# ***MAINTENANCE AND TROUBLESHOOTING OF PROGRESSIVE CAVITY PUMPS***

# *THE PROGRESSIVE CAVITY PUMP AND IT'S GEOMETRY*

- *A progressive cavity pump is a type of positive displacement pump and is also known as a progressing cavity pump, eccentric screw pump or cavity pump. PCP systems use a rotor and stator system that, once turned, causes the cavities to progress upward and move fluid from the intake to the discharge end of the pump.*
- *Rotors are made of Hardened Steel or Stainless Steel and are covered with a Chrome Plating to give resistance to corrosive and abrasive materials. Some liquids affect the Chrome Plating and in those applications a Non-Plated Rotor should be used. The Rotor forms a single helix and rotates eccentrically in the Stator.*
- *Stators are metal tubes with internally molded cavities of Synthetic or Natural Rubber. The Stator has a double helix cavity double the total volume of the rotor.*
- *The Rotor seals tightly against the flexible rubber stator as it rotates, forming tightly sealed cavities which move toward the discharge port, carrying the liquid. Liquid acts as the lubricant between the pumping elements. When combined, as the rotor turns, cavities or pockets nearly half of the total volume are formed in the stator which push the product from the suction toward the discharge end of the pump.*



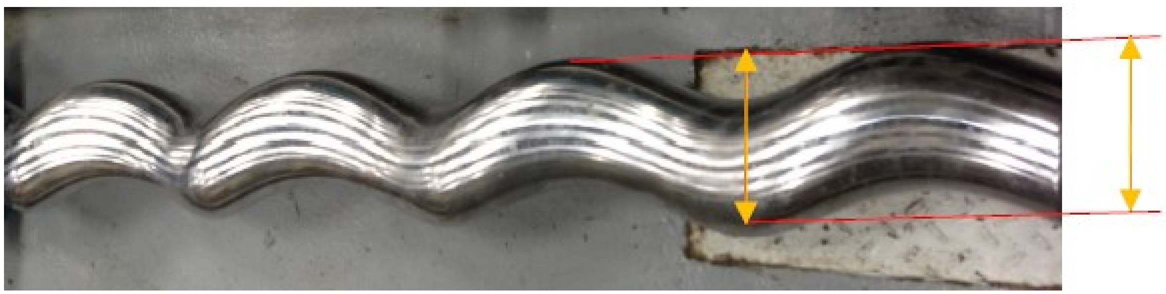
Syno®
PROGRESSIVE CAVITY PUMPS

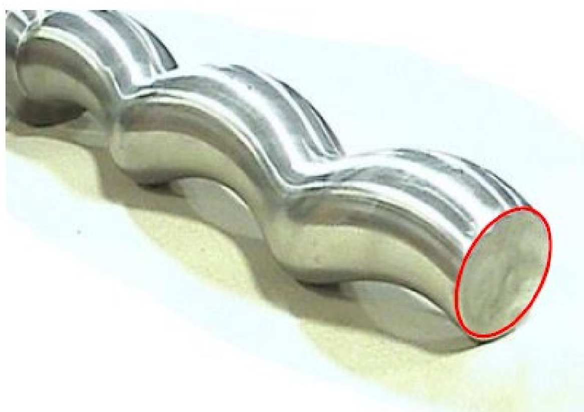
# GEOMETRY OF ROTOR

- *Crest to Crest*

  ***(called Major)***
- *Circular cross-section*

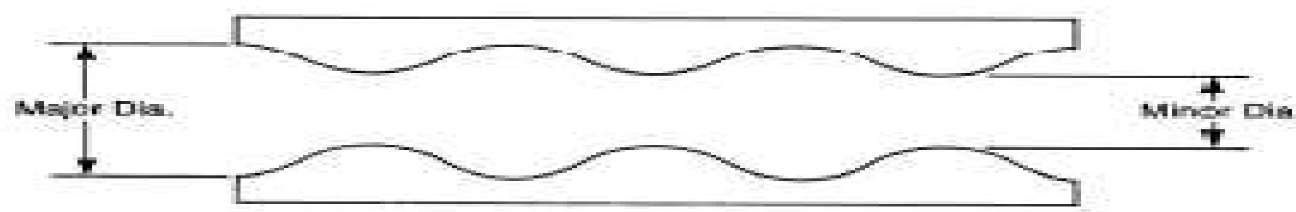
  ***(called Minor)***
- *Machined in a helical shape similar to a corkscrew*



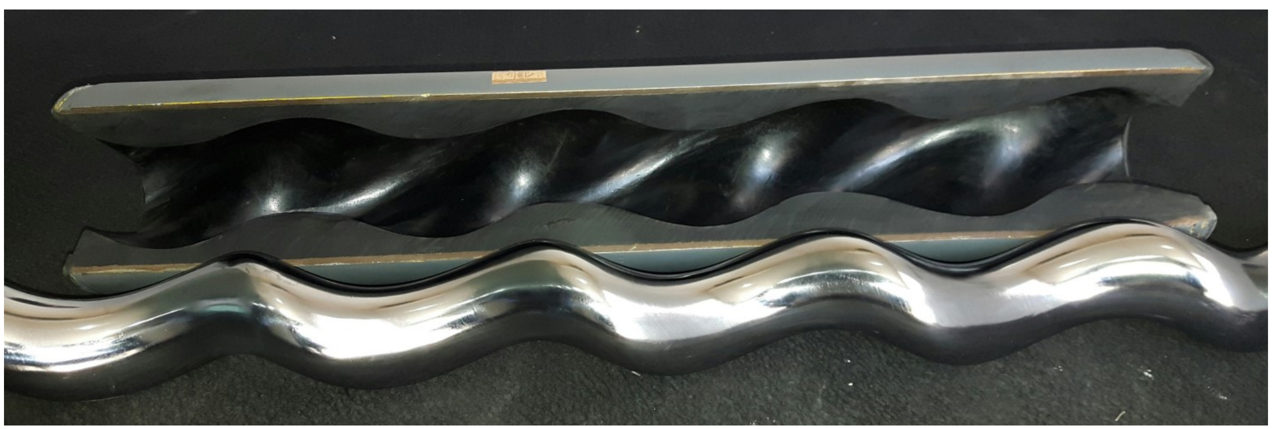


# *GEOMETRY OF STATOR*

- *Oval shaped cavity cross-section.*
- *Similar geometry as Rotor but uses a double helix.*
- *Available in several elastomers, metal, or urethane construction materials.*

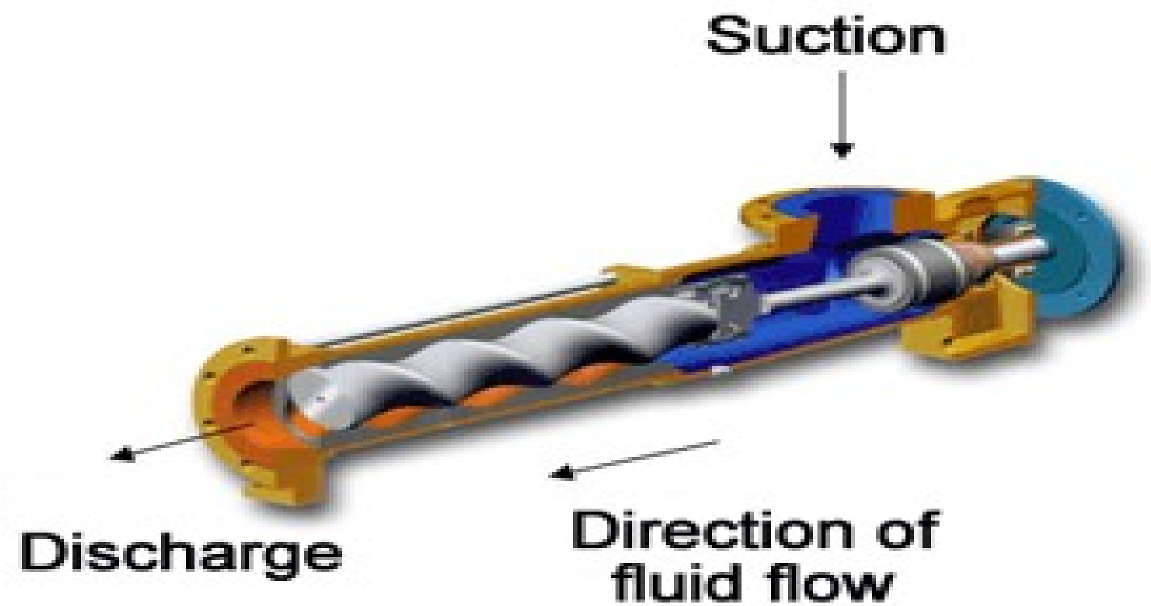



Stator

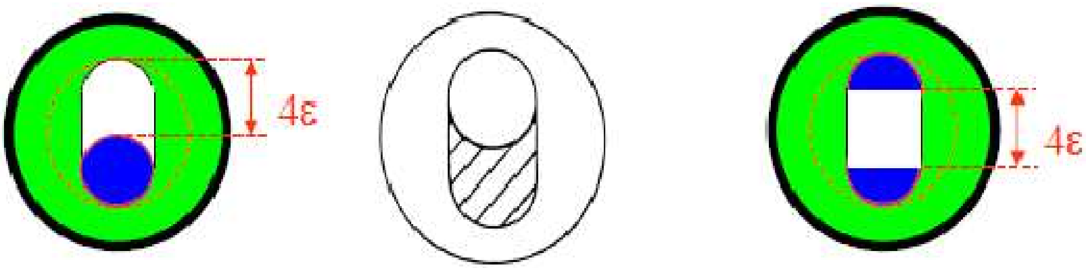


# *CAVITIES*

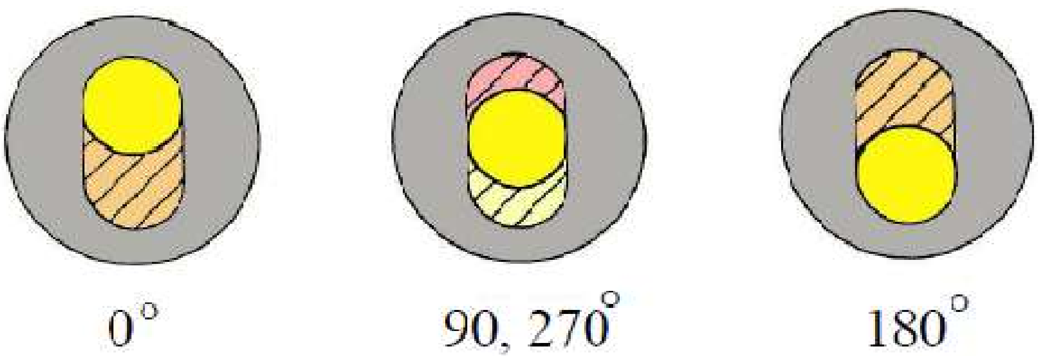
- *As Rotor orbits (turns eccentrically) inside the Stator.*
- *The motion creates cavities and progresses them from suction to discharge.*



# *END VIEW OF ROTOR/STATOR COMBINATION*




- *When the rotor is turned within the stator, the total cross-sectional area of the cavities remains the same regardless of the position of the rotor in the stator (see illustration below).*




- *LOOKING AT END VIEWS OF ROTOR TURNING IN STATOR, AS THE ROTOR COMPLETES ONE REVOLUTION. This feature results in a continuous, non-pulsating flow because the sum of any two opposing cavities is a constant.*

# *APPLICATION VARIABLES*

***APPLICATION INFLUENCES "THE MAJOR THREE"***

- ***Viscosity***
- ***Temperature***
- ***Abrasion***

# ABRASION EFFECTS

- *Abrasive fluids = Wear*

  **Wear is proportional to speed; minimize speed to minimize wear.*

  **De-rate pressure per stage to limit slip amount … 6 Bar for no abrasion; 1.4 Bar for heavy abrasion.*

  **Specify oversize Rotor to increase interference fit = longer life.*

  **Use abrasion resistant Stator material or softer durometer elastomers.*

  **Double chrome rotor for additional Rotor base metal protection.*

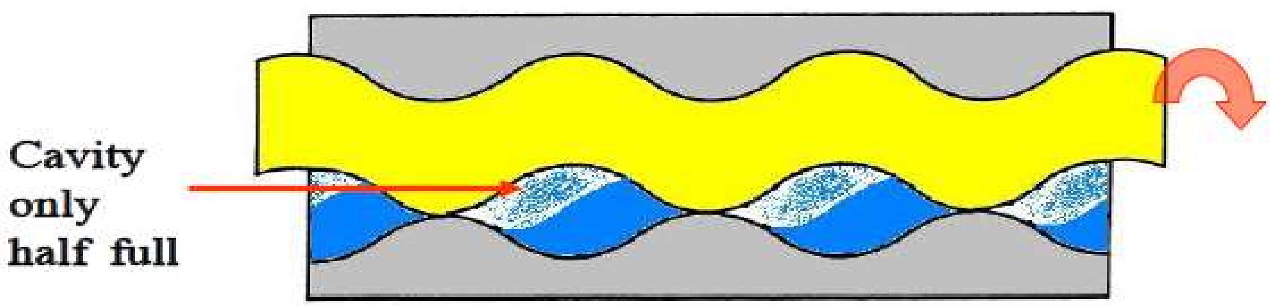
| Abrasive Characteristic | Fluids | Press /Stage |
|---|---|---|
| *None* | *Water, Polymer, Oil* | *6 Bar* |
| *Light* | *Milk or Lime* | *4.5 Bar* |
| *Medium* | *Sludge, Clay or Gypsum Slurries, Chocolate, Drilling Mud* | *3 Bar* |
| *Heavy* | *Emery Dust, Lapping Compounds, Grout, Sand, Granulated Sugar* | *1.4 Bar* |

# *TEMPERATURE EFFECTS*

- *Stator Elastomers swell from 70 to 130° (physical Rotor dimensions require adjustment above this 130° temperature) and Elastomers shrink with Lower temperature (Below 50°).*
- *Metal parts such as the rotor and drive train tend to expand and contract at a negligible rate than elastomer counterparts.*
- *Since Stator is bonded to a metal tube, the rubber can only swell inward on the rotor, or shrink away from the rotor.*
- *This changes the compressive fit between the rotor and stator. Again, to keep a standard fit, the Rotor requires under sizing above 130 º, and over sizing below 50º.*
- *Under extreme heat or cold, elastomer Stators may not be appropriate.*
- *Metal Rotor and Stator combinations can be used for extreme temperature applications because they swell or shrink at the similar rates.*

# *VISCOSITY EFFECTS*

- *The more viscous a fluid, the slower the pump will have to run in order to permit the fluid to flow into the cavity.*
- *Even at reduced speeds, the pump may not develop 100% volumetric efficiency and this must be accounted for in the selection process.*




Loss of Fill (volumetric) Efficiency starts at

*1 CPS = Above 1800 RPM*
*100 CPS = 700 RPM*
*1000 CPS = 150 RPM*
*10,000 CPS = 30 RPM*

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PROGRESSIVE CAVITY PUMPS

# VISCOSITY EFFECTS.... CONTINUED

| Material | Viscosity (centipoise) |
|---|---|
| Water @ 70deg F | 1-5 |
| Blood or Kerosene | 10 |
| Anti-freeze or Ethylene Glycol | 15 |
| Motor Oil SAE 10 or Corn oil | 50-100 |
| Motor Oil SAE 30 or Maple Syrup | 150-200 |
| Motor Oil SAE 40 or Castor Oil | 250-500 |
| Motor Oil SAE 60 or Glycerin | 1-2 thousand |
| Karo Corn Syrup or Honey | 2-3 thousand |
| Blackstrap Molasses | 5-10 thousand |
| Hershey Chocolate Syrup | 10-25 thousand |
| Ketchup or Common Mustard | 50-70 thousand |
| Tomato Paste or Peanut butter | 150-250 thousand |
| Crisco Shortening | 1-2 million |
| Caulking compound | 5-10 million |
| Window Putty (glazing compound) | 100 million |

## SUMMARY

# *How does a SYNO Pump work?*

*The standard PC Pump consists of a Rotor (metal) which rotates within an elastomeric Stator.*

- *The Rotor has a circular cross-section and is machined in a single helix like a corkscrew.*
- *The Stator cavity is molded as a double helix with an oval cross-section. The helix geometry is similar to the Rotor to create an interference fit.*
- *As the Rotor turns inside the Stator it orbits on an eccentric (at an offset around the center axis), this motion creates cavities that progresses from suction to discharge; moving product and building pressure.*

## *ADVANTAGES OF PROGRESSIVE CAVITY PUMPS*

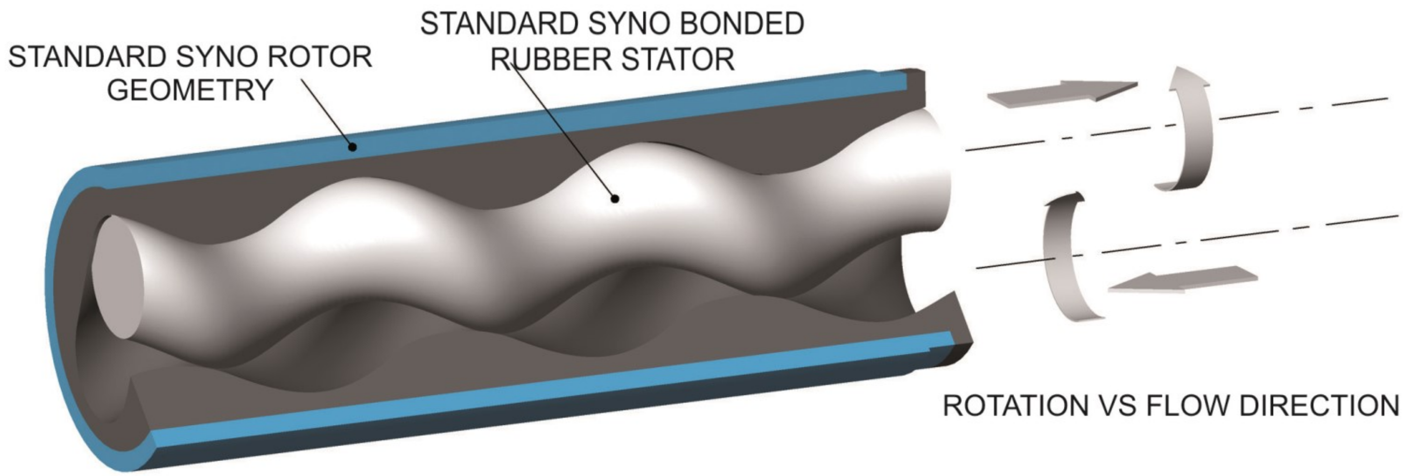
- *The SYNO design creates a low sheer, metered and pulse-less flow.*
- *The PC Pump is able to effectively handle "water-like" to super viscous fluids including levels of air or gases.*
- ✓ ***It can gently pump large particulates and handle abrasive solids.***
- ✓ ***Provides excellent suction capabilities and does not air lock.***
- *The SYNO design creates a low sheer, metered and pulse-less flow.*
- *The flexible geometry of the SYNO Pump allows:*
- ✓ ***Multiple drive end choices (power) and multiple stages (pressure).***
- ✓ ***Syno Pump allows precise control of the interference fit.***

***SYNO CAN BEST MATCH THE PUMP TO YOUR APPLICATION***

# PUMPING PRINCIPLE

- ***(Description of the operation of Syno Progressive Cavity Pump)***

  *The PC Pump is a very simple Pump. There are only two parts. A stationary part, the Stator and a rotating part, the Rotor. It is a positive displacement pump without valves and it delivers a constant flow. The PC Pump is actually a special case of the gear pump. It is a spiral gear pump with an external-tooth gear running in an internal-tooth gear. The internal gear (with external teeth) is called the Rotor and the external gear (with internal teeth) is called the Stator. PC Pumps are usually made in the most basic expression of this principle. The Rotor is a gear with 1 tooth, so it becomes a single threaded helix. The Stator is gear with 2 valleys so it becomes a double threaded helical cavity. The Stator has twice the pitch length of the Rotor.*



## PUMPING PRINCIPLE ... CONTINUED

- ***Consider the Cross-Sections:***

*At cross-section A, there is a fully developed cavity to the left of the Rotor. The cavity on the right is squeezed off (point x). In other words, a cavity has been terminated and another is about to begin. At cross-section B, the stator cavity has rotated 90 degree to the right and point x is now at the bottom of the cross-section. The cavity which was sealed off in cross-section A is now ½ developed. The Rotor has rotated 180°. At this point, it is obvious that there are cavities on both sides of the Rotor. Therefore, when the Rotor was inserted in the Stator, 2 chains of spiral, lenticular on-lapping cavities were formed. At cross-section C, the Stator cavity has rotated 180° and the cavity, which we are following, is at its fullest development. The cavity on the other side of the Rotor has reached its end and is sealed off. The Rotor has rotated 360°.*

*At cross-section D, the Stator has rotated 270° and the cavity is beginning to disappear. The Rotor has rotated 540°.*

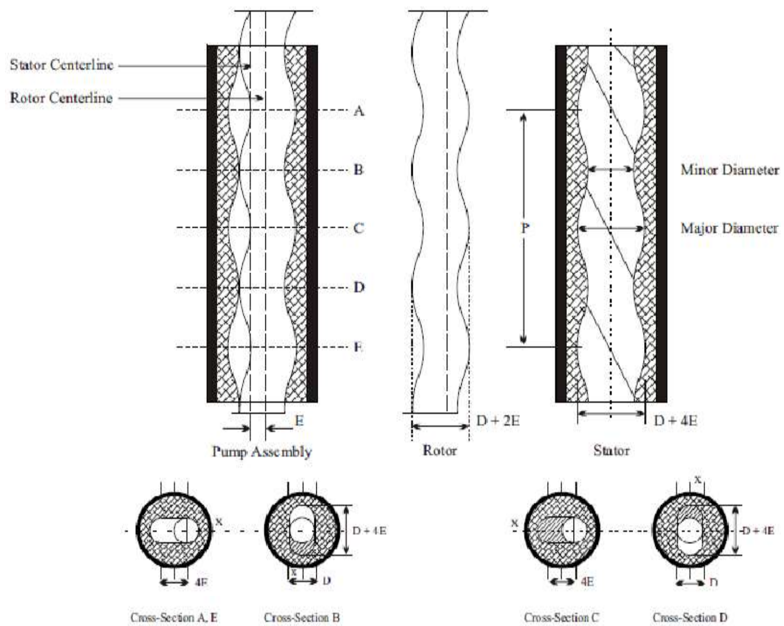
*At cross-section E, we are back where we started. The cavity is sealed off, the Stator has rotated 360° and the Rotor has rotated 720°.*

*Therefore, a cavity is 1 pitch length of the Stator, which are 2 pitch lengths of the Rotor. The cavities are sealed because the Stator is usually molded in an elastomer and there is an interference fir with the metal Rotor.*

*When the Rotor is turned to the right, the cavities spiral up the barrel of the pump without changing size or shape. This is why the PC Pump is an excellent Sludge Pump. If a particle is caught between the Rotor and the Stator wall, it is pressed into the wall as the Rotor passes, then it is expelled into the next cavity. Each cavity in the chain boosts the pressure by an equal amount. Therefore, each cavity is a stage.*

## *PUMPING PRINCIPLE … CONTINUED*

- *The pressure rating of a Progressive Cavity Pump is the pressure at which the pump is the most efficient. Below that rating, the pump is less efficient because of internal friction. Above that rating, the pump is less efficient because of increased slippage. PC Pumps will work at pressures higher than the pressure rating, but the life is shortened. It is recommended that PC Pumps be run at 75% of the rated head for long life in non-abrasive conditions; and 50% of the rated head in abrasive conditions, if possible. The pressure rating of a progressing cavity pump is usually close to 500 kPa per stage, but that varies with the hardness of the elastomer and the geometry of the pump (i.e. short pitch vs. long pitch).*

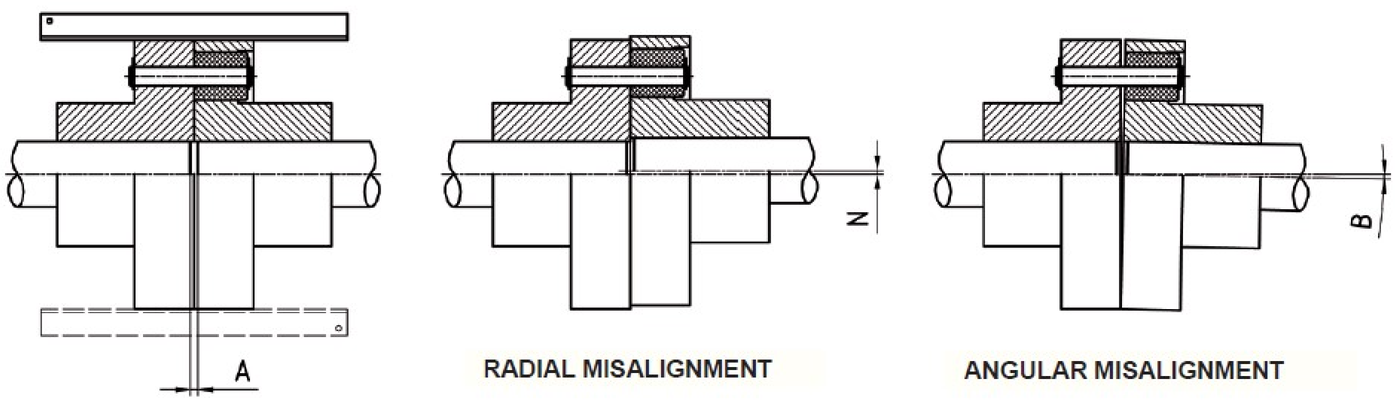


# *MOTOR TRANSMISSION COUPLINGS*

- *Drive for independently mounted progressive cavity pumps is transmitted via flexible couplings designed to absorb impact and torsional vibration. These couplings compensate for both angular and radial misalignment and can sustain variations in load and rotation inversion.* ***The couplings are sized in compliance with DIN 740/2 standards. A coupling is sized so that the maximum moment transmitted by the coupling in different operating conditions is less than the maximum permissible strain for the coupling itself.***

  *Transmission couplings with ATEX marking are available for machines for use in potentially explosive environments. Pumps supplied complete with motor and base are delivered already aligned during assembly. The base plate may be warped, however, if fixed to an uneven surface.* ***Perfect alignment between the pump and motor is essential for correct operation.***

  *As a result, after installation, we recommend checking pump-motor alignment once again, using the values given in the following table as reference.*



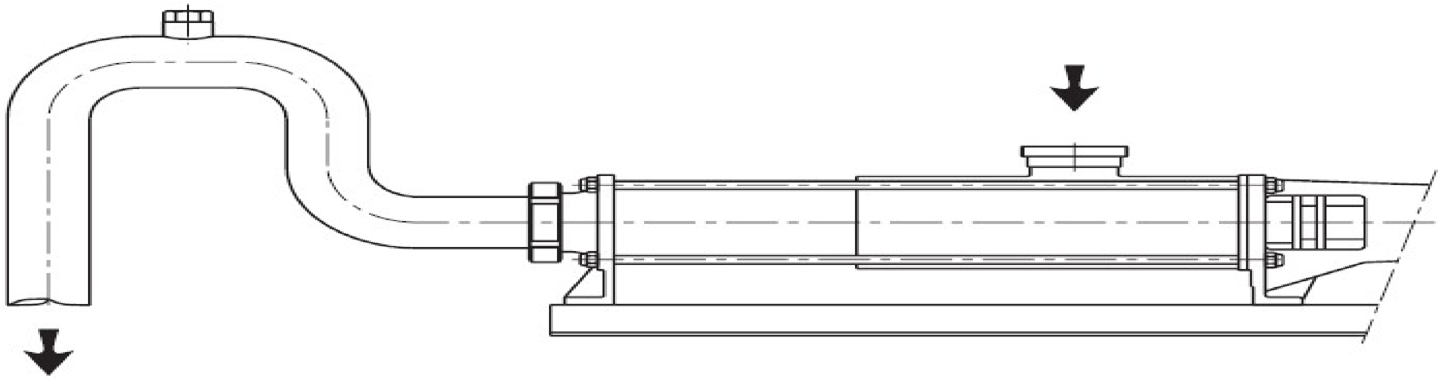

RADIAL MISALIGNMENT

ANGULAR MISALIGNMENT

# *PIPING*

1. *If the pump is installed with a negative head, to prevent the pump from running dry, include a siphon in the pipe with a section of pipe raised above the level of the pump. This ensures that there is always enough product in the pump to prime it at the subsequent start. A tap must be included at the highest point in the siphon to fill the pump before first usage or after the pump has been emptied.*

   *If there is a possibility of the suction intake of the pump emptying, at each start, the vertical section of pipe must contain a volume of product at least equal to the volume of air that must be expelled from the suction intake (or at least 10% more if the pump aspirates from the suction intake).*



2. *To prevent harmful stress, the suction and delivery pipes must be connected to the pump inlet and outlets without forcing. These pipes must be replaceable independently without subjecting the pump to any strain.*

3. *The internal diameter of the pipes must match the diameter of the pump connectors. The pipe diameter must not be less than the connector diameter as this would cause an increase in head loss and reduced machine performance.*

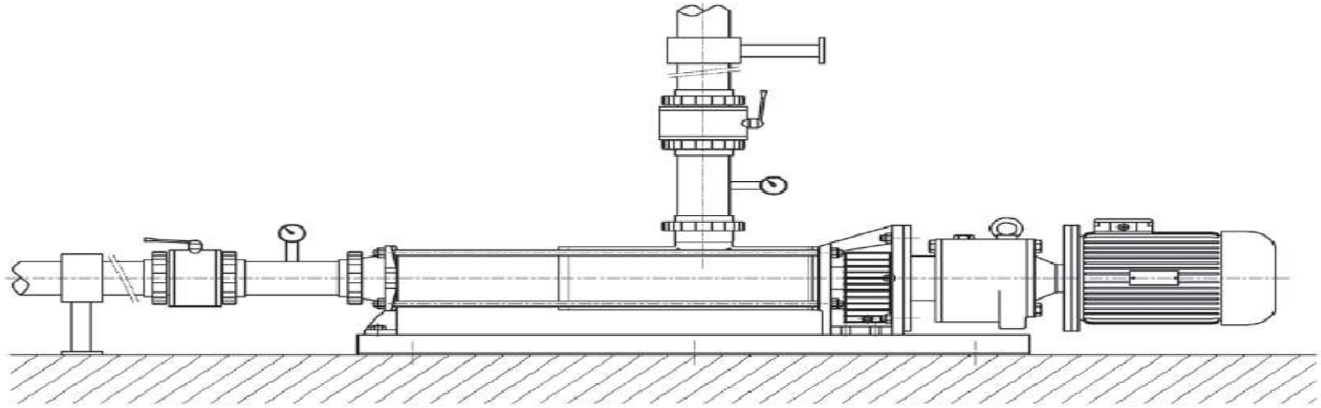
4. *With very long pipes, install a valve at the pump inlet and outlet to permit pump inspection without having to drain the entire system.*

5. *Reduce the number of bends and constrictions in the system as much as possible.*

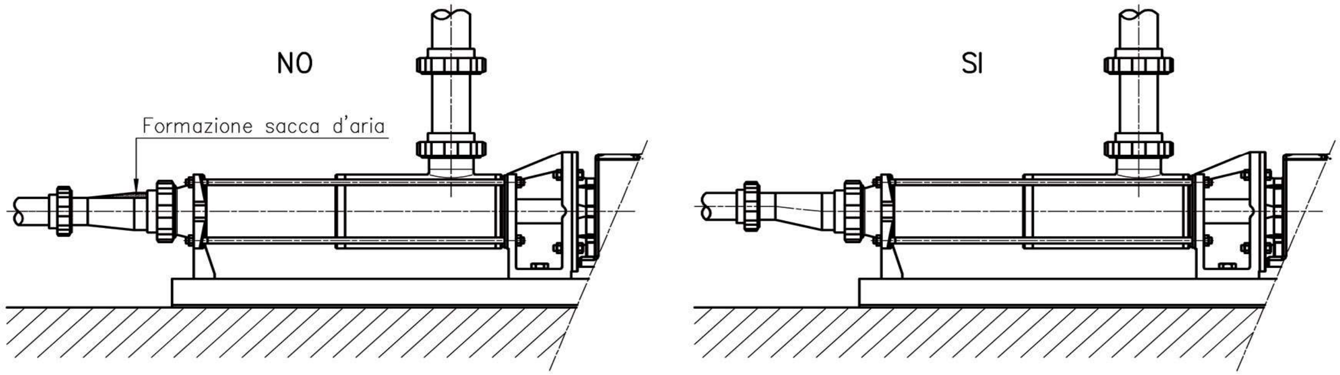
6. *Check the seal tightness of the suction pipe unions to prevent loss of suction capacity.*

7. *When pumping fluids at high temperatures, flexible expansion joints must be included to prevent strain caused by thermal expansion.*

*Installing manometers on the piping and as close to the pump as possible is recommended in order to monitor the operating conditions of the pump.*



8. *Installing a filter at the pump suction intake is recommended to prevent foreign bodies from entering the pump.*
9. *The suction pipe should be as short as possible and should rise slightly toward the pump. Using eccentric reduction adaptors is recommended to prevent the formation of air pockets.*



# ***PUMP MAINTENANCE (GENERAL)***

# *PREVENTIVE MAINTENANCE*

***Most of the maintenance needed for a SYNO pump is based on "look-feel"***

## ***Daily Inspection:***

- *Lip seals in bearing housing*
- *Packing/Mechanical Seal (flow/pressure/noise)*
- *Gear reducer (temp/noise)*

## ***Weekly Maintenance:***

- *Adjust packing (should drip 2-5 times per minute)*
- *Lube packing (typically 2-3 pumps per week)*

## ***Yearly Maintenance:***

- *Replace packing, inspect shaft wear*
- *Replace automatic lubricator (if applicable)*
- *Pull spool piece to inspect pipe internal condition.*

# LUBRICATION SCHEDULE

- ***Bearings:***

  *Bearings are lubricated and the factory and do not normally need periodic re-lubrication recommended only when drive shaft is removed for maintenance.*

- ***Packing:***

  *Once a week or more, frequency determined by process.*

- ***Carden Joints:***

  *Only recommended when Carden Joints are disassembled.*

  *(example;  at the time of rotor replacement)*

# ***FAILURE ANALYSIS***

# ***EXAMPLES OF WORN & FAILED SYNO PARTS***

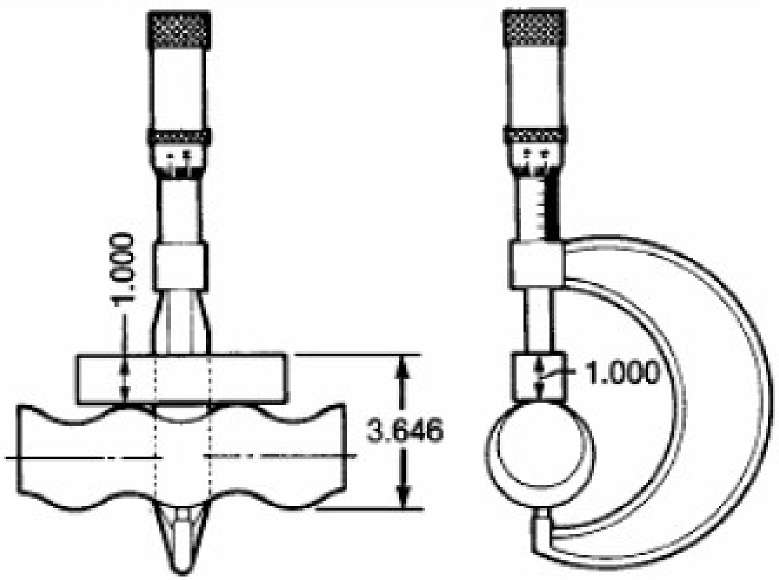
# FAILURE ANALYSIS

- ***Was the failure caused by operator error? Is there a process issue? Was there a mechanical shortfall?***

- *Failure analysis will help to determine future preventative maintenance and narrow the decision making for necessary changes concerning process or equipment.*

PROGRESSIVE CAVITY PUMPS

# *FAILURE ANLAYSIS...... INSPECTING ROTORS*




To check any rotor, place 1.000 inch bar across the crest on one side of the rotor. The micrometer reading minus 1.000 equals the rotor crest to crest diameter. Example: 3.646 in.-1.000 in. = 2.646 in. crest to crest.

Figure 4-4. Measuring Rotor Dimension

| Rotor Capacity | Standard *Crest to Crest Dia. (inches) |
|---|---|
| 008 | 2.772 + .000/—.004 |
| 012 | 2.676 + .000/—.004 |
| 022 | 3.425 + .000/—.004 |
| 036 | 4.015 + .000/—.004 |
| 050 | 4.015 + .000/—.004 |
| 065 | 4.906 + .000/—.004 |
| 090 | 4.906 + .000/—004 |
| 115 | 5.709 + .000/—.004 |
| 175 | 6.584 + .000/—.004 |
| 335 | 5.800 + .000/—.005 |
| 345 | 7.260 + .000/—.004 |
| 620 | 7.128 + .000/—.005 |
| 800 | 7.658 + .000/— .004 |

# FAILURE ANLAYSIS…… INSPECTING STATORS

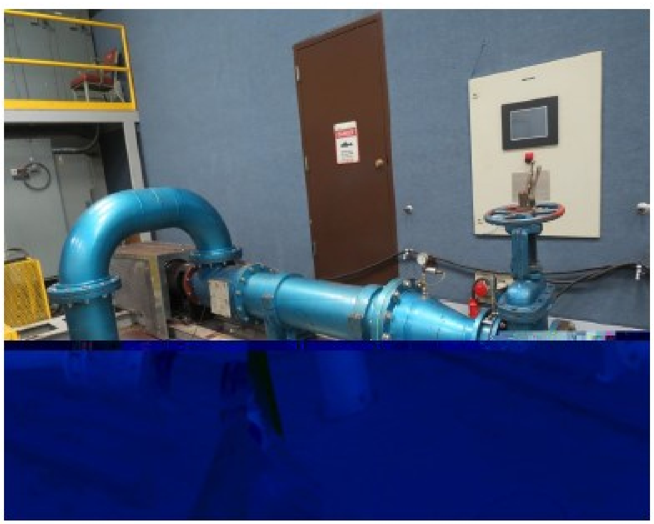
*A worn Stator may appear pitted and gauged, or may appear smooth similar to new.*

*Performance is the best measure of Rotor to Stator fit. If unable to measure performance adequately, suspected Stator wear can be evaluated by a* ***SYNO*** *representative.*

# FAILURE ANLAYSIS

## What is Cavitation and how can I tell if my pump is Cavitating?

*In summary, cavitation is an abnormal condition that can result in loss of production, and equipment damage. In the context of pumps, the term cavitation implies a dynamic process of formation of bubbles inside the liquid, their growth and subsequent collapse as the liquid flows through the pump. It can be* ***vaporous or gaseous.***



*Both types of bubbles are formed at a point inside the pump where the local static pressure is less than the vapor pressure of the liquid (vaporous cavitation) or saturation pressure of the gas (gaseous cavitation, also referred to as "air binding"). The noise and pump vibration is caused by the collapse of the air bubble when it gets pressurized.*

*Typically in a* ***SYNO*** *pump the cause of cavitation is a lack of suction volume. The symptoms are reduced flow, a rumble with vibration or and may include a rapid popping sound.*

# FAILURE ANLAYSIS

- TYPICAL ROTOR ABRASIVE PATTERN WEAR
- NOTE THE TELLTALE RIDGES

PROGRESSIVE CAVITY PUMPS

## *FAILURE ANLAYSIS*

- *ABRASIVE WEAR ON A ROTOR*
- *NOTE THE RIDGES OR GROOVES*

# FAILURE ANLAYSIS

- ABRASIVE WEAR ON A SS 316 ROTOR
- NOTE THE DEEP GAUGING GROOVES

# *FAILURE ANLAYSIS*

- *TYPICAL ROTOR EVEN WEAR PATTERN*
- *A LITTLE TOO WORN TO*

  *RE-PLATE*
- *ADJUSTING THE MAINTENANCE INTERVAL MAY LOWER COSTS*

# *FAILURE ANLAYSIS*

- *CHEMICAL ATTACK TO THE* ***EXPOSED CARBON STEEL BASE METAL OF A CHROME PLATED ROTOR.***
- *A SYMPTOM INDICATING THE ROTOR BASE METAL IS NOT COMPATIBLE WITH THE PROCESS*

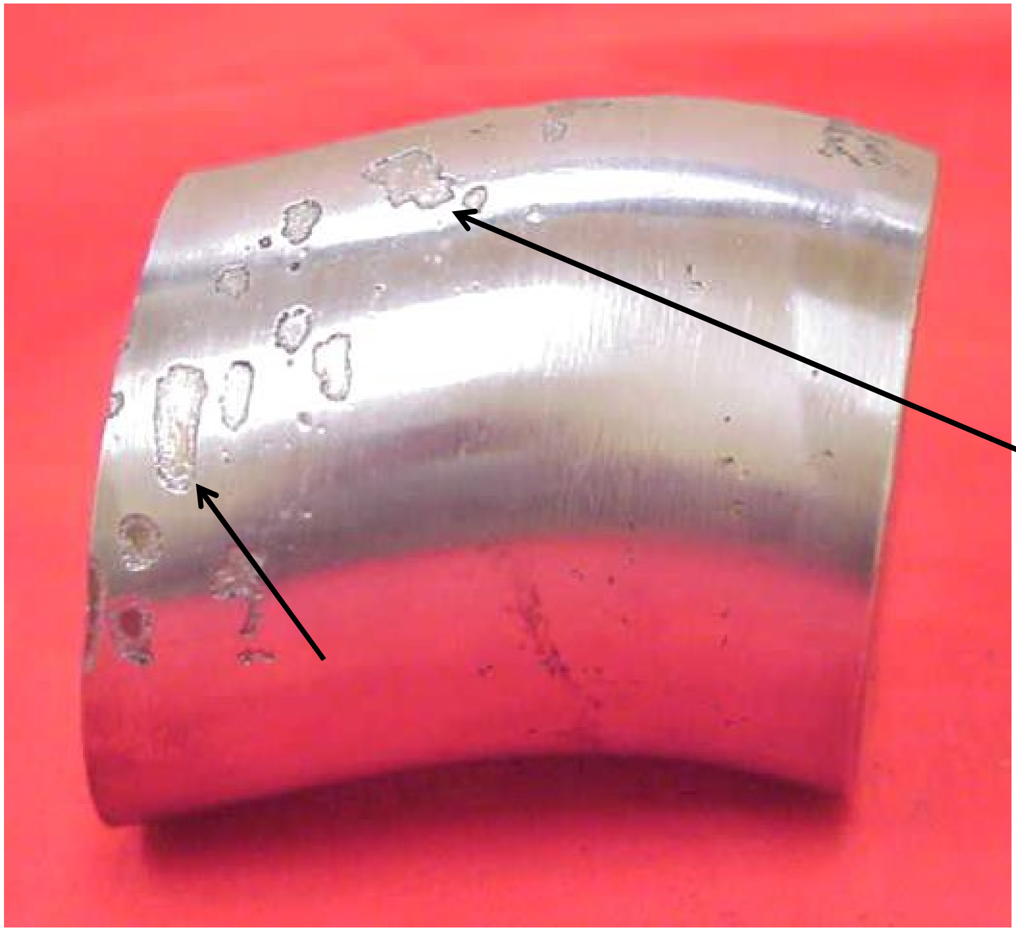
# *FAILURE ANLAYSIS*

- *CHEMICAL ATTACK UNDERMINING THE CARBON STEEL BASE METAL* ***THROUGH*** *THE CHROME PLATING.*

# *FAILURE ANLAYSIS*

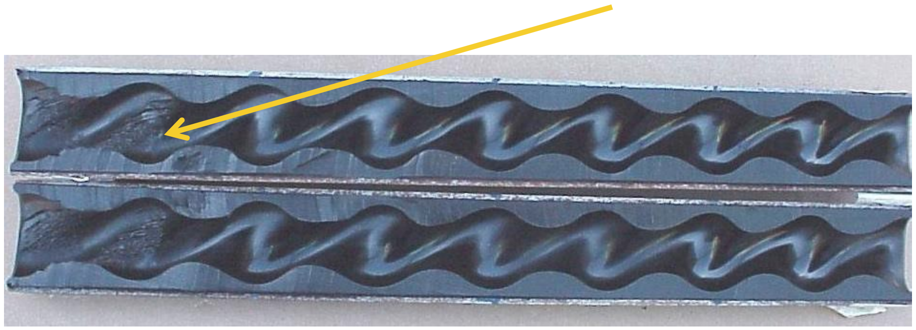
- *CHEMICAL ATTACK TO THE CARBON STEEL BASE METAL* ***THROUGH THE CHROME PLATING.***

# FAILURE ANLAYSIS



- ***CHEMICAL ATTACK TO THE 316 SS BASE METAL UNDER THE CHROME PLATING.***

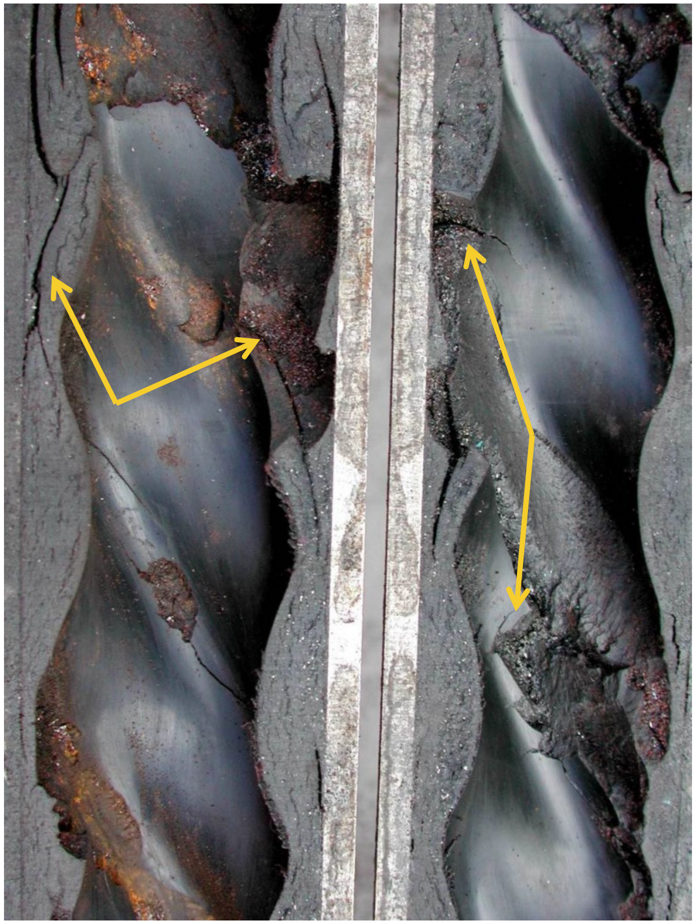
## *FAILURE ANLAYSIS*



- ***THE INNER SURFACE OF A RUN DRY STATOR IS HARD AND HAS A VERY ROUGH TEXTURE.***
- ***AN ORANGE PEEL TEXTURE ALONG SEAL LINES IS A TELLTALE SIGN OF RUN DRY.***

***RUN DRY DAMAGE NORMALLY BEGINS AT THE SUCTION END.***

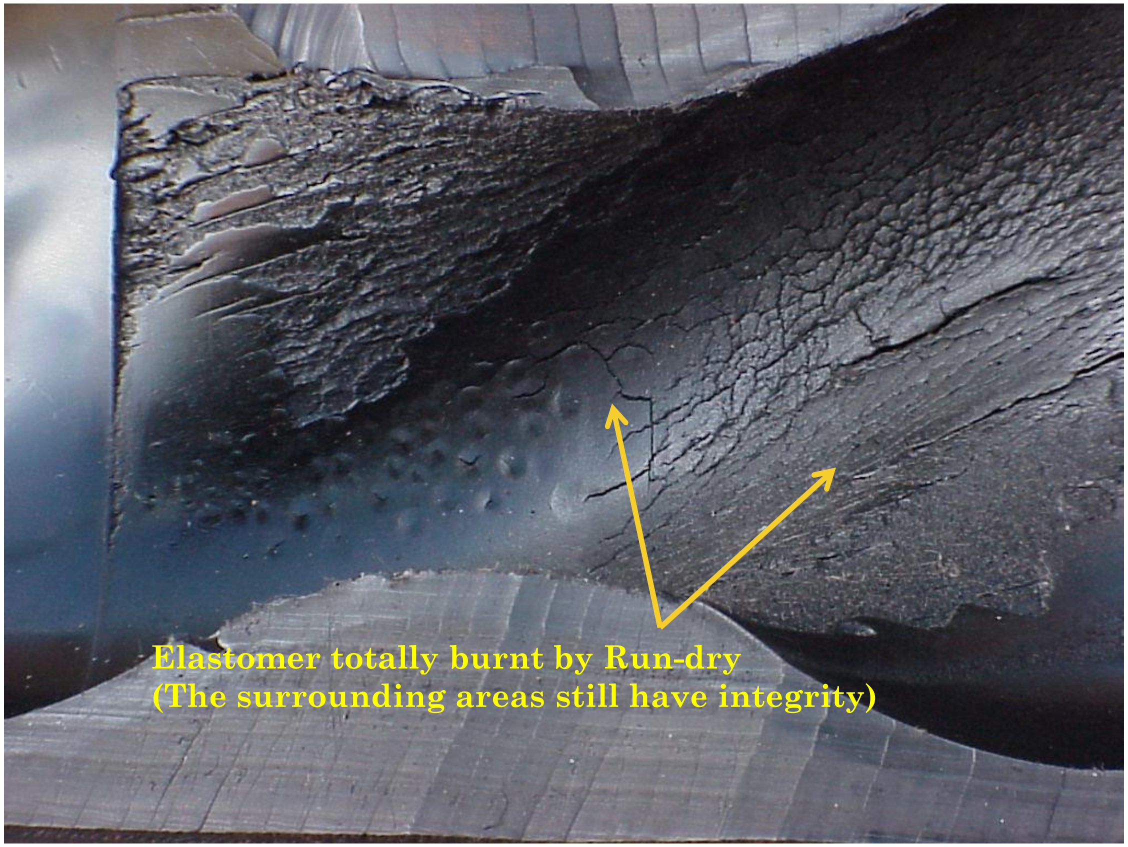
# *FAILURE ANLAYSIS*



- ***CHEMICAL ATTACK AND RUN DRY CAN OFTEN HAVE A SIMILAR APPEARANCE.***
- ***ONCE CHEMICAL ATTACK HAS SET IN RUN DRY WILL EVENTUALLY OCCUR.***
- ***NOTE THE EVIDENCE OF HARDNESS AND ROUGH TEXTURE AND CRACKS THROUGH THE ELASTOMER. THESE DEEP CRACKS THROUGH THE ELASTOMER CAN CONFIRM CHEMICAL ATTACK.***

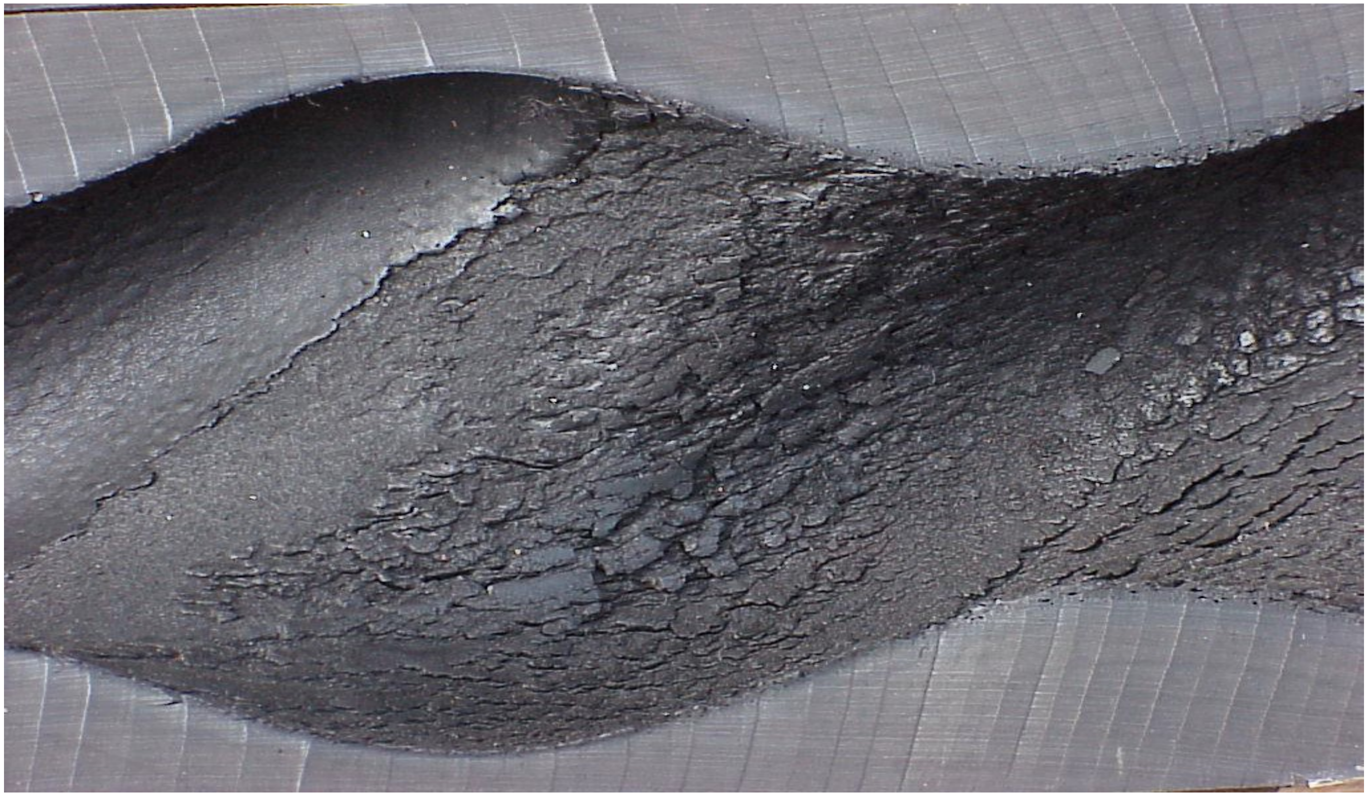
PROGRESSIVE CAVITY PUMPS

# *FAILURE ANLAYSIS*




- ***THE SURFACE OF THE STATOR IS HARD AND HAS AN ORANGE PEEL TEXTURE.***
- ***THE SURFACE BLISTERING AND CRACKING COMBINED WITH A BURNED SMELL AND THE ELASTOMER INTACT IN SURROUNDING AREAS IS CONSISTENT WITH RUN DRY***

## *FAILURE ANLAYSIS*



- ***Elastomer totally burnt by running dry. Note that surrounds areas are perfect.***
- ***This results in a different diagnostic process and narrows the focus when evaluating the loss of performance.***

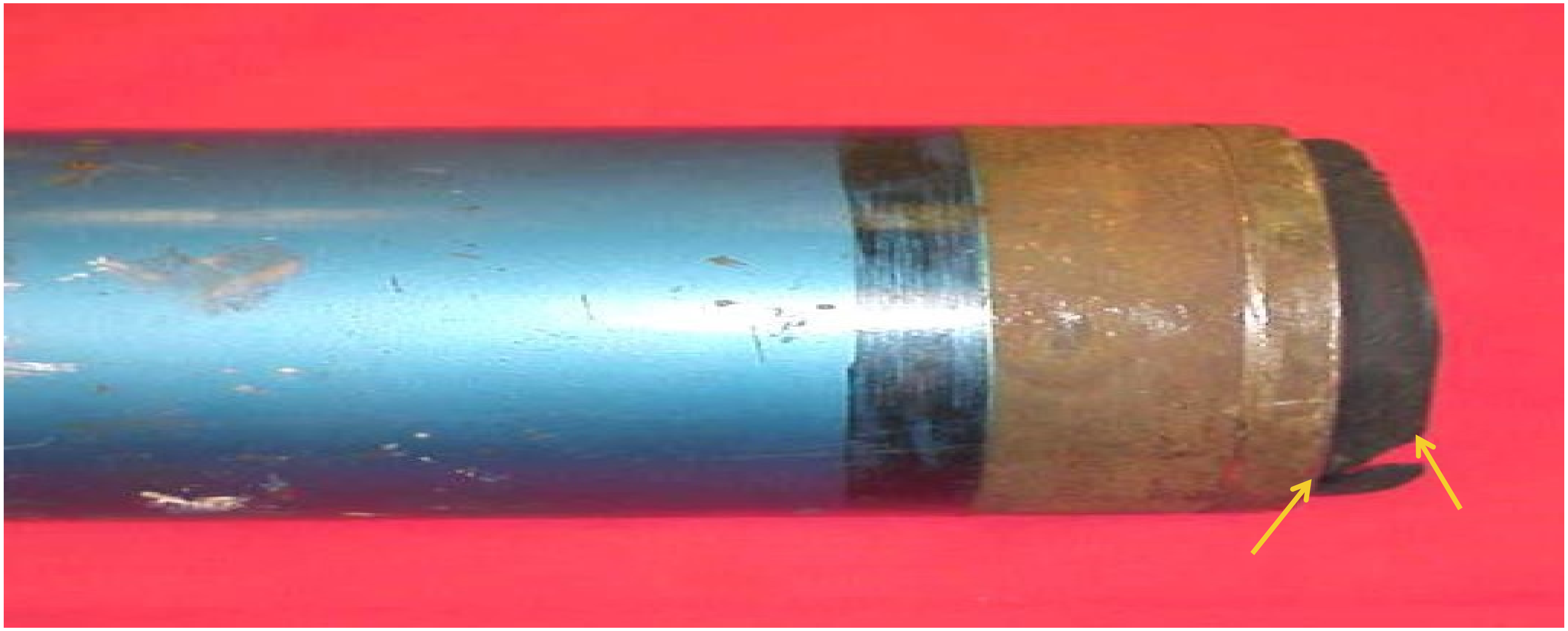
# FAILURE ANLAYSIS

- THE STATOR HAS BECOME SOFT AND TACKY AS A RESULT OF RUN DRY.
- THE ELASTOMER IS SMEARED AND STICKING TO THE ROTOR.
- THE STATOR WILL SMELL LIKE BURNED RUBBER AND HAVE A MELTED APPEARANCE.

## *FAILURE ANLAYSIS*

- ***ELASTOMER SWELLING IS EVIDENT ON THE ENDS OF THIS STATOR.***
- ***SIGNIFICANT SWELLING OR SHRINKING IS A CLEAR SIGN OF CHEMICAL ATTACK.***

# FAILURE ANLAYSIS



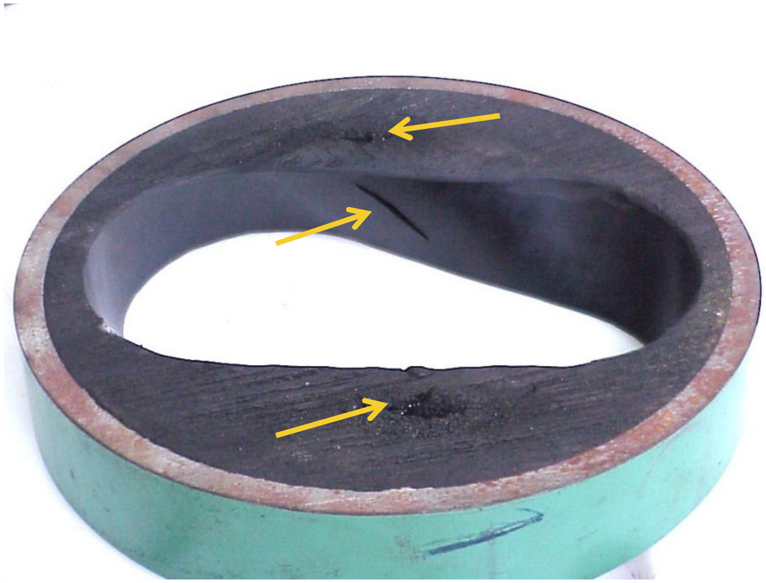
- *CHEMICAL ATTACK HAS CAUSED THIS NITRILE STATOR TO SWELL. NOTE HOW THE RUBBER BULGES OUT PAST THE END OF THE STATOR TUBE.*

  *THIS TYPE OF CHEMICAL ATTACK (SWELLING) COULD OCCUR WITH ANY STATOR ELASTOMER.*

## FAILURE ANLAYSIS

- *DELAMINATION IS THE RESULT OF THE ELASTOMER MOLECULES NOT KNITTING PROPERLY DURING THE MANUFACTURING PROCESS. THE ELASTOMER MAY THEN COME LOOSE IN LAYERS WHILE PUMPING AGAINST HIGH DISCHARGE PRESSURE.*

# FAILURE ANLAYSIS



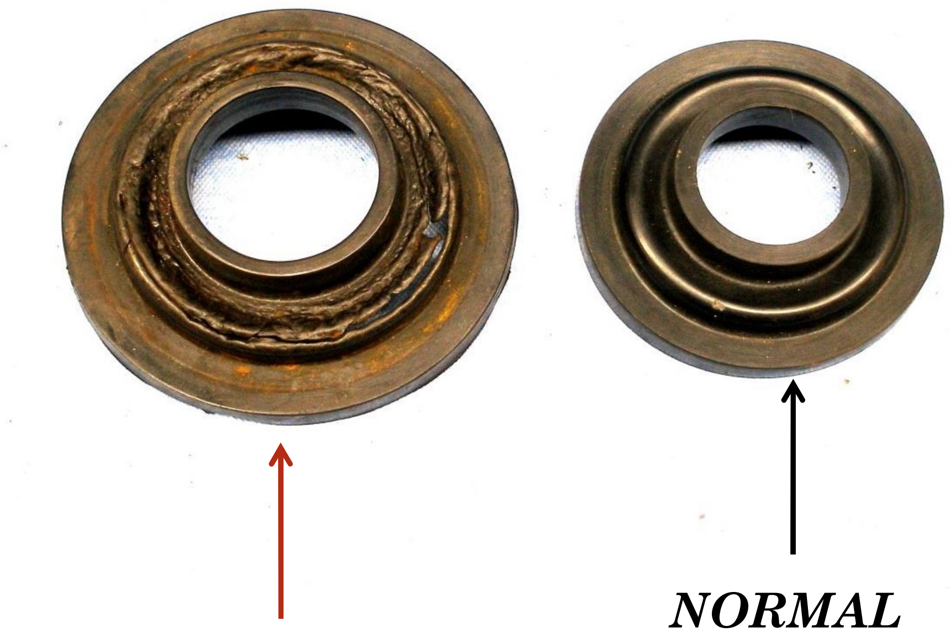
***Hysteresis (fatigue)***

**Action:** ***Cycling loads on elastomer increases internal temperature and causes a secondary vulcanization.***

***Result:*** ***The elastomer loses its elastic properties, becomes very hard and cracks arise in the surrounds areas of cycling loading.***

***LARGE CHUNKS TYPICALLY WILL BREAK LOOSE***

# *FAILURE ANLAYSIS*

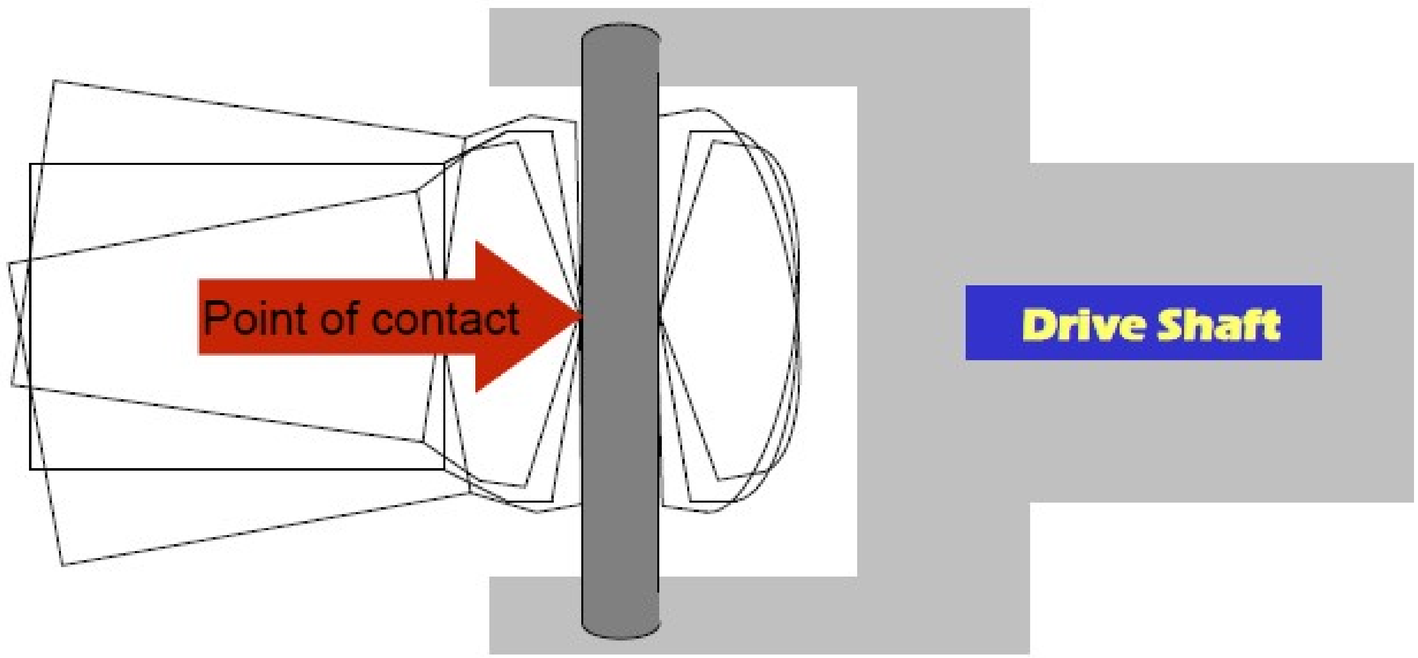


***NORMAL***

***BAD SEAL***

- ***CARDEN JOINT SEALS SHOULD BE INSPECTED FOR DAMAGE WHEN THE PUMP IS SERVICED.***

## *FAILURE ANLAYSIS*




- ***Pin Joint Dynamics – Point Contact in Connecting Rod The "hour glass" shape necessary to transfer motion, results in large thrust loads to be transferred to the pin in a point contact.***

# *FAILURE ANLAYSIS*

- ***TYPICAL PIN WEAR PATTERNS***

# FAILURE ANLAYSIS

- *TYPICAL CONNECTING ROD WEAR PATTERN*

## *FAILURE ANLAYSIS*

- ***EXCESSIVE ROTOR HEAD WEAR***

# *QUESTIONS?*

*For any kind of Query or Technical Assistance, you are requested to contact our* ***Technical Director – Mr. Malkeet Singh (+91 98 38 39 28 39)***

***THANKS***
***FOR YOUR***
***VALUABLE TIME***