the rubber has exceeded a certain temperature, the rubber will take on a smell of burnt rubber. This smell will not go away. Sometimes the outer surface will become charred and hard to the touch. Carbon black may rub off the piston if it has seen very high temperatures. The high temperatures can be a result of the same mechanisms as the urethane piston. As the operating temperature increases, the mechanical properties of the rubber decrease. For black rubber pistons the maximum operating temperature is 225° F (107° C). This maximum temperature is the sum of the fluid medium being pumped plus the frictional heat generated from reciprocating motion.

EXTRUSION: Under extrusion conditions and also while putting rubbers on worn out piston bodies, if the liner is too worn or the rubber is installed on a too worn piston body, the piston rubber fabric will extrude into the gap between the body and liner and be severed. With every stroke more material will extrude into this gap and be severed, leaving a void at the piston rubber / piston body interface. This will continue until the fabric no longer supports the rubber face and the piston lip fails. Visual characteristics include fabric loss, loss of lip material and a rough surface in the rubber lip. In pressures above 2,500 psi, it is not recommended that the customer change piston rubbers on used piston bodies. Beyond this pressure it is not economical to do so because of the reduction in piston rubber life, increased downtime and increased liner wear.

The Supreme piston bodies have grooves machined into the piston flange to gage wear. The deep groove is for operating pressures of 0 to 1,500 psi, the shallow groove is for pressures between 1,500 psi and 2,500 psi. If operation is between one of these two pressure ranges, the appropriate wear groove can be used to gage if the piston body can be redressed with another piston rubber kit to renew the piston. If the wear on any part of the piston flange is deeper than the associated wear groove for the operating pressure, the piston body is considered worn out and should not be redressed with another rubber kit.

ABRASION: Under abrasive conditions, the black rubber piston will show a loss of material and the loss should be uniform in appearance. The rubber may also have longitudinal streaks in the rubber and fabric where solids have been entrapped and reciprocating under pressure in the liner.

CHEMICAL ATTACK: Under chemical attack conditions, the rubber will decrease in hardness and may swell in size depending on the chemical present. The swelling may get to the point where the top of the rubber is cut by the piston end plate. Normally, the piston will smell of solvent base or strong hydrocarbon content. This smell may not last long due to the fact some volatiles evaporate in air.

ID/OD WASHOUT: One type of chemical attack involves oil based muds and the aniline point of the base oil. The relative aromatic content of oil is indicated by its aniline point, which is the temperature in degrees Fahrenheit that oil and a chemical called aniline will mix with each other. Oils having a high aromatic content have a low aniline point. Oils having a low aromatic content have a high aniline point. Consequently the high aniline point diesel oils are the most desirable for use in drilling mud as they will cause less difficulty with the elastomers on the rig. Oils having an aniline point of 170° F or above should not cause any difficulty with the elastomers on the rig. Oils having an aniline point of 150° F to 170° F should not cause any great amount of trouble. Oils with aniline points below 150° may cause some problems with elastomers on the rig. The aniline point of oil may not be able to be checked once mixed with the drilling mud, but the supplier of the diesel oil should be able to supply this data prior to purchase. It is often recorded when initially processed.

The condition of ID/OD washout is hard to determine visually without disassembly of the piston. This condition, although rare, happens when the seal between the rubber ID and the piston hub OD fails. If there are no visible signs of failure on the outside of the piston, this may be the cause of failure. The cause of the ID/OD wash is normally from installing a piston in a liner too worn for the operating pressure. The rubber tries to deform to the liner ID and in doing so, sometime causes a seal failure in the ID of the rubber.

Rubber Operated on Worn Body

Rubber Extrusion Damage

Heat Damaged Piston

Wear from Abrasion

Photographs of a Piston Rubber Operated on a Worn Out Piston Body

Flex Lip in a Worn Out Liner

Flex Lip Heat Damage

Blue Lightning Pistons

The Blue Lightning piston was designed and developed primarily for use in ceramic liners for pressures up to 7,500 psi but can also be used in high chrome iron sleeved liners with great success at all pressures. The benefits of the Blue Lightning include the ability to grow to the size of the liner bore in operation and prevent extrusion of the urethane face stock. The specially formulated urethane compound is highly resistant to abrasion, extrusion and tear. The back-up ring on this piston also centralizes the piston in the liner, reduces friction and prevents the transfer of metal to the liner bore when the piston is about to fail or if minor misalignment is present. This increases the ceramic liner life and reduces scoring of the surface. The specially formulated urethane compound is also resistant to the higher temperatures sometimes used in the industry and can normally operate up to 220º F (104º C). The Blue Lightning piston is recommended for systems with oil based mud and synthetic based mud. It is also recommended for water-based muds when weights are 11 lb/gal or over. The Blue Lightning piston is not recommended for clear water or seawater pumping due to the lack of lubricity of these fluids. As in all urethane pistons, the backflush requirement is recommended at 14 gal/min or greater for each piston.

White Lightning Pistons

The White Lightning piston was developed to be a replaceable style urethane piston. This piston has the abrasion and tear resistance of urethanes with the ability to change inserts if the operating pressures are below the 2,500 psi threshold. The White Lightning is formulated and processed in such a manner to also resist some fluid chemistries that may affect other urethane compounds. This piston can operate in up to 200º F (93º C) service and is rated for 6,000 psi. The White Lightning piston is recommended for systems with oil based mud and synthetic based mud. It is also recommended for water-based muds when weights are 11 lb/gal or over. The White Lightning piston is not recommended for clear water or seawater pumping due to the lack of lubricity of these fluids. As in all urethane pistons, the backflush requirement is recommended at 14 gal/min or greater for each piston.

Green Duo Pistons
The Green Duo piston is a bonded dual durometer piston that is highly resistant to abrasion and tear. The bonded construction resists extrusion under pressure and restricts movement to reduce the build-up of heat. The Green Duo can operate in up to 180º F (82º C) service and has operated at up to 6,300 psi. The Green Duo piston is recommended for systems with oil based mud and synthetic based mud. It is also recommended for water-based muds when weights are 11 lb/gal or over. The Green Duo piston is not recommended for clear water or seawater pumping due to the lack of lubricity of these fluids. As in all urethane pistons, the backflush requirement is recommended at 14 gal/min or greater for each piston.

Supreme Pistons
Supreme pistons are manufactured from an oil resistant Nitrile compound with a cotton fabric back. The face compound is resistant to most chemical compositions that are currently being utilized. The Supreme piston is manufactured for use in both triplex single acting and duplex double acting pumps. The rubber inserts on the Supreme can be changed using a rubber kit, but this is not recommended if operating pressures are over 2,500 psi. Over the 2,500 psi threshold, it becomes cost prohibitive to change inserts due to the increased extrusion of the piston and typical premature failure. The Supreme piston can operate in temperatures up to 225º F (107º C) and can operate in pressures up to 7,500 psi depending on piston size. The Supreme piston is recommended for systems with oil based mud and synthetic based mud. It is also recommended for water-based muds when weights are 11 lb/gal or over. The Supreme piston can be used with clear water and seawater systems with some success. The backflush requirement for the Supreme piston is 10 gal/min or greater for each piston. The Supreme piston bodies have grooves machined into the piston flange to gage wear. The deep groove is for operating pressures of 0 to 1,500 psi, the shallow groove is for pressures between 1,500 psi and 2,500 psi. If operation is between one of these two pressure ranges, the appropriate wear groove can be used to gage if the piston body can be redressed with another piston rubber kit to renew the piston. If the wear on any part of the piston flange is deeper than the associated wear groove for the operating pressure, the piston body is considered worn out and should not be redressed with another rubber kit.

Regular (Natural Rubber) Pistons

The Regular pistons are manufactured from natural rubber that is highly resistant to abrasion and tear. The piston rubbers are mounted on the same bodies as the Supreme piston to allow piston rubber changes at pressures less than 2,500 psi. The Regular rubber can operate in temperatures up to 180º F (82º C) and can operate at pressures up to 5,000 psi. The Regular rubber is recommended for clear water and seawater service. It can also be utilized for water based mud service especially if the mud weight is below 11 lbs/gal. The Regular rubber should not be used in oil or synthetic based mud systems. The Regular rubber is not as resistant to chemical attack as the other pistons and should not be utilized in chemical base operations. The backflush requirement for the Regular rubber is 10 gal/min or greater for each piston.

Flex Lip Pistons

The Flex Lip piston is a bonded style piston with a Nitrile face stock. This piston is oil resistant and is compatible with most drilling fluids currently in use. The Flex Lip piston can operate in temperatures up to 210º F (99º C) and can operate up to 4,500 psi. It is manufactured for use in both triplex single acting and duplex double acting pumps. It is also recommended for water-based muds when weights are 11 lb/gal or over. The Flex Lip piston can be used with clear water and seawater systems with some success. The backflush requirement for the Flex Lip piston is 10 gal/min or greater for each piston. The Flex Lip is not recommended for systems with a high concentration of solids.

Excellent	Blue
Very Good	Green
Good	Yellow
Poor/NR	Red

FEATURES:	Blue Lightning	White Lightning	Green Duo	Supreme	Regular	Flex Lip
Abrasion Resistance	Excellent	Excellent	Excellent	Very Good	Excellent	Very Good
Tear Resistance	Excellent	Excellent	Excellent	Very Good	Excellent	Very Good
Resistance to Oil	Very Good	Very Good	Very Good	Very Good	Poor/NR	Very Good
Chemical Resistance	Very Good	Very Good	Very Good	Very Good	Poor/NR	Very Good
Resistance to Synthetic Oil	Very Good	Very Good	Very Good	Very Good	Poor/NR	Very Good
Temperature Resistance	Excellent	Very Good	Good	Excellent	Good	Very Good
Extrusion Resistance	Excellent	Good	Very Good	Good	Good	Good
Use in Oil Base Muds	Excellent	Excellent	Excellent	Very Good	Poor/NR	Very Good
Use in Synthetic Base Muds	Excellent	Excellent	Very Good	Good	Poor/NR	Good
Use in Water Based Mud >#10	Good	Good	Good	Very Good	Excellent	Very Good
Use in Water Based Mud <#10	Poor/NR	Poor/NR	Poor/NR	Very Good	Excellent	Very Good
Use in Water Based Mud >#11	Good	Good	Good	Very Good	Excellent	Very Good
Use in Water Based Mud <#11	Poor/NR	Poor/NR	Poor/NR	Very Good	Excellent	Very Good
Use in Clear Water	Poor/NR	Poor/NR	Poor/NR	Good	Excellent	Good
Use in Salt Water	Poor/NR	Poor/NR	Poor/NR	Good	Excellent	Good
Use in Low Solids	Excellent	Excellent	Excellent	Very Good	Very Good	Very Good
Use in Moderate Solids	Excellent	Very Good	Very Good	Very Good	Very Good	Very Good
Use in High Solids	Very Good	Good	Good	Good	Good	Poor/NR
Linear Wear Characteristics	Excellent	Excellent	Excellent	Good	Good	Very Good
Use with Ceramic Liners	Excellent	Very Good	Very Good	Very Good	Very Good	Good
Maximum Temperature (Flow Line) (°F)	220	200	180	225	180	210

Table: Piston Application

Piston Storage Procedures

Pistons and piston rubber kits are packaged and coated with rust preventative for short term covered warehouse storage. Pistons and rubber kits exposed to the outside elements and temperature extremes may deteriorate over time. Pistons and rubber kits should be kept in the original unopened boxes away from ground moisture and elevated from concrete floors. Care should be also taken to eliminate conditions that promote condensation in the original box and to keep the box away from direct sources of moisture. Pistons and piston rubber kits are packaged with sealing elements manufactured with elastomeric compounds. Pistons and rubber kits should be stored away from high heat areas. After the piston's seal element is molded, the sealing element starts to age at a linear rate. Heat will increase the rate of aging, cooler temperatures will maintain or reduce the rate of aging. The cooler these pistons and rubber kits can be stored, the longer the sealing element's useful life. The pistons and rubber kits should also be stored away from direct sunlight (ultraviolet radiation), aromatic solvents, moisture and electric motors (ozone production).

When stored properly, as described above, the shelf life of black rubber products (Nitrile, Neoprene, etc.) is five years after the date of manufacture. If stored improperly or in conditions with higher heat this shelf life is reduced accordingly. When stored properly, polyurethane products have a shelf life of four years from the date of manufacture. If stored improperly or in conditions of high heat the shelf life is reduced accordingly. Black rubber and polyurethane products should not be used if the actual age exceeds the shelf life. If they have not been stored properly and if they appear milky or cloudy in color or substantially harder than fresher examples, they should not be used.

VALVES AND SEATS

General Valve and Seat Information
Valves and seats come in many different styles and are designed for many different applications. What is referred to as the drilling valve can be used in drilling, mining, fluid transfer and slurry applications. The drilling valve also comes in a variety of configurations such as full open unitized body, full open plate type assembly, and cross-arm style high, medium and low pressure type bodies. Each drilling valve is designed for a particular application but can sometimes be used with great success in other applications. Another valve referred to as a well service valve can also be utilized in mining and fluid transfer. The well service valve is normally of full open design and is either a unitized body or plate style assembly.

Some of the drilling and well service valves offer different seal or insert materials for different applications. Some go beyond the traditional polyurethane and Nitrile and offer inserts for acidizing, elevated temperatures and chemical pumping. Normally, for medium to high-pressure applications, the polyurethane insert is the most recommended insert. The polyurethane is specially formulated for maximum resistance to extrusion, abrasion, particle embedment and tear. For low pressure or applications where excessive heat is a problem, the Nitrile (308 compound) is normally recommended.

As a valve and its associated seat wear, they become a mated component. The valve and seat wear together to maintain a seal and prevent insert extrusion. If a valve is rotated or removed for inspection and re-installed, the valve and seat are no longer mated and must operate a length of time before they are mated again. During this time period the insert may extrude and the metal components may wear at an accelerated rate. If, when a valve and seat are installed, the end user uses a paintstick to put a mark through the valve and seat for orientation purposes, the valve can be inspected and re-installed in the same location. This will reduce insert extrusion and metal wear while still permitting periodic inspection. If the pressures are low enough to permit insert changes, the valve should still be re-installed back into its original seat and orientation to achieve maximum life.

Installing a new valve in a used seat is never recommended. Installing a used valve from another seat is also not recommended. When installing a new valve and seat, a new spring should always be installed. The spring loses its spring rate (stiffness) over a specified time and number of actuations. A 50-lb/in spring can be reduced to a 5-lb/in spring over time. A lightweight spring can cause valve hammering and can damage both the valve and seat metal components thereby reducing life substantially.

As a pump valve pot deck wears, the actual metal-to-metal seal area between the valve pot and seat is reduced. This contact area on a new valve pot and new seat should be a continuous band and, at a minimum, 80% the full height of the seat contact. As the valve pot wears, this contact band will still be continuous around the seat but the thickness of the band will gradually be reduced. At the point before failure, the continuous contact band could be ½″ or less. Once the band fails to be continuous, a washout between the seat and valve pot will occur. Once a seat is removed from the pot, this contact band can be visually inspected and preventative measures can be taken to eliminate or greatly reduce the possibility of valve pot washout.

Common Types of Valve Failure

The most common types of valve failure involve extrusion, abrasion, corrosion, chemical attack or heat. By a visual inspection of the failed valve and seat, most modes of failure can be easily identified. Inspected parts may show evidence of two modes of failure but one of those is usually the cause of failure, and the other the effect of the failure.

EXTRUSION: Extrusion is the most common type of valve failure. If the metal part of the striking bevel of the valve does not contact the seat, a gap will be present. In operation, the insert material will flow into this gap. The amount of material that flows into the gap will depend on the gap size, the operating pressure and temperature. For a given gap size, the higher the operating pressure, the more of the insert material will flow into the gap. Once the material is into the gap, a portion of it can be pinched or severed off. This action, over time, results in a missing section of the insert at the insert/valve body interface. This results in a torn appearance. This tearing action of the insert can continue until a large enough section is lost to cause ultimate valve failure. The gap can be caused by solids in the system, misaligned or worn upper valve guide or installing a new valve into a worn seat. A gap can also be caused by re-orienting the existing valve in the same seat (rotating the valve).

ABRASION: Simple abrasion is different than abrasion from corrosion. Simple abrasion is directly attributed to the fluid medium being pumped and its abrasive qualities. Sand, quartz, iron filings, etc. are all very abrasive materials. Even though the valve body and seat are heat treated to increase the hardness and the insert is highly resistant to abrasion, these components will abrade down. Fluid mediums with abrasive matter are continuously supplied to and through the valve and seat. This matter gets crushed into sharp pieces by the metal part of the valve and tries to embed itself into the insert material causing small tears. Over time the surface of the insert will wear down faster than the valve body and a loss of insert seal will take place. The valve will fail at this point.

CORROSION: On a microscopic level, clean metal rusts instantly. As a valve actuates under pressure in certain fluid mediums, the insert wipes the adjacent seat area to clean metal. On a microscopic level, rust develops in this area immediately. After the next valve actuation, the insert wipes this rust off and the area is clean metal again. Over many actuations, small microscopic pits begin to form due to this rusting/wiping action. After time, these microscopic pits start to merge together and after still more time they grow to the visual stage. At this stage, this corrosion pitting with very sharp edges begins to abrade the insert. As the pitting continues and the pits grow larger, the more abrasive they are to the insert. Over time, the insert will be abraded to the point that there is no interference between the insert and the seat. At that point, the valve will fail. The time frame before failure depends on how corrosive the fluid medium is, how fast the pump strokes and the operating pressure.

Rust protects metal from further rusting because it keeps some of the air from reaching the base metal. Since the other areas of the valve and seat do not get this wiping action, no corrosion pitting may be evident in these areas, only on the seat area adjacent to the insert. For conditions such as these, there are seats designed to resist this corrosion pitting. Some are flash chrome plated, some chrome plated and some electroless nickel plated. There are different plating materials for different seat designs.

CHEMICAL ATTACK: Some chemicals and chemical compounds can inhibit the insert material. They can cause a reduction in mechanical properties, swelling of the insert or a breakdown of the insert material. Normally, if an insert has been inhibited by chemistry, the insert will soften. If the insert has softened, it may also have a solvent or hydrocarbon smell to it if inspected immediately out of the pump. Once out of the pump, the chemical that attacked the insert may start to evaporate so it is important to check it as soon as possible after removal. An insert inhibited by chemicals is not normally detected by visual means.

HEAT: As the operating temperature increases, the physical properties of elastomers decrease. Normally, since the valve actuation produces very little frictional heat, the insert selection can be based on the maximum fluid temperature expected.

Roughneck Extrusion Damage

Two Valves Used in Seat

Supreme Extrusion Damage

Valve Manually Rotated

Large Solids and Abrasion

Solids and Corrosion

Supreme Seat Corrosion

Roughneck Seat Corrosion

Age Hardened Insert

Roughneck Drilling Valve and Seat

The Roughneck Drilling valve is a full open valve designed for maximum flow characteristics. It has a one-piece unitized case hardened alloy steel body with a snap on insert. The Roughneck Drilling valve with the standard polyurethane insert has a maximum temperature rating of 180º F (82º C), maximum pressure rating of 7,500 psi and is designed for a solids content from low to high. The limited metal-to-metal bearing area of this valve allows its use in the higher concentrations of solids due to the ability of the valve to crush particulate matter rather than get hung open and washcut. Inserts of other materials are available for this valve for varying conditions.

Supreme Drilling Valve and Seat

The Supreme Drilling valve is a cross-arm style valve designed for low weight. It has a three-piece body consisting of the body, insert and knock-on nut. The valve body is manufactured from alloy steel that is case hardened. The Supreme Drilling valve with the standard polyurethane insert has a maximum temperature rating of 180º F (82º C), maximum pressure rating of 6,500 psi and is designed for low to moderate solids concentrations. Inserts of other materials are available for this valve for varying conditions.

Roughneck HP Drilling Valve and Seat

The Roughneck HP Drilling valve is a full open valve designed for maximum flow characteristics. It has a one-piece unitized case hardened alloy steel body with a snap on insert. The Roughneck HP Drilling valve with the standard polyurethane insert has a maximum temperature rating of 180º F (82º C), maximum pressure rating of 7,500 psi and is designed for a solids content from low to moderate. Inserts of other materials are available for this valve for varying conditions.

Super Service Drilling Valve and Seat

The Super Service Drilling valve is a cross-arm style valve designed for low weight. It has a five-piece body consisting of the valve body, insert, snap ring and two plates. The valve body and seat are manufactured from heat-treated alloy steel for hardness and strength. The Super Service Drilling valve with the standard Buna insert has a maximum temperature rating of 240º F (115º C), a maximum pressure rating of 2,000 psi with muds heavier than 10 lbs/gal and 1,000 psi with water and muds up to 10 lbs/gal. This valve can be operated in conditions of low to heavy solids.

Silver Top Drilling Valve and Seat

The Silver Top Drilling valve is a cross-arm style valve designed for low weight. It has a five-piece body consisting of the valve body, insert, snap ring and two plates. The valve body and seat are manufactured from heat-treated alloy steel for hardness and strength. The Silver Top Drilling valve with the standard Buna insert has a maximum temperature rating of 240º F (115º C), a maximum pressure rating of 1,000 psi with muds heavier than 10 lbs/gal and 750 psi with water and muds up to 10 lbs/gal. This valve can be operated in conditions of low to heavy solids.

Service Master II Well Service Valve and Seat
The Service Master II Well Service valve is a full open valve designed for maximum flow characteristics. It has a one-piece unitized case hardened alloy steel body with a snap on insert. The Service Master II valve with the standard polyurethane insert has a maximum temperature rating of 180º F (82º C), maximum pressure rating of 20,000 psi and is designed for a solids content from low to moderate.

Roughneck Well Service Valve and Seat
The Roughneck Well Service valve is a full open valve designed for maximum flow characteristics. It has a one-piece unitized case hardened alloy steel body with a snap on insert. The Roughneck Well Service valve with the standard polyurethane insert has a maximum temperature rating of 180º F (82º C), maximum pressure rating of 20,000 psi and is designed for a solids content from low to high.

Other Valves and Seats
The FK-N and FK-1 are valves categorized as drilling valves. The FK-N is of the full open type and the assembly is made up of five parts. The FK-1 is of the cross-arm style and constructed from a three-piece assembly. Both the FK-N and FK-1 valves have a temperature rating with the standard polyurethane insert of 180º F (82º C). Both valves can be utilized when the solids content is low to moderate. The pressure rating for the FK-N and FK-1 valve is 5,000 psi.

The Master I and Master II valves are categorized as drilling valves. These valves are designed in both the full open and cross-arm style. Both styles have a one-piece unitized alloy steel body and the standard insert is polyurethane for a maximum temperature rating of 180º F (82º C). Both designs can be utilized with solids content from low to moderate. The pressure rating for the Master I and Master II valve is 7,500 psi.

The Service Master I valve is categorized as a well service valve. This valve is of full open design and consists of a five-piece body assembly. This valve is being replaced over time by the one-piece Service Master II valve.

Excellent	Blue
Very Good	Green
Good	Yellow
Poor/NR	Red

FEATURES:	Roughneck Ureth.	Roughneck WL	Roughneck HT	Roughneck HP Ureth.	Roughneck HP WL	Supreme Ureth.	Supreme WL	Supreme 308	Super Service 308	Silver Top 308	FK-N	FK-1	Master I & II
Abrasion Resistance	Excellent	Very Good	Very Good	Excellent	Very Good	Excellent	Very Good	Good	Good	Good	Excellent	Excellent	Excellent
Tear Resistance	Excellent	Very Good	Very Good	Excellent	Very Good	Excellent	Very Good	Good	Good	Good	Excellent	Excellent	Excellent
Resistance to Oil	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
Chemical Resistance	Good	Very Good	Very Good	Good	Very Good	Good	Very Good	Very Good	Very Good	Very Good	Good	Good	Good
Resistance to Synthetic Oil	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
Temperature Resistance	Good	Very Good	Very Good	Good	Very Good	Good	Very Good	Excellent	Excellent	Excellent	Good	Good	Good
Extrusion Resistance	Excellent	Very Good	Very Good	Very Good	Very Good	Good	Good	Good	Good	Good	Excellent	Good	Very Good
Use in Oil Base Muds	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
Use in Synthetic Base Muds	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
Use in Low Solids	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Use in Moderate Solids	Excellent	Excellent	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Very Good	Very Good	Good	Very Good
Use in High Solids	Very Good	Very Good	Very Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good
Use in Pressures <1,000 psi	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Very Good	Very Good	Very Good	Excellent	Excellent	Excellent
Use in Pressures 1,000 – 2,000 psi	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Very Good	Very Good	Poor/NR	Excellent	Excellent	Excellent
Use in Pressures 2,000 – 3,000 psi	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Poor/NR	Poor/NR	Excellent	Excellent	Excellent
Use in Pressures 3,000 – 5,000 psi	Excellent	Excellent	Excellent	Excellent	Excellent	Very Good	Very Good	Poor/NR	Poor/NR	Poor/NR	Very Good	Very Good	Excellent
Use in Pressures 5,000 – 6,300 psi	Excellent	Excellent	Very Good	Excellent	Excellent	Very Good	Very Good	Poor/NR	Poor/NR	Poor/NR	Very Good	Very Good	Very Good
Use in Pressures 6,300 – 7,500 psi	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Good	Poor/NR	Poor/NR	Poor/NR	Good	Good	Good
Flow Characteristics	Very Good	Very Good	Very Good	Good	Good	Very Good	Very Good	Very Good	Very Good	Very Good	Good	Very Good	Excellent
Corrosion Resistant Seat Available	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N	N
Maximum Temperature (°F)	180	200	220	180	200	180	200	250	250	250	180	180	180

Table: Application Data for Drilling Style Valve and Seats

Excellent	Very Good	Good	Poor/NR
Blue	Green	Yellow	Red

FEATURES:	Roughneck Std. Ureth.	Roughneck Inj. Ureth.	Roughneck Viton	Roughneck Buna	Roughneck Acid Resis.	Serv. Mast. II Std. Ureth.	Serv. Mast. II Bonded	Serv. Mast. II Buna	Serv. Mast. I Std. Ureth.	FK-N Ureth.	FK-N Buna
Abrasion Resistance	Excellent	Very Good	Good	Good	Very Good	Excellent	Excellent	Good	Excellent	Excellent	Good
Tear Resistance	Excellent	Very Good	Good	Good	Very Good	Excellent	Excellent	Good	Excellent	Excellent	Good
Resistance to Oil	Very Good	Very Good	Excellent	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
Chemical Resistance	Good	Very Good	Excellent	Very Good	Very Good	Good	Good	Very Good	Good	Good	Very Good
Resistance to Synthetic Oil	Very Good	Very Good	Excellent	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
Temperature Resistance	Good	Good	Excellent	Very Good	Good	Good	Good	Very Good	Good	Good	Very Good
Extrusion Resistance	Excellent	Very Good	Good	Good	Very Good	Excellent	Excellent	Good	Excellent	Excellent	Good
Use in Clean Fluids	Excellent	Excellent	Very Good	Very Good	Excellent	Excellent	Excellent	Very Good	Excellent	Excellent	Very Good
Use in Low Solids	Excellent	Very Good	Good	Good	Very Good	Excellent	Excellent	Good	Very Good	Very Good	Good
Use in Moderate Solids	Very Good	Good	Poor/NR	Poor/NR	Good	Very Good	Very Good	Poor/NR	Good	Good	Poor/NR
Use in High Solids	Good	Poor/NR	Poor/NR	Poor/NR	Poor/NR	Good	Very Good	Poor/NR	Poor/NR	Poor/NR	Poor/NR
Use in Pressures <2,000 psi	Excellent	Excellent	Very Good	Very Good	Excellent	Excellent	Excellent	Very Good	Excellent	Excellent	Very Good
Use in Pressures 2,000 psi – 4,000 psi	Excellent	Excellent	Good	Good	Excellent	Excellent	Excellent	Good	Excellent	Excellent	Good
Use in Pressures 4,000 psi – 8,000 psi	Excellent	Very Good	Good	Good	Very Good	Excellent	Excellent	Good	Very Good	Very Good	Good
Use in Pressures 8,000 psi – 12,000 psi	Excellent	Very Good	Good	Good	Very Good	Excellent	Excellent	Good	Good	Good	Good
Use in Pressures >12,000 psi	Excellent	Good	Good	Good	Good	Excellent	Excellent	Good	Poor/NR	Poor/NR	Poor/NR
Use in Hot Oil Transfer (>300°F)	Poor/NR	Poor/NR	Very Good	Poor/NR	Poor/NR	Poor/NR	Poor/NR	Poor/NR	Poor/NR	Poor/NR	Poor/NR
Use in Geothermal (200 - 250°F)	Poor/NR	Poor/NR	Very Good	Good	Poor/NR	Poor/NR	Poor/NR	Good	Poor/NR	Poor/NR	Good
Flow Characteristics	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Very Good	Very Good	Very Good
Temperature Limit (°F)	180	185	350	250	185	180	180	250	180	180	250

Table: Application Data for Well Service Style Valve and Seats

Valve and Seat Storage Procedures

Valves, seats and valve insert kits are packaged and coated with rust preventative for short term covered warehouse storage. Valves, seats and valve insert kits exposed to the outside elements and temperature extremes may deteriorate over time. Valves, seats and valve insert kits should be kept in the original unopened boxes away from ground moisture and elevated above concrete floors. Care should be also taken to eliminate conditions that promote condensation in the original box and keep the valves, seats and liners away from direct sources of moisture. Valves, seats, and valve insert kits are packaged with sealing elements manufactured with elastomeric compounds. Valves and valve insert kits should be stored away from high heat areas. After the valve insert seal element is molded, the sealing element starts to age at a linear rate. Heat will increase the rate of aging, cooler temperatures will maintain or reduce the rate of aging. The cooler these valves and valve insert kits can be stored, the longer the sealing element's useful life. The valves and insert kits should also be stored away from direct sunlight (ultraviolet radiation), aromatic solvents, moisture and electric motors (ozone production).

When stored properly, as described above, the shelf life of black rubber products (Nitrile, Neoprene, etc.) is five years after the date of manufacture. If stored improperly or in conditions with higher heat, this shelf life is reduced accordingly. When stored properly, polyurethane products have a shelf life of four years from the date of manufacture. If stored improperly or in conditions of high heat, the shelf life is reduced accordingly. Black rubber and polyurethane products should not be used if the actual age exceeds the shelf life. If they have not been stored properly and if they appear milky or cloudy in color or substantially harder than fresher examples, they should not be used.

BACKFLUSH SYSTEMS

There are many different types of backflush systems. Some are integral to the rod or inside the rod body, some are integral to the rod clamp or piped into the clamp, and some are clamped to the outside of the rod. Each type of system can be effective if it delivers the required amount of fluid, removes heat from the liner and piston, and can be directed in such a manner as to cover the complete liner bore in the duration of one stroke.

Minimum flow requirements for the backflush are 14 gal/min for urethane pistons, and 10 gal/min for the black rubber type pistons. This flow is required for each piston. To measure the backflush flow while the triplex pump is off and the backflush pump on, disconnect the line after the last elbow and/or valve and place the pipe into a one-gallon jug. For urethane pistons, the one-gallon jug should fill in 4 seconds, for black rubber pistons 6 seconds. If it takes longer to fill the jug than that stated above, the frictional heat generated at the piston will reduce the operating life.

The backflush supply normally comes from a holding tank or directly from seawater. If a holding tank is utilized, care should be taken to clean out the tank at specified intervals to keep solids from circulating continuously through the system and clogging up the supply lines. Some operations with holding tanks utilize some water soluble-oil to aid the lubrication of the piston and further reduce frictional heat. If a water soluble-oil is used, it should be of the non-detergent type and be environmentally friendly to the location in case of runoff. It should also have a fungus and bacteria inhibitor so that the supply does not promote growth. Concentration should be approximately 20 parts water to 1 part water-soluble oil. Mission Mystique is one of the products regularly used for this purpose.

Tank based systems have a tendency to build up heat. The larger the tank, the slower this heat build-up will occur. Fans and cooling devices have been used effectively to reduce this heat. The cooler the backflush supply is, the better it removes heat from the liner and piston, which increases piston life.

The backflush pump should have its own driver and should be independent of the rotational speed of the main positive displacement pump. The flow requirements of the backflush pump should be full flow at full pressure throughout the main positive displacement pump's operation. Backflush systems that are driven from the jackshaft of the main positive displacement pump do not have the flow or pressure required for proper lubrication, cooling and flushing of the liners.

LINER RETENTION SYSTEMS

General Information

The different types of liner retention systems include liner clamps, liner lock nuts, liner retaining rings, hydraulic actuated liner retention systems and spring actuated liner retention systems. Each type of retention system is designed to keep the liner engaged to the fluid end (or wear plate) and to reduce the possibility of liner gasket failure and subsequent washcut of the mating components. Some retention systems require periodic maintenance to keep the liner sealed to the fluid end. Some require only correct initial installation.

Liners are typically indexed into the fluid end by the use of two areas of the liner body. One area, known as the guide, keeps the liner concentric to the imaginary centerline of the crosshead. The other, known as the face, keeps the liner perpendicular to this same centerline. If the guide in the fluid end (or pump frame) or the face of the module (or wear plate) is worn, dented or washcut, the liner will either be out of concentricity or perpendicularity to the imaginary crosshead centerline and premature liner/piston wear will result in direct relation to how far out of square the liner is. Any dirt or contaminating matter between the liner and liner guide or liner face and module can also cause the liner to be out of square. It is particularly important that these areas be clean and free of any solid contaminant before installing a liner. This also occurs when the crosshead slide is worn beyond the point recommended by the pump manufacturer. Rod breakage can also occur when one or more of the areas are out of alignment.

The liner guide area is normally positioned on the outside of the liner closest to the fluid end and will typically be tight fitting in the module or pump frame. At times, it may be necessary to remove paint from the liner in this area to aid in the installation. The liner face is normally the surface of the liner that is directly outside the area of the liner gasket. This face, and the mating face of the module, must be kept flat to insure the liner is square to the fluid end and reduce the possibility of extrusion of the liner gasket. Gasket extrusion can lead to a fluid washcut of the liner, wear plate, and/or fluid end.

Similarly, the liner retention system also has areas that must remain square to affect a proper clamping force. If certain areas of the liner retention system are damaged, an uneven clamping force may result causing damage to the related components including the retention system, liner, wear plate or module. Any face of the liner retention system that contacts the liner must remain flat, free from dents and free from contaminants to produce the desired clamping affect. Dents and/or contaminants can cause areas of high point loads and may result in product failure due to the increased localized stress on the component. Any dents or dings encroaching into the area of the face should be filed down to the surrounding flat surface to avoid this point loading.

Liner Clamps

The internal section of a liner clamp is designed with either a straight side and a beveled side or two beveled sides depending on the pump manufacturer. Both types operate in basically the same manner: by tightening the flange bolts, the two halves are brought closer together. As the clamps come closer together, the bevel on the clamp and adjacent component draw the parts together. Both of these faces must be free of dents, high points and contaminants to ensure proper fit. These faces should also be visually inspected before use to ensure proper contact. The area of actual contact can normally be seen and this area should not have a profile that is different from the adjacent areas such as indented sections or highly burnished areas.

When fully and properly assembled to recommended torque, a clamp should still have a gap between the clamp flanges. This indicates that the clamp and/or clamp collar is not too worn in the internal/external section to affect a proper clamping force. If, once the clamp is properly tightened, there is no gap between the halves, the clamp or clamping collar is worn out and should not be used.

After installing a clamp and tightening it to specification, some clamps can become loose. It is always recommended to retighten a clamp back to specification every so often (when the pump is not in operation) to ensure the proper clamping force and reduce the possibility of liner gasket failure.

Some liner clamps are equipped with a hinge on one side of the clamp flange. The hinge pins and the hole in the clamp flange wear over time and may need to be replaced before they become too worn to permit proper clamp operation. Hinge blocks should also be inspected regularly to determine if they have too much wear.

Liner Lock Nuts

The hammer-up lock nut type liner retention system is basically a nut torqued by a sledgehammer to create a clamping force against the liner to hold it tight to the fluid end (or wear plate). This system can involve just the hammer-up lock nut or can also utilize a split ring depending on the design. The applied torque on the liner would be determined by strength and swing of the operator, friction in the threads, weight of the sledgehammer, plus the space the operator has to work in. Since these many factors are involved, the actual clamping force exerted on the liner will vary from installation to installation.

The face of the hammer-up lock nut must be kept flat and free of high points and contaminants to ensure proper loading. If the assembly contains any split rings, these faces must also remain flat to ensure proper contact. The threads should also be visually inspected for torn threads, dents, excessive wear and contaminants. High points, faces not flat and contaminant matter can cause the hammer-up lock nut to loosen in service. This can result in liner gasket extrusion and failure, which can wash out the mating components.

Liner hammer-up lock nuts can loosen normally in service due to vibration and the pump pressure pulses. It is highly recommended that these hammer-up lock nuts be retightened at regular intervals when the pump is not in operation to reduce the possibility of a nut loosening and extruding a gasket and eventually washing out the fluid end. A loose nut can also cause excessive gasket movement during the pump pressure pulses that tend to wear the mating components by abrasive action. Over time, this wear can start a series of gasket failures that may continue until the module or wear plate is replaced.

Liner Retaining Rings

A liner retaining ring is basically a ring that is fastened to the fluid end through the pump frame using studs and nuts. The ring uses the combined nut torque to clamp the liner to the module or wear plate. Both the front and back face of this ring must remain flat and free of dents, high spots, excessive wear and contaminants to ensure the proper clamping force is utilized and to keep the ring faces square to the liner and fluid end.

The nuts that tighten the retaining ring to the fluid end or wear plate should be tightened to the pump manufacturer's specifications in a crisscross pattern slowly bringing up each nut to the specified torque. This method will ensure even distribution of load, reduce the possibility of stud breakage and keep the ring square to the fluid end. On the ring retainer type of system, the bottom nuts are sometimes difficult to access. The most common type of failure in this retention system is usually directly related to not tightening these bottom nuts correctly as described above. Fluid end washouts usually occur on the bottom part of the module (or wear plate) at the gasket when these nuts are not correctly tightened.

Normally, vibration and the pump pressure pulses do not loosen this type of liner retention system once tightened to specification. However, after installing this system, it is recommended that the nuts be checked to ensure they remain tight after the initial run has concluded.

Hydraulic Actuated Liner Retention System
The hydraulically actuated retention system utilizes a hydraulic cylinder to provide an initial clamping force until a threaded ring can be tightened to maintain the clamping force in operation. This system utilizes a bayonet lock device for quick assembly and removal to reduce the time it takes to change out a liner. The hydraulically actuated system is offered as a premium aftermarket device and normally does not come as standard equipment on pumps.

The male bayonet lock adapter should be inspected at regular intervals and should be free from dents, high spots and contaminant matter to ensure the proper and uniform clamping force and to keep the liner in the proper alignment. Irregularities such as dents, high spots and contaminant matter can cause high point loads and may result in product failure due to the increased localized stress on the component. It can also cause liner misalignment, which can result in premature liner and piston wear.

Normally, vibration and the pump pressure pulses do not loosen this type of liner retention system once tightened to specification. However, after installing this system, it is recommended that the nuts be checked to ensure they remain tight after the initial run has concluded.

Spring-Actuated Liner Retention System
The spring-actuated retention system utilizes a hydraulic cylinder to compress a series of spring washers. This allows the system to be installed and removed. Once the hydraulic cylinder has been deactivated, the series of spring washers provide the clamping force to hold the liner to the fluid end (or wear plate). This system utilizes a cam lock device for quick assembly and removal to reduce the time it takes to change out a liner. The spring-actuated system is offered as a premium aftermarket device and normally does not come as standard equipment on pumps.

The male cam lock adapter should be inspected at regular intervals and should be free from dents, high spots and contaminant matter to ensure the proper and uniform clamping force and to keep the liner in the proper alignment. Irregularities such as dents, high spots and contaminant matter can cause high point loads and may result in product failure due to the increased localized stress on the component. It can also cause liner misalignment which can result in premature liner and piston wear.

Normally, vibration and the pump pressure pulses do not loosen this type of liner retention system once installed to specification. Normal usage of this system does reduce the effectiveness of the springs and, over time, the springs may not provide the required preload to engage the liner to the module enough to stop liner gasket extrusion or washcuts. The spring washers in this system should be inspected and replaced periodically according to the original manufacturer's specifications.

GASKETS

General Information

Pump gaskets described in this section include valve cap gaskets, cylinder head gaskets, liner gaskets, module gaskets and liner wear plate gaskets. All the gaskets referenced above are static seals that come in a variety of designs, constructions and materials. Although static in design, these gaskets do move minutely in service during pumping and can wear the associated components. Some materials and constructions can wear these associated components faster than others. Some gaskets are designed to have a metal-to-metal backup; others are designed for use in minimal gap situations. Each design is constructed to operate at the pump's maximum rated pressure under normal conditions.

On initial gasket installation, each gasket should be greased. This helps the gasket stay in location on assembly and reduces the abrasive action on the associated components during operation. All areas in relation to the gasket location should be free of solid debris, nicks, dents and old gasket material prior to gasket assembly.

On face seal gaskets where the gasket operates under internal pressure, the gasket should assemble tightly in the counterbore outside diameter. The gasket should also protrude slightly from the metal face so compression on initial assembly will affect a seal. On these types of seals, the inside diameter of the seal should not contact metal. This area, or void, on the inside of the seal allows the seal material to flow once compressed and allows for thermal expansion of the seal in service. It will also allow for any swelling from moisture absorption or swelling from chemical attack if the seal material is not totally compatible with the fluid medium. If there was no gap, the seal growth would separate the metal faces due to simple hydraulic action.

In some pumps, multiple seal material selections and constructions can be made. Each material and construction is designed for a particular purpose. Normally the original equipment seal is designed for the broadest range of service. Other gaskets are also offered and usually these gaskets are for a narrower set of service conditions than the original. Although these gaskets are sometimes specified for a narrower range, they can sometimes out perform the original gaskets if they are operated in their specified range. Outside this range they may be substandard to the original equipment specified. A gasket's useful range can be determined by operating conditions such as fluid compatibility, fluid temperature and operating pressure.

Gasket Installed on Worn Valve Cap and Not Greased Prior to Operation

Homogeneous Rubber Gaskets

These gaskets are non-reinforced solid rubber gaskets and can be manufactured from a variety of oil resistant elastomer compounds. Normally the homogeneous gaskets are utilized when no gap between the metal backup is present. Homogeneous rubber gaskets are not highly resistant to extrusion but normally operate well in elevated temperatures up to 250º F (121º C) than the other type of gaskets. They are also resistant to most chemical compositions used in the drilling industry today. They offer low wear rates to the associated components and remain soft even at the lower temperatures.

Homogeneous Rubber Gaskets with Fabric Reinforcement

These gaskets are designed with a homogeneous rubber primary seal element with a fabric impregnated rubber backup. The primary seal is designed to initiate the seal; the backup is designed to resist extrusion of the primary seal. This type of sealing element is normally utilized when no gap or very small gap is present. Although reinforced by a rubber-impregnated fabric, this seal can extrude under pressure if the gap is too large for the operating pressure. Movement of this seal from pressure cycles can wear the associated components more than the solid rubber homogeneous gaskets due to the addition of this fabric impregnated rubber, but this gasket is more resistant to extrusion under pressure than the solid rubber type.

These gaskets are resistant to most chemical compounds found in the drilling industry and can be used at elevated temperatures up to 225º F (107º C) using standard compounds.

Fabric Impregnated Rubber Gaskets
Fabric impregnated rubber gaskets are manufactured with the entire seal made from fabric-impregnated rubber. These seals have no homogeneous rubber seal elements in the design. The gaskets are very rigid in comparison to the other gaskets and are utilized when no gap or a small gap is present in the metal-to-metal backup. Movement of this seal from pressure cycles can wear the associated components more than the solid rubber homogeneous gaskets due to the addition of this fabric impregnated rubber, but this gasket is more resistant to extrusion under pressure than the solid rubber type and the fabric reinforced rubber type.

These gaskets are resistant to most chemical compounds found in the drilling industry and can be used at elevated temperatures up to 225º F (107º C) using standard compounds.

Homogeneous Polyurethane Gaskets
Homogeneous polyurethane gaskets are non-reinforced solid polyurethane gaskets formulated from specialized proprietary compounds. These materials are formulated for their high resistance to tear and extrusion and have excellent resistance to abrasion. Homogeneous polyurethane gaskets are normally recommended in designs where there are no gaps in the metal-to-metal backups due to the lack of an anti-extrusion device or reinforcement of the compound. These gaskets offer excellent wear characteristics to the associated components equal to or better than the homogeneous rubber gaskets and have better mechanical properties.

The compounds utilized during manufacturing offer good resistance to the common chemical compounds normally found in the drilling industry. These gaskets can be utilized at the lower to moderate temperature range with a maximum temperature rating of 185º F (85º C) using standard compounds.

Dual Durometer Polyurethane Gaskets
Dual durometer polyurethane gaskets are designed with a soft polyurethane primary seal element and a harder durometer polyurethane backup. The primary seal is designed to initiate the seal; the backup is designed to resist extrusion of the primary seal. These materials are formulated for their high resistance to tear and extrusion and have excellent resistance to abrasion. This type of sealing element is normally utilized when no gap or a very small gap is present. Although reinforced by hard durometer polyurethane, this seal can extrude under pressure if the gap is too large for the operating pressure. These gaskets offer excellent wear characteristics to the associated components equal to or better than the homogeneous rubber gaskets and have better mechanical properties.

The compounds utilized in manufacturing offer good resistance to the common chemical compounds normally found in the drilling industry. These gaskets can be utilized at the lower to moderate temperature range with a maximum temperature rating of 185º F (85º C) using standard compounds.

Temperature Resistant Homogenous Polyurethane Gaskets
The temperature resistant homogeneous polyurethane gaskets are specially formulated to operate at elevated temperatures. These materials are also formulated for their high resistance to tear and extrusion and have excellent resistance to abrasion. Temperature resistant homogeneous polyurethane gaskets are normally recommended in designs where there are no gaps in the metal-to-metal backups due to the lack of an anti-extrusion device or reinforcement of the compound. These gaskets offer excellent wear characteristics to the associated components equal to or better than the homogeneous rubber gaskets and have better mechanical properties.

Excellent	Blue
Very Good	Green
Good	Yellow
Poor/NR	Red

FEATURES:	Homogeneous Rubber	Fabric Reinf. Rubber	Fabric Impreg. Rubber	Homogeneous Polyurethane	Dual Durometer Poly.	Temp. Resist. Poly.
Abrasion Resistance	Good	Good	Good	Excellent	Excellent	Very Good
Tear Resistance	Good	Good	Good	Excellent	Excellent	Very Good
Resistance to Oil	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
Chemical Resistance	Very Good	Very Good	Very Good	Good	Good	Very Good
Resistance to Synthetic Oil	Very Good	Very Good	Very Good	Very Good	Very Good	Very Good
Temperature Resistance	Excellent	Very Good	Very Good	Good	Good	Very Good
Extrusion Resistance	Good	Excellent	Excellent	Very Good	Excellent	Very Good
Use in Higher Temperature (>200°F)	Excellent	Very Good	Very Good	Poor/NR	Poor/NR	Very Good
Wear to Associated Components	Excellent	Good	Good	Excellent	Excellent	Excellent
Backup with No Gap Conditions	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Backup with Slight Gap Conditions	Good	Excellent	Excellent	Very Good	Excellent	Very Good
Backup with Moderate Gap Conditions	Poor/NR	Very Good	Very Good	Good	Very Good	Good
Use in Worn Pump Conditions	Poor/NR	Good	Good	Poor/NR	Good	Poor/NR
Temperature Limit (°F)	250	225	225	185	185	220

Table: Application Data for Gaskets

The compounds utilized during manufacturing offer very good resistance to the common chemical compounds normally found in the drilling industry. These gaskets can be utilized at the lower to moderate temperature range with a maximum temperature rating of 210º F (98º C) using the temperature resistant compounds.

Gasket Storage Procedures

Gaskets are packaged in protective bags for short term covered warehouse storage. Gaskets exposed to the outside elements and temperature extremes may deteriorate over time. Gaskets should be kept in the original unopened protective bag away from ground moisture and elevated above concrete floors. Care should be taken to eliminate conditions that promote condensation in the packaging. Keep the gaskets away from direct sources of moisture. Gaskets should be stored away from high heat areas. After gaskets are molded, the gasket starts to age at a linear rate. Heat will increase the rate of aging, cooler temperatures will maintain or reduce the rate of aging. The cooler these gaskets can be stored, the longer the gaskets' useful life. The gaskets should also be stored away from direct sunlight (ultraviolet radiation), aromatic solvents, moisture and electric motors (ozone production).

When stored properly, as described above, the shelf life of black rubber products (Nitrile, Neoprene, etc.) is five years after the date of manufacture. If stored improperly or in conditions with higher heat, this shelf life is reduced accordingly. When stored properly, polyurethane products have a shelf life of four years from the date of manufacture. Black rubber and polyurethane products should not be used if the actual age exceeds the shelf life. If they have not been stored properly and if they appear milky or cloudy in color or substantially harder than fresher examples, they should not be used.

MODULES

General Information
Pump modules come in many different forms. There are monoblock modules, segmented valve over valve modules, one-piece “L” shaped modules and two piece “L” shaped modules. Although each type of module is of a different configuration and may have certain benefits over other designs, the basic maintenance remains the same.

When installing the module to the pump, or the module to the module or module jewelry, the contact surfaces must be flat, free of dents, high points or contaminants. Studs used in securing modules and jewelry should be installed with clean anti-seize compound and tightened in an alternating crisscross pattern to slowly bring each nut up to the manufacturer’s recommended torque. This method will reduce the possibility of stud breakage due to uneven stud loading. A calibrated torque wrench is recommended for this service.

The threads on threaded caps and rings and liner retainers should be visually inspected at regular intervals during normal disassembly for thread deformation or damage prior to reuse. These components should also be visually inspected for damage or wear to areas that contact seals and/or act as a guide. Components found to be damaged or worn should be replaced. The threads of acceptable components should be coated with clean anti-seize compound or grease prior to installation and tightened to the manufacturer’s recommended specification. At regular intervals, when the pump is not in operation, threaded caps and retainers should be retightened to specification. Pump pulsations, vibration and pressure can cause some coarse connections to loosen over time.

Upper Valve Guide Bushings
Upper valve guides and upper valve guide bushings can have a major effect on valve and seat life. In systems with upper guides, the guide acts as a bearing and a centering device to ensure the valve operates in a concentric manner with the seat. As the piston moves in the suction stroke, the fluid movement pulls the suction valve open and toward the piston. In the pressure stroke, the fluid movement pushes the discharge valve open, allowing flow to occur. Due to these actions, the

upper valve guide on the valve body wears the upper valve guide bushing to one side. As the upper valve guide wears, the valve becomes somewhat cocked in the seat. The more cocked the valve becomes, the more effect the worn upper valve guide bushing has on valve life. Worn upper valve guide bushings do not allow the valve to contact the seat squarely and can cause premature valve and seat wear. Very worn upper valve guide bushings can cause catastrophic valve failure by breaking off the valve's upper valve guide, lower valve guide or some of the lower guide legs. This is due to the valve not contacting the seat squarely on initial seating and once the pressure seats the valve this action puts stress on the upper and lower guide system of the valve. This causes a slight bending of the guides, which, over time, may result in upper or lower valve guide breakage. A worn upper valve guide bushing also contributes to premature wearing of the seat bore or lower guide hole.

Valve Seat Installation

To reduce the possibility of washcut pump decks and cracked modules, the valve seat taper and the pump pot taper should be cleaned of all rust preservatives, contaminant matter and moisture. The valve seat and pump deck taper must be clean and dry prior to seat installation. Any moisture or contaminant matter between the valve seat taper and the pump deck taper can cause a lubricating effect that may cause the seat to continue down into the deck in operation and can result in module cracking due to the wedging effects. Non-cleaned tapers can also cause washouts due to the lack of metal-to-metal seal that is required for proper operation. It is also recommended that the area of the seat that contacts the insert be cleaned of all rust preservative and contaminant matter before installation. Depending on the materials utilized, the rust preservative chemistry may not be compatible with the valve insert material.

The valve seat taper and pump deck taper are manufactured to very precise dimensions and tolerances. These include the actual taper, roundness of taper, flatness of taper and the taper dimensions. These precise manufacturing processes and dimensional control allow the metal-to-metal seal that is required under pressure. Because of the precision nature of these surfaces, sanding, lapping, grinding or emery cloth polishing of these surfaces is not recommended. These actions can result in the creation of a low spot on the taper which can reduce the area of support and the metal-to-metal sealing ability of the assembly. Any contaminants found on the valve seat or pump deck taper should be removed in a nonabrasive circular manner, careful not to disturb the original metal surface. High spots from dents on top of the pump deck should be repaired. If these high spots from dents extend down into the tapered surface, they should be repaired carefully removing only the elevated section of the taper using a circular motion and not an up and down motion.

Good Taper Contact National Pump

Poor Taper Contact API Taper Pump

Washed Out Module (Module Worn Out)

Once the tapered surfaces are clean and dry, install the valve seat into the pump deck taper, carefully avoiding the transfer of fluids and contaminants from adjacent surfaces. Once the valve seat is firmly in place in the pump taper, install a used valve without an insert into the seat by hand. If a new valve with an insert is used at this point, the insert will absorb most of the energy to drive the seat in and a positive seal between the valve seat taper and pump deck taper may not be realized.

With the old valve (without insert) in place, a metal pipe or bar should be placed on the valve upper stem (on stemless valves, the top of the valve). Once the pipe or bar is in place, strike the bar with a metal hammer (3-5 lb metal hand sledge works well) until the seat is correctly seated in the pump deck. Normally correct seating can be determined when the valve and pipe (or bar) begins to bounce off the seat when impacted with the hammer. To check if the seat is properly installed, try to remove the seat by hand. If it cannot be removed by hand, the seat should be properly installed in the pump deck. In pump operation, the valve seat will be driven down further to the proper location from pump pressure and valve actuation.

Valve Seat Removal

There are two types of valve seat puller systems, manual and hydraulic. Manual systems can sometimes be used if the valve seats are smaller in size, the operating pressures are low and the seat has not been in the pump for an extended period of time. For all other types of valve seats and conditions, the hydraulic valve seat puller is recommended due to the force required to remove the seat. Because of the high forces required to remove some valve seats it is recommended that the hydraulic pump be moved as far away from the hydraulic jack as possible with about two feet of slack in the hydraulic line. The jack and puller assembly can jump once the seat is pulled out of the pump deck. It is recommended that the hydraulic jack be anchored with chain to the module prior to operating the hand pump. This will reduce the possibility of damage to the pump deck, the module and the hydraulic jack.

Once the valve seat puller head and stem are installed (see the paragraphs below for installation procedures) place the hydraulic jack over the puller stem and on the top of the valve pot or (“H” block, if the puller assembly is equipped with an “H” block). Ensure that the hydraulic jack is centered in the middle of the valve pot opening to avoid stem breakage or bending. Assemble the center bushing over the puller stem and into the hydraulic jack. Thread the puller stem nut onto the puller stem being careful not to rotate the puller stem. If the puller stem is rotated, this may disengage the puller head from the proper location and may lead to puller head damage or breakage. Once the puller stem nut contacts the center stem bushing, continue to tighten the puller stem nut with a wrench until the hydraulic jack is fully depressed and there is a tight connection. Attach the hydraulic hose and the hydraulic pump to the hydraulic cylinder. Switch hydraulic pump valve to the closed position and operate pump until the seat is free. If the hydraulic piston in the hydraulic cylinder is extended in operation to the height indicator, open the hydraulic pump valve, retighten puller stem nut to depress the hydraulic piston to original position and restart the procedure. If the hydraulic piston is extended beyond the height indicator located on the hydraulic cylinder, damage to the seals in the hydraulic cylinder may result.

J-Hook Puller Heads
J-hook puller heads are used for pulling cross-arm style seats such as Supreme, Super Service and FK-1 seats. The puller head should be fully engaged and the puller stem should be threaded completely through the puller head and onto the seat. This action pulls the puller head tight to the bottom of the seat and indexes the head for proper operation. If the puller head is not indexed correctly, the individual J-hooks can be bent or broken during the seat pulling operation. If properly installed, the J-hook puller head should be able to pull the seat without repositioning the hydraulic seat puller piston.

The most common reason for premature J-hook puller head failure in service is that they are not properly indexed with the seat prior to pulling the seat. Seats that have been in pumps for prolonged periods or seats that have been hammered by the valve due to old springs, improper suction or water hammer are sometimes difficult to remove. If the hydraulic jack is not centered in the valve pot opening, this will also cause one side of the puller to have higher loads imposed and can cause bending or failure.

Split Jaw Puller Heads

Split jaw puller heads are used for pulling full open style seats such as Roughneck, Service Master, Mission Master and FK-N. They are also utilized when pulling the cross-arm style Silver Top seat.

For the full open style seats, the puller head should be partially threaded onto the puller stem and then inserted into the seat. The puller stem then should be threaded completely through the puller head once the head is into the seat. If the head is not completely threaded through at this point, the ears of the puller head will bend or break off causing premature failure.

For the Silver Top seats, the puller head should be partially threaded onto the puller stem and then inserted into the seat. The puller stem should then be threaded completely through the puller head until the bottom of the stem is tight with the hub in the middle of the seat. If the head is not completely threaded through at this point, the ears of the puller head will bend or break off causing premature failure.

The most common reason for premature split jaw puller head failure is that the puller stem is not threaded completely through the puller head prior to pulling the seat. If the stem is not completely threaded through, the bottom portion of the puller head is not properly supported and this area will yield under the high loads imposed during the pulling operation.

Seats that have been in pumps for prolonged periods or seats that have been hammered by the valve due to old springs, improper suction or water hammer are sometimes difficult to remove. If the hydraulic jack is not centered in the valve pot opening, this will also cause one side of the puller to have higher loads imposed and can cause bending or failure. It is imperative that the split jaw type puller head used is the one designed specifically for the particular seat.

Drop String Puller Heads

Drop string puller heads are used for pulling full open style seats such as Roughneck, Service Master, Mission Master and FK-N. These puller heads have a string attached to the puller head to aid in the assembly to the puller stem. To install the puller head, the head is lowered at an angle into the seat and then turned upright (hub up, flange down) and manually held in place by the attached string. Holding the attached string with the puller head in place, the puller stem is threaded into the puller head. The stem must be threaded into the puller head until the stem comes out the bottom of the head (full depth). If the puller stem is not threaded into the puller head the entire depth, the puller head or puller stem can fail during operation.

The most common reason for premature drop string puller head failure is the puller head is either not centered properly in the seat or the puller stem was not threaded into the puller head completely. The hub on the drop string puller head is designed to center the puller head in the seat. If the puller head is inverted (hub down) there can be an uneven load imposed on the flanges and the flange with the highest load can bend or fail. If the hydraulic jack is not centered in the valve pot opening, this will also cause one side of the puller to have higher loads imposed and can cause bending or failure.

Wobble Plate Puller Heads

The wobble plate puller head is used for pulling the Roughneck full open style drilling seats only. These puller heads have a slot manufactured in the bore to allow insertion into the seat with the puller stem attached. These puller heads can only be utilized with 2" diameter puller stems. To utilize this puller head, thread a 2″ heavy hex nut to the bottom of the puller stem with the flat side of the nut up. Thread the stem completely through the nut. Install a 2″ flat washer on top of the nut. Install the wobble plate puller head with the radius side of the flange up, these radii fit into the seat radii to centralize the puller head. While cocking the puller head, insert the assembly through the seat bore. Pull up on the assembly to engage the puller head and ensure that it is centralized in the seat bore.

The most common reasons for premature wobble plate puller head failure is that it is used on an improper stem/nut size, assembled upside down or not centralized in the seat bore. It can also fail prematurely if the nut/washer is not flat (has high spots). If the hydraulic jack is not centered in the valve pot opening, this will also cause one side of the puller to have higher loads imposed and can cause bending or failure.

Other Seat Removal Methods

Other seat removal methods, which include torch cutting or heating the seat and applying cold water, are sometimes utilized but not recommended. Heating of the seat transfers this heat to the module and can affect the physical properties of the steel and reduce the surface hardness. Torch cutting can also cause great damage to the pump deck taper if the cutting is not done carefully. The heating of the seat to cause thermal expansion of the seat can lead to softening of the pump deck taper and also puts additional stress on the taper. This stress, if high enough, can cause crack initiation in a surrounding area. During normal pump operation this crack initiation could propagate and cause premature module failure.

Module Storage Procedures

New modules are furnished with a painted exterior and the interior is coated with a rust preventative to allow for short term covered warehouse storage. Modules exposed to the outside elements and temperature extremes may deteriorate over time. Modules should be stored away from areas that promote condensation and should be elevated above concrete floors. The module may have open ports where moisture may enter. It is recommended that the inside of the module be periodically monitored for the accumulation of moisture on the areas of the gasket glands, above the valve pot taper, in the through bores and in the threaded holes. Any corrosion found should be removed by wire brush and recoated with a rust preventative to eliminate further corrosion pitting. Corrosion pitting of the gasket land areas can be detrimental to gasket operation due to abrasion.

PISTON RODS

General Information
There are many different types of piston rods for triplex pumps. Flanged one-piece, threaded one-piece, flanged two-piece, flanged self aligning, threaded self aligning, internal backflush, hydraulically actuated quick disconnect and spring actuated quick disconnect are some of the more popular types. Some piston rod designs have advantages over others in certain situations and operating conditions. The basic design of a piston rod is an intermediate load carrying member to transmit the high loads imposed on the piston face to the crankshaft in a straight line. In new pumps with new components, this load is transmitted in a straight line to the crankshaft. As the pump power end and the direct linkage to the fluid end wear, some of the load can be shifted from straight line load to angular loading by pump misalignment. Worn crossheads and crosshead slides usually contribute to the power end part of the misalignment. Non-flat or non-square flange and connection faces of the crosshead extension rod, sub rod and/or piston rod usually contribute to the rod linkage part of the misalignment.

The piston rod contact faces that are perpendicular to the centerline of the rod must remain flat. If these faces have dings, dents or contaminant matter, this will cause the centerline of the piston rod to change in respect to the crosshead extension centerline and will result in non-uniform loading of the flange. If this non-uniform loading is great enough it may cause premature failure of the crosshead extension flange, piston rod flange and/or piston rod stud. High spots on the piston rod flanges and the mating component can usually be visually identified as a highly burnished area on one or more of the components. The cause for the burnished area should be corrected as soon as practical to reduce the possibility of premature failure of one or more of the components. This high spot, besides reducing the life of the mating component, can also induce misalignment which can reduce the life of the piston and liner due to the increased drag that may result.

Piston to Piston Rod Assembly
The piston to piston rod assembly should not damage any of the critical surfaces. The use of a pipe wrench, hammer or vise on the flange is not recommended. To remove the old piston, place the main part of the rod

body in a vise with pipe fitting jaws. Loosen piston rod nut and remove the old piston. Clean the rod flange face that contacts the piston to remove all dried contaminants, fluids and grease. Use non-abrasive means if possible, wire brush only if needed. Visually inspect this flange face for high spots or burnished areas. Remove the new piston from the box and lightly grease or oil the o-ring. Place the o-ring in the piston counterbore and mount the piston on the rod with the piston bore sleeve in place for 1-1/2″ diameter rod stubs. Remove the piston bore sleeve for piston rod stubs of 1-5/8″ diameter. Apply anti-seize compound to the remaining exposed threads of the rod coming out of the piston. Ensure that the piston rod nut that contacts the piston hub face is flat and free from burrs and high spots. If an elastic stop nut is used (recommended), test the nut for use in service. If the elastic portion of the nut can be threaded on the rod by hand, the nut is too worn for service. Assemble an acceptable or new nut on the rod and tighten to specification. For 1-1/2″ threaded connections torque to 525 ft/lbs (the weight of one 175 lb. man on a 3-foot wrench or wrench/cheater combination). Clean the crosshead end piston rod flange face and the crosshead extension rod flange face and pilot or pilot hole. Use non-abrasive means, if possible. Wire brush only if needed. Visually inspect the flange faces for high spots or burnished areas. Visually inspect the pilot and pilot hole for damage. Assemble the piston and piston rod assembly to the crosshead extension if no damage is found.

Typical Failures of One Piece Flange Type Rods

Typically the one piece flanged rod fails at the main body of the rod just below the flange radius. These failures indicate a bending type of failure. The bending can be a result of pump misalignment, worn out clamps, pump not properly supercharged or the flanges of the piston rod or crosshead extension rod not flat, or contaminant matter between the faces. Either situation can induce bending in the rod with respect to the crosshead extension and cause failure over time. The time period would be based on the severity of the condition and the pump operating parameters. Normally, once the situation presents itself, the condition will worsen with time until the cause is identified and fixed. Since the failures in each set of conditions can look identical, it would be recommended that the areas of inspection to find out the cause be limited to the ones that are inexpensive. This would include visual inspection of flange faces, noises or vibration due to water hammer (supercharger problems) or visual inspection of the clamp. If these areas do not yield any conclusive evidence, the pump alignment should be checked.

Typical Failures of Threaded One Piece Rods

Typically, the threaded one piece rod fails at the location where the thread meets the main body of the rod (the threaded section breaks off). This type of failure can usually be attributed to either a bending type of failure or improper torque applied on installation. The bending can be a result of pump misalignment, pump not properly supercharged, the shoulder of the piston rod or crosshead extension rod not flat, or contaminant matter between the shoulder faces. Either situation can induce bending in the rod with respect to the crosshead extension and cause failure over time. The time period would be based on the severity of the condition and the pump operating parameters. Normally, once the situation presents itself, the condition will worsen with time until the cause is identified and fixed. Since the failures in each set of conditions can look identical, it would be recommended that the areas of inspection to find out the cause be limited to the ones that are inexpensive. This would include visual inspection of shoulder faces, noises or vibration due to water hammer (supercharger problems) or rod tightening procedures. If these areas do not yield any conclusive evidence, the pump alignment should be checked.

Typical Failures of Flanged Two Piece Rods

The flanged two piece rod typically fails in the same manner as the flanged one piece rod, at the main body of the rod close to the flange radius. This can occur on the piston rod or piston sub rod. These failures indicate a bending type of failure. The bending can be a result of pump misalignment, worn out clamps, pump not properly supercharged or the flanges of the piston rod, sub rod or crosshead extension rod not flat or contaminant matter between the faces. Either situation can induce bending in the rod or sub rod with respect to the crosshead extension and cause failure over time. The time period would be based on the severity of the condition and the pump operating parameters. Normally, once the situation presents itself, the condition will worsen with time until the cause is identified and fixed. Since the failures in each set of conditions can look identical, it would be recommended that the areas of inspection to find out the cause be limited to the ones that are inexpensive. This would include visual inspection of flange faces, noises or vibration due to water hammer (supercharger problems) or visual inspection of the clamps. If these areas do not yield any conclusive evidence, the pump alignment should be checked.

Typical Failures of Self-Aligning Rods

NOTE

The Self-Aligning piston rod does not come pre-torqued from the factory. The rod must be torqued to specification prior to use or premature failure may result.

Typically the Self-Aligning rod fails at the connection between the piston rod and sub rod where the piston rod threaded stub meets the piston rod main body. These failures indicate a bending type of failure. When properly assembled and torqued to specification, a moderate amount of pump misalignment can be absorbed by the Self-Aligning rod. If the piston rod is improperly assembled to the sub rod (improperly torqued), the loads typically handled by the sub rod and polyurethane pad can be transferred to the piston rod threaded stub. This action can cause the threaded stub to crack in service.

Care must also be taken when handling the piston rod. The threaded stud should be protected from dings and dents that may cause thread distortion. Thread distortion on the threaded stub can cause galling when threaded into the sub rod. If galling occurs, this action may destroy both the piston rod and sub rod.

Before assembly, ensure that there is no visual evidence of thread distortion. Apply anti-seize compound liberally to the male thread and tighten to specification. For connections with a 2-1/2″ threaded stub, tighten to 800 to 850 ft/lbs (the weight of a 200 lb. man on a 4-foot wrench or wrench/cheater combination). For connections with a 1-1/2″ threaded stub, tighten to 600 to 650 ft/lbs (the weight of a 200 lb. man on a 3-foot wrench or wrench/cheater combination).

The flange face of the sub rod coupling should be visually inspected before use to ensure that the face is flat and free of contaminant matter. The crosshead extension should also be inspected in the same manner. If either face is not flat, coupling cracking and breakage can result. The rod load must be spread out over the entire surface of the sub rod coupling. If contaminant matter or a high spot is present, the high loads imposed at this location can initiate a crack which could then propagate throughout the coupling face.

Changing the Self-Aligning Rod pad in the coupling should be done on the following schedule:

1. When operating in Supreme high chrome iron sleeved liners, change the pad every liner change out for that particular cylinder.
2. When operating in Ceramic liners, change out the pad after every two piston change outs.

Piston Rods with Internal Backflush
Piston rods with an internal backflush system require periodic inspection to ensure that entry ports, drilled holes and nozzle ports are free of contaminant matter and scale build-up. As the backflush fluid circulates, contaminant matter and circulating solids can plug up an internal backflush system. This matter can also reduce the flow capacity to the point that it impacts piston and liner life. Corrosion can also become a major factor in flow restriction. All internal and external ports should be cleaned periodically to remove corrosion and scale which inhibits the flow path. As the black rubber pistons require 10 gal/min minimum for each piston and polyurethane pistons require 14 gal/min minimum for each piston, any reduction can impact piston life dramatically.

Typical Failures of Spring Actuated Quick Disconnect Rods
Spring actuated quick disconnect rods utilize simple hydraulic pressure to depress a set of beveled washers, so assembly and disassembly can be done in a time efficient manner. Also included in the assembly are set pins to keep the unit assembled in operation. The beveled washers act as springs in the assembled unit and these weaken over time. Periodic inspection should be performed on the release link (center portion) of the assembly to ensure that the spring force is within specification. Since this section is not repairable, it is recommended that a new section be installed if the old one is found to be below specified load ratings. Installing a worn out release link into the assembly can cause the set pins to come out or bending of the rod body. Either result can lead to catastrophic rod failure that may cause damage to the fluid end and power end of the pump.

Care must also be taken to visually inspect the pin holes in the release link, piston rod and crosshead extension rod for wear. If wear in these holes has caused the set pins to loosen out of specification, the pins may come out in service and possibly damage the fluid end or power end. The set pins should also be visually inspected for wear and deformation. Worn or deformed set pins may also come out of the assembly in operation.

Due to the design, the spring actuated quick disconnect rods have a small shoulder flange that takes the entire load normally spread out over a greater area on conventional flanged rods. For this reason it is critical that the shoulder faces be visually inspected for flatness and be kept free of contaminants before use. Dings, dents or contaminant matter between these faces on assembly can cause high point loading, rod misalignment and possible rod failure.

The spring actuated quick disconnect rods do have the ability to compensate for a slight amount of pump misalignment. Because of the limited amount of shoulder face contact and the small diameter of the rod stub it is not recommended solely for alignment purposes and should not be utilized when misalignment is moderate or severe. The high loads imposed from misalignment on the small diameter rod stub can bend or break the stub causing component failure.

PISTON ROD CLAMPS

General Information

The internal section of a piston rod clamp is designed with either a straight side and a beveled side or two beveled sides depending on the pump manufacturer. Both types operate in basically the same manner: by tightening the flange bolts, the two halves are brought closer together. As the clamps come closer together, the bevel on the clamp and adjacent component draw the parts together. Both of these faces must be free of dents, high points and contaminants to ensure proper fit. These faces should also be visually inspected before use to ensure proper contact. The area of actual contact can normally be seen and this area should not have a profile that is different from the adjacent areas such as indented sections or highly burnished areas.

When fully and properly assembled to recommended torque, the piston rod clamp should still have a gap between the clamp flanges. This indicates that the clamp and/or clamp collar is not too worn in the internal/external section to affect a proper clamping force. If, once the clamp is properly tightened, there is no gap between the halves, the clamp or clamping collar is worn out and should not be used.

After installing a clamp and tightening it to specification, some clamps can become loose. It is always recommended to retighten a clamp back to specification every so often (when the pump is not in operation) to ensure the proper clamping force and reduce the possibility of liner gasket failure.

Some piston rod clamps are equipped with a hinge on one side of the clamp flange. The hinge pins and the hole in the clamp flange wear over time and may need to be replaced before they become too worn to permit proper clamp operation. Hinge blocks should also be inspected regularly to determine if they have too much wear.

NOTES:

NATIONAL OILWELL VARCO

Corporate Headquarters
7909 Parkwood Circle Drive
Houston, Texas 77036
United States
Phone: 713 375 3700
Fax: 713 346 7687

Manufacturing
311 Diesel Drive
Scott, Louisiana 70583
United States
Toll Free: 800 544 3437
Fax: 337 233 1301

National Oilwell Varco Sales and Service Locations

Mailing Address
P.O. Box 4638
Houston, Texas 77210
United States
Phone: 713 462 4110
Fax : 281 517 0340

Customer Service Center
11300 Windfern
Houston, Texas 77064
United States
Phone: 713 462 4110
Fax: 281 517 0340

Alice, Texas
Phone: 361 664 0588
Fax: 361 664 4222

Casper, Wyoming
Phone: 307 235 2751
Fax: 307 235 9003

Edmonton, Canada
Phone: 780 490 3363
Fax: 780 490 3366

Houston, Texas
Phone: 713 462 4110
Fax: 281 517 0340

Kilgore, Texas
Phone: 903 983 3531
Fax: 903 983 5212

New Iberia, Louisiana
Phone: 337 365 2582
Fax: 337 365 0120

Odessa, Texas
Phone: 432 368 0014
Fax: 432 368 0171

Oklahoma City, Oklahoma
Phone: 405 670 8771
Fax: 405 670 8775

For your nearest National Oilwell Varco distributor, call 1 800 800 4110 (within United States/Canada) or 713 462 4110 (outside United States)

International Locations

Australia
21 Mine Street
Redbank, QLD 4301
Australia
Phone: 61 7 3280 2800
Fax: 61 7 3280 2899

Brazil
Avenida Prefeito Aristeu Ferreira da Silva
70 - Novo Cavaleiros
Macae, RJ 27930-070
Brazil
Phone: 55 22 2773 5401
Fax: 55 22 2773 3631

Dubai
Nr. R/A 13, Daimler Chrysler Street
Plot MO 0682
Jebel Ali Free Zone
Dubai
UAE
Phone: 971 4 8838776
Fax: 971 4 8838795

Germany
Eddesser Strasse 1
Edemissen, Niedersachsen 31234
Germany
Phone: 49 5176 9767 Ext. 0
Fax: 49 5176 9767 Ext. 22

Indonesia
Jakarta Stock Exchange Building
Gedung Bursa Efek Jakarta
Tower 1, 28th floor
Jl. Jendral Sudirman Kav 52-53
Jakarta, 12190
Indonesia
Phone: 62 21 515 9886
Fax: 62 21 515 9878

Netherlands
Gooiland 12
Beverwijk, 1948 RC
The Netherlands
Phone: 31 251 240504
Fax: 31 251 250954

Norway
Korsvikfjorden Industriområde
N-4639
Kristiansand, Vest-Agder
Norway
Phone: 47 38 192000
Fax: 47 38 192311

Lagerveien 8
N-4033
Stavanger, Rogaland
Norway
Phone: 47 51 818181
Fax: 47 51 800547

Russia
5 Ulansky Pereulok
3rd Floor
Moscow, 101000
Russian Federation
Phone: 7 495 775 2540
Fax: 7 495 981 3470

Scotland
Badentoy Crescent
Badentoy Park, Portlethen
Aberdeen, Aberdeenshire AB12 4YD
Scotland
Phone: 44 1224 343610
Fax: 44 1224 343626

Singapore
9 Tuas Avenue 5
Singapore, 639335
Singapore
Phone: 65 6861 1566
Fax: 65 6861 0728

Venezuela
Avenida 68 con Calle 158
Ampliacion Zona Industrial
II Etapa
Municipio San Francisco, Zulia
Venezuela
Phone: 58 261 7362636
Fax: 58 261 7362950

www.nov.com

corporatemarketing@nov.com

Downhole Solutions

Drilling Solutions

Engineering and Project Management Solutions

Lifting and Handling Solutions

Production Solutions

Supply Chain Solutions

Tubular and Corrosion Control Solutions

Well Service and Completion Solutions

PP010001142 Rev. 06