PROIEX

PROGRESSIVE CAVITY PUMP MANUAL

Version 07/03

PREFACE

This manual is intended as a guide for the selection, operation and routine maintenance of Protex down-hole progressive cavity pumps.

The information, specification and illustration are up to date at time of printing. Our policy is one of continued development and therefore we reserve the right to amend any of the information contained in this manual without prior notice.

For more information about Protex PCP equipment, or technical assistance in evaluating your requirements, please contact your Protex representative.

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1.1 PROGRESSIVE CAVITY PUMP HISTORY

The PC pump has a long history. It was invented and designed in the late 1920's by the Frenchman Rene Moineau. Moineau set out to design a rotary compressor and in the process created a new rotary mechanism to be used for the utilization of variations in the pressure of a fluid, which he referred to as "capsulism". His goal was to make it possible to use this capsulism in pumps, compressors, or motors.

The Moineau principle has been utilized in many industries in a wide variety of applications since its licensing. It has been used as a pump in just about every industry: chemical, coal, food, metalworking, mining, paper, petroleum, textile, tobacco, and water and wastewater treatment. In the petroleum industry, the PC pump has been utilized as a surface transfer pump for over 56 years.

In the mid - 1950's, the progressing cavity pump principle was applied to hydraulic motor applications by reversing the function of the progressing cavity pump. The device was then being moved by fluid instead of pumping fluid. With the pump elements being driven by drilling mud or other fluids, it became the prime mover for drill motors. The Moineau principle is now being widely used in the petroleum drilling industry.

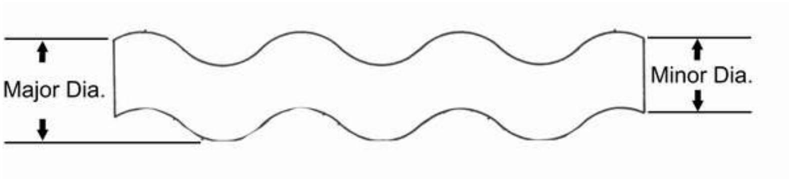
Then in the early 1980'5, the PC pump was utilized as an artificial lift method in the petroleum industry. And very soon in became know as an alternative pump to conventional lift methods and to establish a new marketplace for the PC pump.

The pump is applied to artificial lift by attaching the pump elements to the tubing and rod string. The stator is run on the end of the tubing, and the rotor is attached to the bottom of the rod string and landed in the stator. The rods and rotor are rotated through a wellhead drive assembly that is designed to carry the weight of the rod and the fluid column.

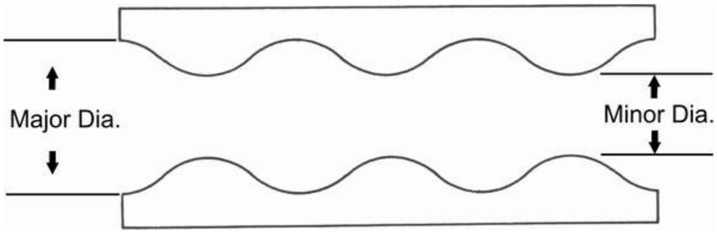
Currently, the PC pump is being widely used for lifting fluids from depths of 2000m, and deeper in oil and gas wells. The progressing cavity pump offers to the petroleum industry a great number of advantages over traditional lift equipment, of which the most important is lowering the cost per barrel lifted.

1.2 PROGRESSIVE CAVITY PUMP DESIGN

The Progressing Cavity Pump design consists of a single external threaded helical gear (rotor) that rotates eccentrically inside a double internal threaded helical gear (stator) of the same minor diameter and twice the pitch length.

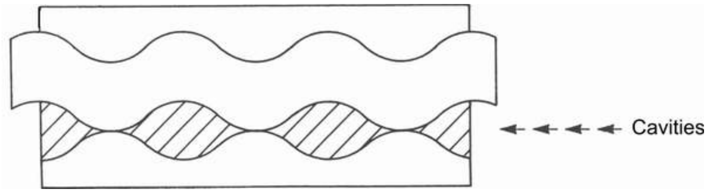


Rotor



Stator

The capacity of the pump is determined by the size of the cavity formed when the rotor is placed in the stator.

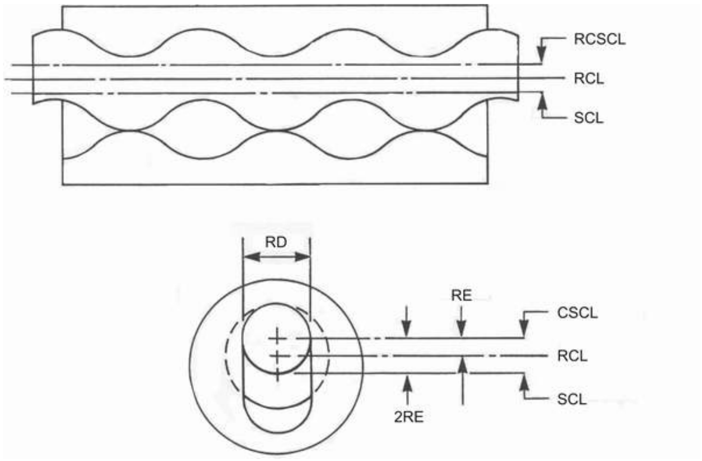


The rotor and stator form a series of sealed cavities, 180 degrees apart, that progress from the suction to the discharge end of the pump as the single external threaded helical rotor rotates. As one cavity diminishes, the opposing cavity increases at the same rate, which keeps the fluid moving at a fixed flow rate that is directly proportional to the rotational speed, resulting in a pulsationless positive displacement flow. The total cross-sectional area of the cavities remains the same regardless of the position of the rotor in the stator.

End views of Rotor turning in Stator as the Rotor completes one revolution

The displacement of the PC pump in addition to being a function of the speed, is directly proportional to three design constants:

1. The cross-sectional diameter of the rotor;
2. Its eccentricity (or radius of the helix);
3. The stator pitch.



Where:

RCSCL – Rotor cross section centerline

RCL – Rotor centerline

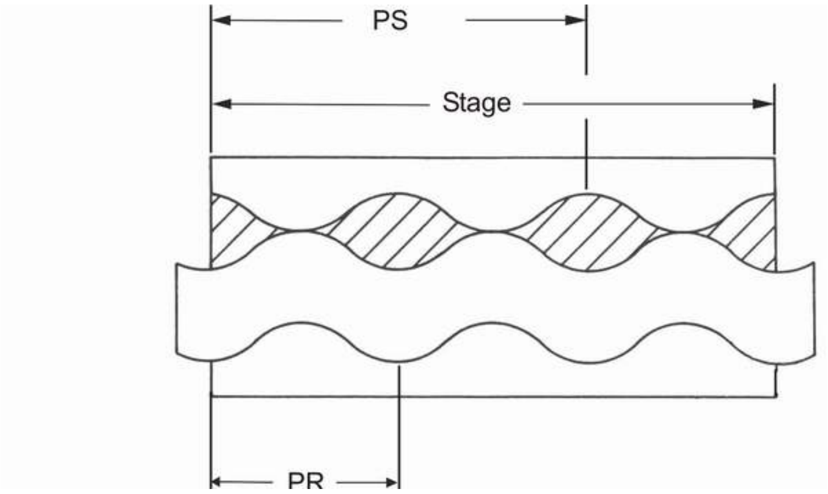
SCL – Stator centerline

RD – Rotor diameter

RE – Rotor eccentricity

CSCL – Cross section centerline

The pressure capability in a progressing cavity pump is a function of the number of times the seal lines that are formed by the rotor and stator are repeated or the number of stages within the pump. Normally, a stage is designed to be 1.5 times the pitch length of the stator or 3 pitch length of the rotor.



PS – Stator Pitch
PR – Rotor Pitch

This insures a proper seal between the rotor and stator. The more seal lines or stages a pump has, the more the pressure capabilities increase, allowing a pump to perform at a greater depth in a well.

Pump pressure rating is 100psi/stage.

As the pressure increases for a given number of stages and speed, the flow rate will decrease. This reduction in flow rate caused by the higher pressure is called "slip".

All progressing cavity pumps experience slippage between the suction and discharge ends. The amount of slip is determined by the pressure and is independent of speed.

Three factors that will affect the amount of slip within a PC pump due to pressure are: the number of seal lines or stages, the viscosity of the fluid being pumped, and the compression fit between the rotor and stator.

2.1 MATERIALS OF CONSTRUCTION

The development of materials of construction for the progressing cavity pump is an ongoing effort by the Protex.
The stator consists of a steel tube with an elastomer that is permanently bonded to the inside and molded in the configuration of a double helix.

The external single helical rotor is normally alloy steel, machined to an exact tolerance, and then chrome plated. Great care and quality control during manufacturing of the rotor and stator insure that the user will receive the best performance possible from the PC pump. Pump test performance is a very good indicator of quality.

As the progressing cavity pump becomes more widely accepted, the need for improvements in elastomer developments of the stator will increase in order to apply the pump to a greater range of producing wells.
Currently, Protex provides four elastomer compounds on the market for use with the downhole progressing cavity pump, all of which are compounds formulated from nitrile rubber, also referred to as Buna N. Its co-polymers are acrylonitrile and butadiene. The acrylonitrile content ranges form 20% to 50%. As the acrylonitrile content is increased, the oil and solvent resistance improves, its tensile strength increases, hardness increased, the abrasion resistance increases, the high temperature resistance improves, and its resilience and permeability qualities decrease. Acrylonitrile content is usually the first consideration when designing a nitrile compound.
The four variations of the compound are:

PX20 - Medium-High Acrylonitrile.

PX40 - Ultra-High Acrylonitrile.

PX80/85 - Hydrogenated, Highly Saturated Nitrile (HSN) - Very High Acrylonitrile.

2.2 ELASTOMER CHARACTERISTICS

PX20 - MEDIUM-HIGH ACRYLONITRILE (ACN) NITRILES

The medium-high acrylonitrile elastomer has good oil and solvent resistance. This elastomer can be applied in oil of less than 28 API, and in application of high water cuts or 100% water. It has excellent abrasion and mechanical properties. The temperature limitation of this type of elastomer is 121 degrees C. This elastomer is best suited for wells with high CO2.

PX40 - ULTRA-HIGH ACRYLONITRILE (ACN) NITRILES

The ultra-high acrylonitrile elastomer has very good oil and solvent resistance. The higher ACN content gives this elastomer increased aromatic swell resistance. This elastomer can be applied in oil of 28 API to 43 API gravities. In oils of this type, a fluid sample should be tested to check the degree of aromatic swell. This elastomer also has good resistance to swell from treating chemicals; however, all chemicals should be tested with the elastomer prior to applying the products. The mechanical properties and abrasion resistance is good. The temperature range of this elastomer is 121 degrees C.

PX80/85 - HIGHLY SATURATED NITRILE (HSN) VERY-HIGH ACRYLONITRILE

This elastomer resistance to aromatic swell is lower than that of the ultra-high (ACN) nitriles. The mechanical properties and abrasion resistance are very good. The temperature range is the highest of the three elastomers at 177 degrees C. This elastomer has fair resistance to hydrogen sulphide and good resistance to iron sulphide. Again, the well conditions should be examined closely before applying the product.

CHARACTERISTICS	PX20	PX40	PX80	PX85
ELASTOMER TYPE	BUNA	HIGH NITRILE	SATURATED NITRILE	STURATED NITRILE
ACN CONTENT	MEDIUM	VERY HIGH	HIGH	VERY HIGH
MAXIMUM TEMPERATURE	121° C	121° C	177° C	177° C
ABRASION RESISTANCE	★★★★	★★★★	★★★★★	★★★★★
DYNAMIC PROPERTIES	★★★★★	★★★★★	★★★★★	★★★★
GAS PERMEABILITY	★★★	★★★★	★★★★	★★★★★
WATER RESISTANCE	★★★★★	★★★★★	★★★★★	★★★★★
AROMATICS RESISTANCE	★★★	★★★★	★★★★	★★★★★
H2S RESISTANCE	★★★	★★★★	★★★★	★★★★
CO2 RESISTANCE	★★★★★	★★★★★	★★★★★	★★★★★

2.3 PC PUMP IDENTIFICATION

First digits in the PCP model indicate the maximum head produced by the PC pump and measured in meters. Two letters indicate the stator tube OD.

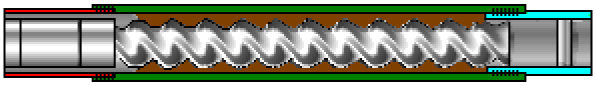
LETTER MARKINGS	OUTSIDE DIAMETER OF THE STATOR	
	INCH	MM
PC	3.13	79.50
PT	3.50	88.90
PH	3.75	95.25
PX	4.50	114.30

The last digits indicate the production rate per day at the rotor speed of 100 rpm.

Example:

12-PX-31

MAXIMUM
HEAD 1200 METERS



RATE
31 M3/DAY
@ 100 RPM

STATOR'S OUTSIDE DIAMETER
4.50 INCHES

2.4 TYPICAL PROGRESSIVE CAVITY PUMP CONFIGURATION

3.1 EQUIPMENT SELECTION CONSIDERATIONS

Performance and applications parameters the PCP system is designed to work under are dependent on:

- Production requirements
- Location of perforations
- Well bore fluids
- Pumping fluid level
- Pump intake and discharge pressures
- Casing and Tubing specifications
- Sucker Rod or Drive String specifications
- Well bore deviations
- Drive String / Tubing contact points
- Rotor / Stator internal friction
- Fluid movement friction loss
- Flow line pressures
- Well bore contaminants
- Load to be carried by Well Head Drive

Computer aided software tools are available to determine the correct pump size, rod and tubing size, wellhead drive system, horsepower and torque requirements.

Note: A **"System Design Form"** should be completed for each well so the applications engineer can make full use of the software tools and along with experience, can select the best-suited components and accessories for each application.

4.1 WELL PREPARATION

Well bore clean up should be performed before installation of the Stator. The removal of debris and sand build up from the bottom of the well should go as deep as possible below the perforations and at least two to three meters below the projected landing depth of the pump.
The pump suction should be landed in or below the perforations wherever possible or practical. Contact your Protex representative for pump landing recommendations for wells that produce sand, high GOR's or wells with special completion requirements.

4.2 STATOR INSTALLATION

THE STATOR IS RUN INTO THE WELL ON THE END OF THE TUBING STRING.

1) The tubing string selected should:

   - Be large enough to handle the expected flow rate.
     (reduces pressure losses)
   - Prevent tensile failures.
   - Prevent failures due to internal / external pressures.
   - Prevent failure due to corrosion.

2) Always install the Stator with the **Tag bar (Stop Pin)** or **Inlet Sub** on the **bottom.**

   - Model 95 pumps (Imperial Model 600) have a special **Orbit Tube** welded onto the top of the stator to accommodate the orbiting motion of the rotor. Do not confuse this Orbit tube with the Tag Bar.

3) If required, make up No-Turn tool on bottom of inlet sub and tighten. Tighten the inlet sub to the stator and the tubing to stator connection.

   - **Do not swage down at the pump discharge,** Swage to smaller tubing.
   - Size at least one (1) full joint above the stator.
   - For Stators of such length that the above is not possible install the longest possible pup joint on top of stator before swaging down (1.8m minimum preferred).

4) Tighten all connections, **Refer to table for Recommended Tubing Make Up Torque.**

   - Run the stator to the required depth and land the tubing in the tubing head as per wellhead manufacturers recommended procedure.

NOTE: Refer to Clause 7.1 for recommended make-up torque for tubing.

4.3 ROTOR INSTALLATION

THE ROTOR IS RUN INTO THE WELL ON THE END OF THE SUCKER ROD STRING.

WARNING: Additional couplings at the stator discharge may restrict the fluid flow; as well the orbiting motion of the rotor can cause increased tubing wear. Therefore whenever possible connect the first sucker rod directly to the rotor or use a pony rod as long as possible.

1) Inspect the rods and couplings for wear and defects before installation.

   - Tighten the rotor to sucker rod connection.

   - Proper make up of connections is crucial while running in well.

2) Before entering the stator - Record the **Rod String Weight.**

   - Insert the rotor into the stator; the rod string may rotate to the right.

3) Put all the rod weight onto the tag bar.

   - Make a mark on the sucker rod at the flow tee = **Zero Rod Weight.**
   - Re-check the rotor landing a couple of times to make sure the ZERO ROD WEIGHT mark on the sucker rod is even with the flow tee.

4) Pick the rod string up off the tag bar until ROD STRING WEIGHT is achieved.

   - This pulls tension in the rod string.

   - Make another mark on the sucker rod at the flow tee = **Rod String Weight.**

5) Refer to table - **Polished Rod Pullback**
From the table, pick the rod size and the appropriate pump model, go down the Column to lift rating of the pump. This is the additional **Inches of Pullback.**

   - This aligns the rotor within the stator.

   - Pick up the rod string the required distance. (Inches of Pullback)

   - Make a mark on the sucker rod at the flow tee = **Operating Point.**

6) Add the length of the Wellhead Drive Assembly to the OPERATING POINT.

   - This becomes the **Clamping Point.**

   - Allow an additional 2” to 12” for Polished Rod Stick Up above the CLAMPING POINT.

7) Pull that sucker rod, plus one more from the well, and lay them down.

   - From the **CLAMPING POINT**, measure the distance DOWN to the pin on the rod.

   - Take that distance PLUS 25 FT. (length of additional sucker rod pulled out), PLUS 6” to 12” for Polished Rod Stick Up = **Make up Distance.**

   - SUBTRACT Polished rod length from MAKE UP DISTANCE = **Feet of Additional pony rods required.**

8) Make up additional Pony Rods and Polished Rod onto Rod String.

- Run into well until clamping point is positioned above the flow tee at the height of the wellhead drive when installed.

9) Clamp Polished Rod securely at the Flow Tee and remove lifting pony from Polished rod.

- File any Burrs from Polished Rod and install Bull Nose.

POLISHED ROD PULL BACK (INCHES)

Fluid Level (Meters)	3/4" API Grade "D" Sucker Rods												
	Pump Nominal Displacement (M3/day @ 100 RPM)												
	4	10	15	17	20	31	32	52	64	80	95	120	145
300	8"	8"	8"	9"	12"	16"	16"	16"	16"	N/A	N/A	N/A	N/A
600	13"	13"	13"	21"	21"	21"	21"	24"	24"	N/A	N/A	N/A	N/A
900	17"	19"	19"	19"	22"	25"	25"	25"	N/A	N/A	N/A	N/A	N/A
1200	20"	24"	24"	24"	28"	31"	31"	N/A	N/A	N/A	N/A	N/A	N/A
1500	24"	26"	28"	28"	30"	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1800	26"	28"	30"	32"	32"	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

POLISHED ROD PULL BACK (INCHES)

Fluid Level (Meters)	7/8" AI Grade "D" Sucker Rods												
	Pump Nominal Displacement (M3/day @ 100 RPM)												
	4	10	15	17	20	31	32	52	64	80	95	120	145
300	8"	8"	8"	8"	10"	16"	16"	16"	16"	16"	16"	20"	28"
600	11"	12"	12"	12"	18"	20"	20"	20"	20"	20"	20"	24"	30"
900	13"	16"	16"	16"	20"	25"	25"	25"	25"	25"	25"	N/A	N/A
1200	16"	20"	20"	20"	24"	29"	29"	29"	29"	N/A	N/A	N/A	N/A
1500	20"	22"	24"	24"	26"	30"	30"	30"	N/A	N/A	N/A	N/A	N/A
1800	22"	24"	26"	26"	28"	32"	32"	N/A	N/A	N/A	N/A	N/A	N/A

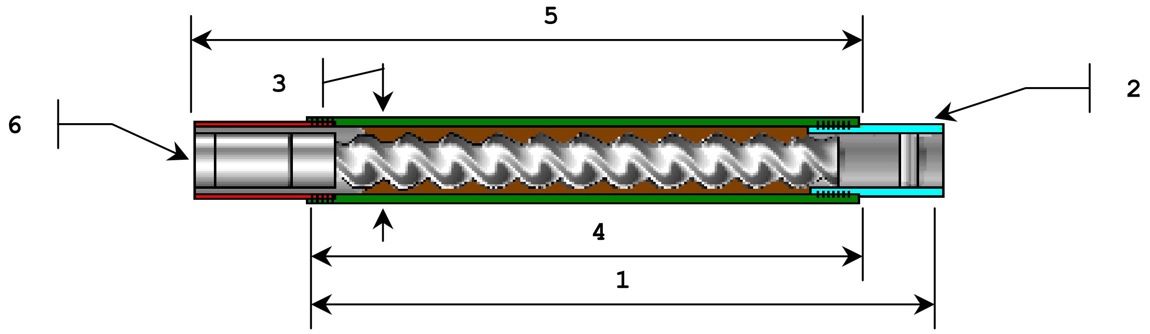
POLISHED ROD PULL BACK (INCHES)

Fluid Level (Meters)	1" API Grade "D" Sucker Rods												
	Nominal Pump Displacement (M3/Day @ 100 RPM)												
	4	10	15	17	20	31	32	52	64	80	95	120	145
300	8"	8"	8"	9"	12"	16"	16"	16"	16"	16"	16"	20"	22"
600	9"	11"	11"	12"	12"	19"	19"	19"	19"	19"	19"	24"	24"
900	11"	13"	13"	13"	16"	22"	22"	22"	22"	22"	22"	28"	28"
1200	12"	16"	16"	16"	20"	24"	24"	26"	26"	30"	30"	N/A	N/A
1500	15"	20"	20"	20"	24"	28"	28"	30"	30"	34"	N/A	N/A	N/A
1800	20"	24"	24"	24"	28"	32"	32"	36"	36"	N/A	N/A	N/A	N/A

5.1 PROGRESSIVE CAVITY PUMPS PRODUCT LINE

MODEL		DISPLACEMENT		LIFTING CAPACITY	
METRIC	IMPERIAL	M3PD/RPM	BFPD/RPM	METERS OF H2O	FEET OF H2O
6-PC-4	20-PC-025	0.04	0.25	600	2000
9-PC-4	30-PC-025	0.04	0.25	900	3000
12-PC-4	40-PC-025	0.04	0.25	1200	4000
15-PC-4	50-PC-025	0.04	0.25	1500	5000
18-PC-4	60-PC-025	0.04	0.25	1800	6000
6-PT-10	20-PT-063	0.10	0.63	600	2000
9-PT-10	30-PT-063	0.10	0.63	900	3000
12-PT-10	40-PT-063	0.10	0.63	1200	4000
15-PT-10	50-PT-063	0.10	0.63	1500	5000
18-PT-10	60-PT-063	0.10	0.63	1800	6000
6-PT-17	20-PT-095	0.17	0.95	600	2000
9-PT-17	30-PT-095	0.17	0.95	900	3000
12-PT-17	40-PT-095	0.17	0.95	1200	4000
15-PT-17	50-PT-095	0.17	0.95	1500	5000
18-PT-17	60-PT-095	0.17	0.95	1800	6000
9-PX-31	30-PX-195	0.31	1.95	900	3000
12-PX-31	40-PX-195	0.31	1.95	1200	4000
15-PX-31	50-PX-195	0.31	1.95	1500	5000
18-PX-31	60-PX-195	0.31	1.95	1800	6000
6-PT-32	20-PT-200	0.32	2.00	600	2000
9-PT-32	30-PT-200	0.32	2.00	900	3000
12-PT-32	40-PT-200	0.32	2.00	1200	4000
15-PT-32	50-PT-200	0.32	2.00	1500	5000
6-PX-52	20-PX-340	0.52	3.40	600	2000
9-PX-52	30-PX-340	0.52	3.40	900	3000
12-PX-52	40-PX-340	0.52	3.40	1200	4000
15-PX-52	50-PX-340	0.52	3.40	1500	5000
7-PX-64	22-PX-400	0.64	4.00	700	2200
9-PX-64	30-PX-400	0.64	4.00	900	3000
12-PX-64	40-PX-400	0.64	4.00	1200	4000
6-PH-80	20-PH-500	0.80	5.00	600	2000
9-PH-80	30-PH-500	0.80	5.00	900	3000
10.5-PH-80	35-PH-500	0.80	5.00	1050	3400
12-PH-80	40-PH-500	0.80	5.00	1200	4000
7-PX-95	22-PX-600	0.95	6.00	700	2200
9-PX-95	30-PX-600	0.95	6.00	900	3000
12-PX-95	40-PX-600	0.95	6.00	1200	4000
8-PX-120	27-PX-750	1.20	7.50	800	2600
10-PX-120	33-PX-750	1.20	7.50	1000	3300
12-PX-120	40-PX-750	1.20	7.50	1200	4000
6-PX-145	20-PX-900	1.45	9.00	600	2000
7.5-PX-145	25-PX-900	1.45	9.00	750	2500
9-PX-145	30-PX-900	1.45	9.00	900	3000

MODEL		STATOR DIMENSIONS					ROTOR DIMENSIONS		
		1	2	3		4	5	6	
Metric	Imperial	Overall Length (m)	Coupling Threads	Overall Diameter (mm)	Overall Diameter (inch)	Tube Overall (m)	Overall Length (m)	Pin Connection (mm)	Pin Connection (inch)
6-PC-4	20-PC-025	1.68	2 7/8 8 RD EUE	73	2.88	1.53	1.61	19.05	3/4
9-PC-4	30-PC-025	2.30				2.15	2.20		
12-PC-4	40-PC-025	2.98				2.83	2.88		
15-PC-4	50-PC-025	3.63				3.48	3.53		
18-PC-4	60-PC-025	4.28				4.13	4.18		
6-PT-10	20-PT-063	1.97	2 7/8 8 RD EUE	88.9	3.5	1.82	1.85	22.23	7/8
9-PT-10	30-PT-063	2.78				2.63	2.68		
12-PT-10	40-PT-063	3.60				3.45	3.50		
15-PT-10	50-PT-063	4.42				4.27	4.32		
18-PT-10	60-PT-063	5.25				5.10	5.15		
6-PT-17	20-PT-095	2.45	2 7/8 8 RD EUE	88.9	3.5	2.30	2.45	22.23	7/8
9-PT-17	30-PT-095	3.49				3.34	3.39		
12-PT-17	40-PT-095	4.55				4.40	4.45		
15-PT-17	50-PT-095	5.62				5.47	5.52		
18-PT-17	60-PT-095	6.67				6.52	6.57		
9-PX-31	30-PX-195	5.33	3 1/2 8 RND EUE	114.3	4.5	4.57	4.93	25.4	1
12-PX-31	40-PX-195	6.86				6.10	6.45		
15-PX-31	50-PX-195	8.38				7.62	7.97		
18-PX-31	60-PX-195	9.92				9.14	9.50		
6-PT-32	20-PT-200	4.74	2 7/8 8 RD EUE	88.9	3.5	4.59	4.63	22.23	7/8
9-PT-32	30-PT-200	6.93				6.78	6.83		
12-PT-32	40-PT-200	9.14				8.98	9.03		
15-PT-32	50-PT-200	11.34				11.19	11.24		
6-PX-52	20-PX-340	4.80	3 1/2 8 RD EUE	114.3	4.5	4.40	4.90	25.4	1
9-PX-52	30-PX-340	8.00				7.24	7.60		
12-PX-52	40-PX-340	10.42				9.65	10.01		
15-PX-52	50-PX-340	12.83				12.07	12.43		
7-PX-64	22-PX-400	7.32	3 1/2 8 RND EUE	114.3	4.5	6.56	6.91	25.4	1
9-PX-64	30-PX-400	9.51				8.74	9.10		
12-PX-64	40-PX-400	11.69				10.93	11.28		
6-PH-80	20-PH-500	8.19	2 7/8 8 RND EUE	95.25	3.75	8.05	7.08	25.4	1
9-PH-80	30-PH-500	11.62				11.48	10.51		
10.5-PH-80	35-PH-500	13.34				13.2	12.23		
12-PH-80	40-PH-500	15.06				14.91	13.94		
7-PX-95	22-PX-600	7.79	3 1/2 8 RND EUE	114.3	4.5	7.03	7.38	25.4	1
9-PX-95	30-PX-600	10.08				9.32	9.67		
12-PX-95	40-PX-600	12.37				11.61	11.96		
8-PX-120	27-PX-750	11.26	3 1/2 8RND EUE	114.3	4.5	10.51	10.87	25.4	1
10-PX-120	33-PX-750	13.81				13.08	13.45		
12-PX-120	40-PX-750	16.42				15.67	16.00		
6-PX-145	20-PX-900	10.18	3 1/2 8 RND EUE	114.3	4.5	9.42	9.75	25.4	1
7.5-PX-145	25-PX-900	12.49				11.72	12.09		
		14.80				14.04	14.4		



6.1 IDENTIFICATION OF THE MOST COMMON STATOR FAILURES

Identification:
- Roughened, worn or scuffed surfaces usually on the minor diameter of the stator

Cause:
- Due to normal wear and abrasion. Influenced by quantity and abrasiveness of fluid solids content, pump speed, elastomer type

Remedy:
- Reduce particle velocity through the pump, running pump at lower speeds, and by adding more stages to the pump

Identification:
- Missing rubber primarily along the rotor/stator seal lines. Rubber is typically hard, shiny and irregular

Cause:
- Pressure drop across pump has exceeded 100 psi per stage

Remedy:
- Select a pump with a greater number of stages
- Ensure rotor is landed properly
- Frequent flush-bys to minimize plugged pump discharges (high solid content fluids)
- Ensure proper pump sizing

Identification:
- Signs of chemical attack or fluid incompatibility include elastomer swelling, softening, or blistering
- Results in a loss in pump efficiency, and an increase in the torque required to turn the pump

Cause:
- Light end hydrocarbons and aromatics result in an increase in volume of the elastomer and softening of the surface

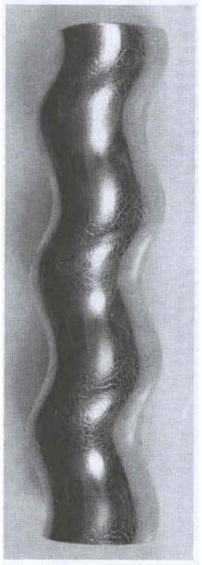
Remedy:
- Proper elastomer selection
- Pump sizing practices

6.2 IDENTIFICATION OF THE MOST COMMON ROTOR FAILURES

Identification:
- Extreme abrasive wear through the chrome plating and into the rotor base metal on the major diameter of the rotor

Cause:
- Producing highly abrasive fluids
- Excessively tight rotor/stator interference fit
- Incorrect spacing, rotor /tubing contact

Remedy:
- Complete through well bore cleanouts
- Ensure correct interference fit for the application
- Insure proper rotor spacing procedure



Identification:
- Chrome has cracks on the surface

Cause:
- Restricted intake
- Pump is oversized
- High temperature

Remedy:
- Complete well cleanout procedure
- Reduce pump speed or use smaller pump
- Ensure correct elastomer is used

7. USEFUL INFORMATION

7.1 Recommended Make-up Torque for Tubing

Size		Weight		Grade	Makeup Torque	
SI	Imperial	SI	Imperial		SI	Imperial
60.3 mm	2.375 in	7.0 kg/m	4.7 lbs/ft	H40	1340 N*m	990 ft*lbs
60.3 mm	2.375 in	7.0 kg/m	4.7 lbs/ft	J55	1750 N*m	1290 ft*lbs
60.3 mm	2.375 in	7.0 kg/m	4.7 lbs/ft	C75	2310 N*m	1700 ft*lbs
60.3 mm	2.375 in	7.0 kg/m	4.7 lbs/ft	L80	2390 N*m	1760 ft*lbs
60.3 mm	2.375 in	7.0 kg/m	4.7 lbs/ft	N80	2450 N*m	1800 ft.*lbs
60.3 mm	2.375 in	7.0 kg/m	4.7 lbs/ft	C90	2610 N*m	1920 ft*lbs
60.3 mm	2.375 in	7.0 kg/m	4.7 lbs/ft	P-105	3080 N*m	2270 ft*lbs
73.0 mm	2.875 in	9.7 kg/m	6.5 lbs/ft	H40	1700 N*m	1250 ft*lbs
73.0 mm	2.875 in	9.7 kg/m	6.5 lbs/ft	J55	2230 N*m	1650 ft*lbs
73.0 mm	2.875 in	9.7 kg/m	6.5 lbs/ft	C75	2940 N*m	2170 ft*lbs
73.0 mm	2.875 in	9.7 kg/m	6.5 lbs/ft	L80	3050 N*m	2250 ft*lbs
73.0 mm	2.875 in	9.7 kg/m	6.5 lbs/ft	N80	3120 N*m	2300 ft*lbs
73.0 mm	2.875 in	9.7 kg/m	6.5 lbs/ft	C90	3340 N*m	2460 ft*lbs
73.0 mm	2.875 in	9.7 kg/m	6.5 lbs/ft	P-105	3940 N*m	2910 ft*lbs
88.9 mm	3.500 in	13.8 kg/m	9.3 lbs/ft	H40	2340 N*m	1730 ft*lbs
88.9 mm	3.500 in	13.8 kg/m	9.3 lbs/ft	J55	3090N*m	2280 ft*lbs
88.9 mm	3.500 in	13.8 kg/m	9.3 lbs/ft	C75	4080 N*m	3010 ft*lbs
88.9 mm	3.500 in	13.8 kg/m	9.3 lbs/ft	L80	4240 N*m	3200 ft*lbs
88.9 mm	3.500 in	13.8 kg/m	9.3 lbs/ft	N80	4330 N*m	3200 ft*lbs
88.9 mm	3.500 in	13.8 kg/m	9.3 lbs/ft	C90	4650 N*m	3430 ft*lbs
88.9 mm	3.500 in	13.8 kg/m	9.3 lbs/ft	P-105	5490 N*m	4050 ft*lbs
101.6 mm	4.000 in	16.4 kg/m	11.0 lbs/ft	H40	2630 N*m	1940 ft*lbs
101.6 mm	4.000 in	16.4 kg/m	11.0 lbs/ft	J55	3470 N*m	2560 ft*lbs
101.6 mm	4.000 in	16.4 kg/m	11.0 lbs/ft	C75	4600 N*m	3390 ft*lbs
101.6 mm	4.000 in	16.4 kg/m	11.0 lbs/ft	L80	4780 N*m	3530 ft*lbs
101.6 mm	4.000 in	16.4 kg/m	11.0 lbs/ft	N80	4880 N*m	3600 ft*lbs
101.6 mm	4.000 in	16.4 kg/m	11.0 lbs/ft	C90	5250 N*m	3870 N*m
114.3 mm	4.500 in	19.0 kg/m	12.8 lbs/ft	H40	2930 N*m	2160 ft*lbs
114.3 mm	4.500 in	19.0 kg/m	12.8 lbs/ft	J55	3870 N*m	2860 ft*lbs
114.3 mm	4.500 in	19.0 kg/m	12.8 lbs/ft	C75	5130 N*m	3780 ft*lbs
114.3 mm	4.500 in	19.0 kg/m	12.8 lbs/ft	L80	5340 N*m	3940 ft*lbs
114.3 mm	4.500 in	19.0 kg/m	12.8 lbs/ft	N80	5450 N*m	4020 ft*lbs
114.3 mm	4.500 in	19.0 kg/m	12.8 lbs/ft	C90	5870 N*m	4330 ft*lbs

These values have been extracted from API Recommended Practice 5C1 “Recommended practice for Care and use of Casing and Tubing”. The torque values listed above represent the optimum makeup torque. The maximum and minimum torque are 75% and 125% of the optimum values, respectively.

7.2 SUCKER ROD SPECIFICATIONS

Maximum Recommended Sucker Rod Torque Values

NORRIS SUCKER RODS AND PONY RODS					
Rod Size (Inches)	Grade D Carbon	Grade D Alloy	Grade D Special Alloy (78)	Special Service (96)	Special Service (97)
3/4"	430	460	470	500	500
7/8"	675	735	750	800	800
1"	1010	1100	1110	1200	1200
1-1/8"	N/A	1570	1590	N/A	1700
1-1/4"	N/A	2000	2100	N/A	2500

Above values are in “Foot Pounds”

Sucker Rod Weight and Dimensions

SUCKER RODS			COUPLINGS			
Rod Size (Inches)	T&C Weight (Lb. / Ft.)	API Thread Size	Slim Hole OD (Inches)	Regular OD (Inches)	Oversized OD (Inches)	Length (Inches)
3/4"	1.63	1-1/6"	1-1/2"	1-5/8"	1-13/16"	4"
7/8"	2.22	1-3/16"	1-5/8"	1-13/16"	2"	4"
1"	2.90	1-3/8"	2"	2-3/16"	N/A	4"
1-1/8"	3.67	1-9/16"	2-1/4"	2-3/8"	N/A	4-1/2"

7.3 USEFUL FORMULAS

$$\text{Polished Rod Speed} = \frac{\text{Production Rate (m3/day)}}{\text{Pump Nominal Displacement (m3/day/rpm)}}$$

$$\text{Torque (Ft. Lbs.)} = \frac{\text{Total Net Lift (m) x Nominal Disp (m3/day/100rpm)}}{125} + \text{Friction Torque}$$

Total Net Lift (m) = Dynamic Fluid Level (m) + Flowline Backpressure (m)

$$\text{Horse Power} = \frac{\text{RPM x Torque}}{5252} = \frac{\text{Amps x Volts x Eff x PF x 1.73}}{746}$$

Where:

Eff = electric motor efficiency

PF = motor power factor

$$\text{Specific Gravity} = \frac{141.5}{\text{API} + 131.5}$$

$$\text{Belt Length} = 2C + \frac{\pi}{2}(D + d) + \frac{(D - d)^2}{4C}$$

Where:

C = center distance between sheaves

D = pitch dia. of Drive Sheave

d = pitch dia. of Primemover Sheave

Fresh Water Gradient = 0.433 PSI/Foot = 9.8 Kpa/Meter

Fresh Water Sp. Gr. = 1.0

Specific Gravity/API Conversion

Oil Density (Kg/M3)	Specific Gravity	API
780	0.780	49.8
800	0.800	45.3
820	0.820	41.0
840	0.841	36.9
860	0.861	32.9
880	0.881	29.2
900	0.901	25.6
920	0.921	22.2
940	0.941	18.9
960	0.961	15.8
965	0.966	15.0
970	0.971	14.3
975	0.976	13.5
980	0.981	12.8
985	0.986	12.1
990	0.991	11.3
995	0.996	10.6
1000	1.001	9.9
1020	1.012	7.1

TIME REQUIRED TO FILL TUBING STRING

Tubing Size	Pumping Rates			
	25 BPD	5M3/day	100 BPD	20M3/day
2-3/8"	22 min / 100 ft	29 min / 50 m	6 min / 100 ft	7 min / 50 m
2-7/8"	33 min / 100 ft	43 min / 50 m	8 min / 100 ft	11 min / 50 m
3-1/2"	50 min / 100 ft	65 min / 50 m	13 min / 100 ft	16 min / 50 m

7.4 CONVERSIONS

Length = Feet x 0.348 = Meters
Meters x 3.281 = Feet
Inch x 0.0254 = Meters
Meters x 39.36996 = Inch

Area = Sq. Feet x 0.0929 = Sq. Meters
Sq. Meters x 10.764 = Sq. Feet

Volume = Cu. Feet x 0.02832 = Cubic Meter
Cubic Meter x 35.31 = Cubic Feet

Mass = Pounds x 0.4536 = kilograms
Kilograms x 2.205 = Pounds

Force = Pound·Force x 0.445 = DecaNewtons
DecaNewtons x 2.25 = Pound·Force

Torque = Pound·Force · Foot (lbf·ft) x 1.356 = Newton· meter (N·m)
Newton meter x 0.738 = Pound·Force · Foot (lbf·ft)

Pressure = PSI x 6.895 = Kpa
Kpa x 0.145 = PSI

Flow Rate = USGPM x 34.3 = BPD
USGPM x 5.451 = M3/day
Barrels x 0.159 = Cubic Meters
Cubic Meters x 6.29 = Barrels
1 Barrel = 42 US Gallons = 35 Imperial Gallons

Protex CIS Ltd Warranty

This shall be the only warranty given by Protex CIS Ltd ("Company"), and no other warranty by Company, Express or Implied, shall be applicable, including any implied warrant of merchantability or any implied warranty of fitness for a particular purpose.

Subject to the limitations and conditions herein, Company warrants its products (with the exception of stuffing boxes) to be free from defects in workmanship and material under normal use and service for a period of twelve (12) months from the date of installation or eighteen (18) months from the date of shipment, whichever occurs first. Company warrants stuffing boxes to be free from defects in workmanship and material under normal use and service for a period of three (3) months from the date of installation or nine (9) months from the date of shipment, whichever occurs first.

Company's obligations under this warranty shall be limited to repairing, replacing or issuing credit for, at Company's option, any product or parts it finds to be defective in material or workmanship. Company must be given a reasonable opportunity to investigate. Shipping and handling in connection with this warranty will be at customer's expense. Products sold by Company, but manufactured by another company, will carry only the warranty of the manufacturer, and the customer will rely solely on that warranty. Services provided by Company are warranted for a period of ninety (90) days from the date the services are rendered. The liability of Company for any loss or damage resulting to the customer or user or any third party from any defect in any product or service will not, in any case, exceed the selling price that Company received from the customer for the product or service. The above shall be the customer's exclusive remedy with respect to products or services. In no event will company be liable for incidental, consequential, special, indirect or other damages of any nature.

This warranty will not apply and will be void if the product fails as a result of down hole corrosion; non-compatibility of produced fluid with the stator and/or rotor; general wear and abrasion; incorrect installation, removal, use or maintenance; operation outside of the manufacturer's recommended guidelines; alteration; accident; abuse or negligence. Hydraulic wellhead drives, hydraulic power transmission units or stuffing boxes sold individually for use with equipment not manufactured by Company will not be covered under this warranty.

Company does not warrant that any of the products sold by it, if used or sold in combination with other equipment or used in the practice of methods or processes, will not, by virtue of such combination or use, infringe patents of other, and Company shall not be liable for any patent infringement arising from, or by reason of, any such use or sale. Furthermore, Company shall not be liable for any patent infringement arising from, or by reason of, any use or sale of any materials, equipment or products not of Company's manufacture or for the use or sale of any materials, equipment or products, or other goods specially made, in whole or in part, to the customer's design specifications.