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Maintenance and Troubleshooting of Progressing Cavity Pumps

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The Progressing Cavity Pump and it's Geometry

- A progressing cavity (PC) pump, or a single screw pump, is a positive displacement pump and therefore a fixed volume is displaced with each revolution of the pump's Rotor.
- The Rotor forms a single helix (like a corkscrew) and rotates eccentrically in the Stator.
- The Stator has a double helix cavity (like a double corkscrew) double the total volume of the rotor.
- 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.

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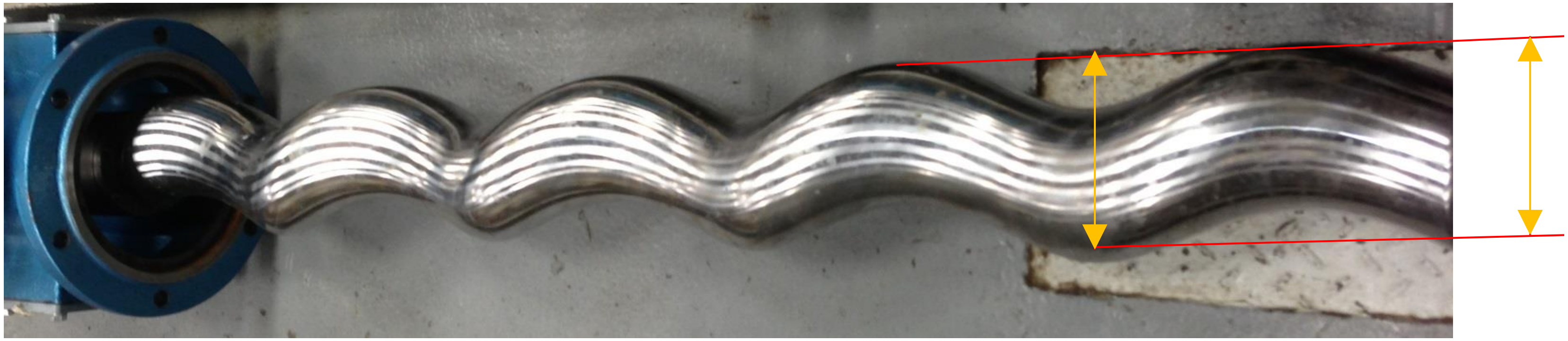
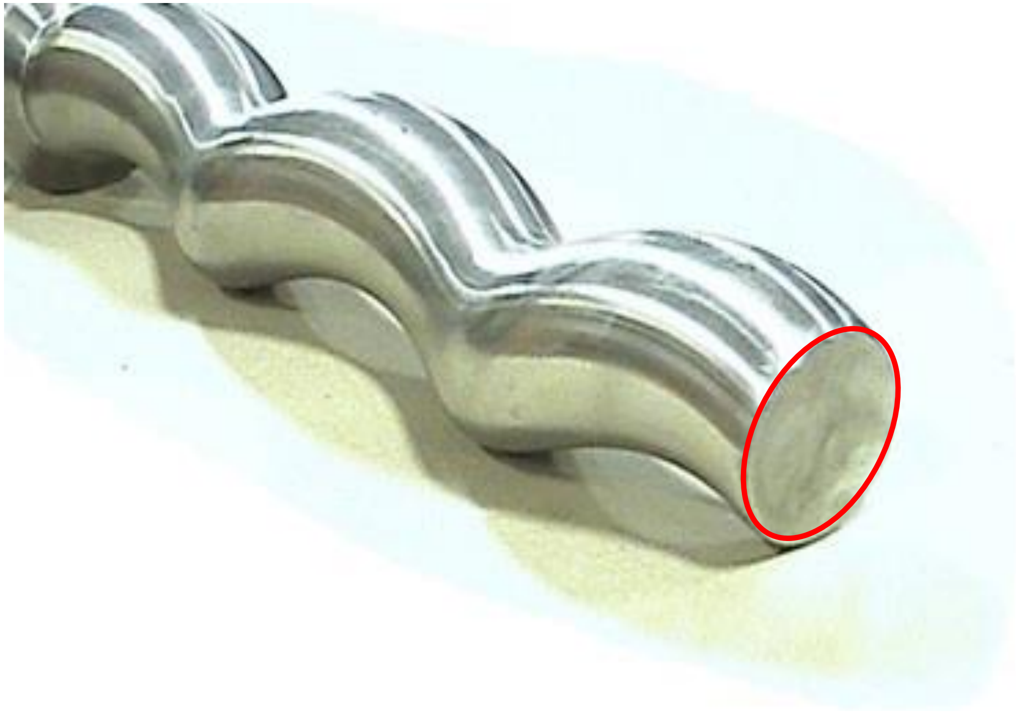
Rotor Geometry





- Crest to crest
- ❖ **(called Major)**
- Circular cross-section
- ❖ **(called Minor)**
- Machined in a helical shape similar to a corkscrew

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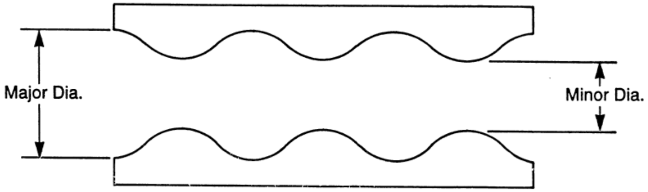
Stator Geometry

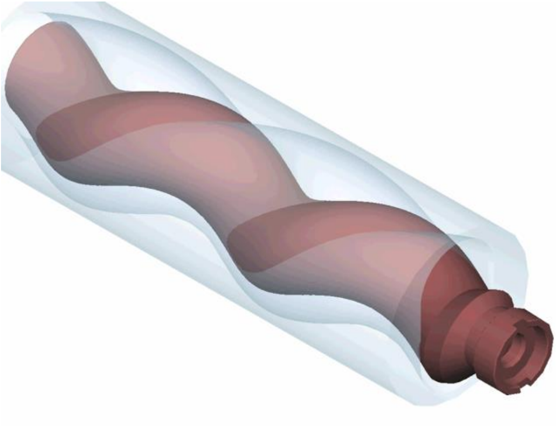
- Oval shaped cavity cross-section.
- Similar geometry as Rotor but uses a double helix.
- Available in several elastomers, metal, or urethane construction materials.

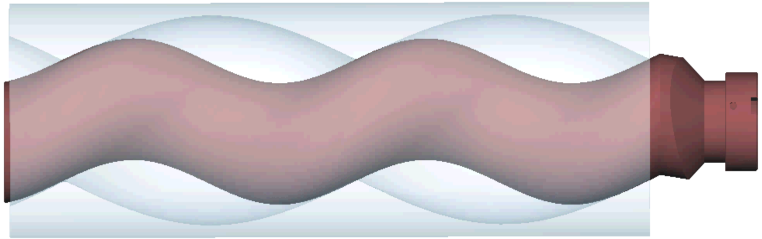


Stator

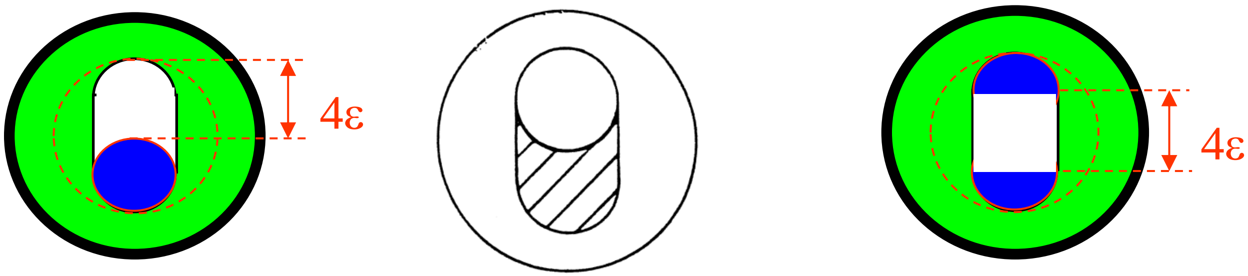
Cavities

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

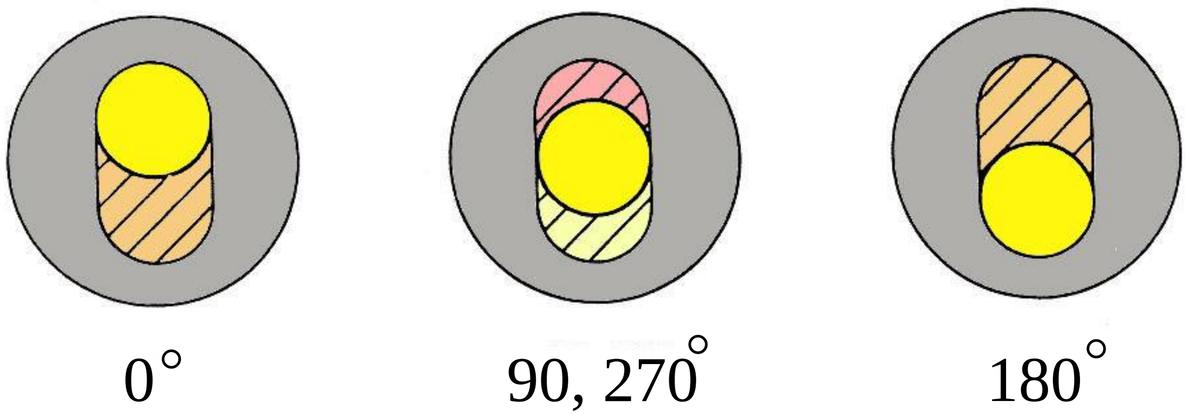




End View of Rotor/Stator Combination



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 BIG THREE"

- ✓Abrasion
- ✓Temperature
- ✓Viscosity

Effects of Abrasion

- Abrasive fluids = Wear
  - Wear is proportional to speed; minimize speed to minimize wear.
  - De-rate pressure per stage to limit slip amount ... 87 PSI for no abrasion; 20 PSI for heavy abrasion.
  - Specify oversize Rotor to increase interference fit = longer life.
  - Use abrasion resistant Stator material or softer durometer elastomers: RM 100M, RM 103, Urethane etc.
  - Double chrome rotor for additional Rotor base metal protection.

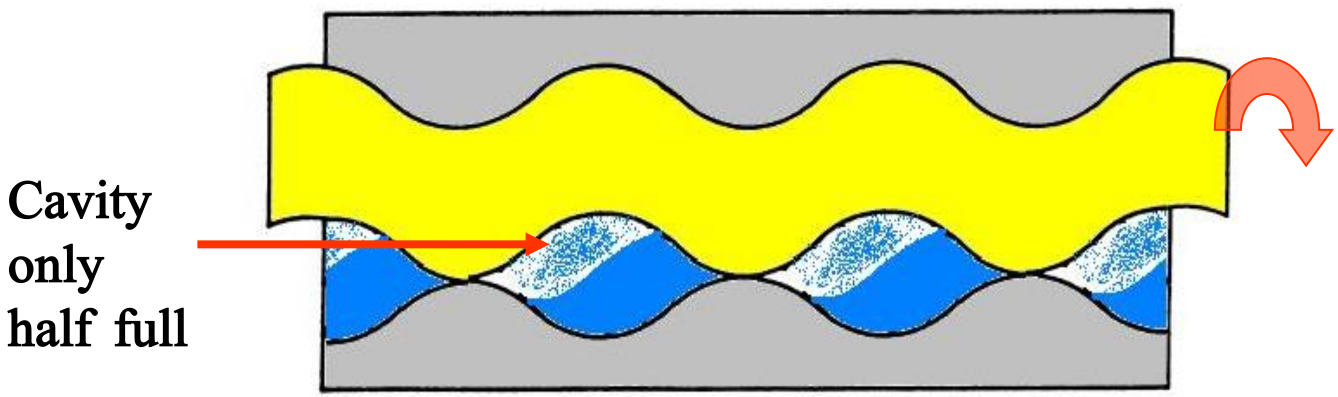
Abrasive Characteristic	Fluids	Press/stage
None	Water, Polymer, Oil	87 PSI
Light	Milk or Lime	65 PSI
Medium	Sludge, Clay or Gypsum Slurries, Chocolate, Drilling Mud	43 PSI
Heavy	Emery Dust, Lapping Compounds, Grout, Sand, Granulated Sugar	20 PSI

Effects of Temperature

- 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.

Effects of Viscosity

- 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

Effects of Viscosity

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 MOYNO 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**.**

Summary
Progressing Cavity Pump Advantages

- The **MOYNO** design creates a low shear, 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 flexible geometry of the **MOYNO** pump allows.
  - ❖ Multiple drive end choices (power) and multiple stages (pressure).
  - ❖ **MOYNO** pumps allow ***precise*** control of the interference fit.

- **MOYNO** can **best** match the pump to your application.

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General Maintenance

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PUMP MAINTENANCE

Preventative Maintenance

Most of the maintenance needed for a **MOYNO** pump is based on “look-feel”

DAILY INSPECTION;

- Lip seals on bearing housing
- Packing/Mech seal (flow/pressure/noise)
- Gear reducer (temp/noise).

WEEKLY MAINT;

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

YEARLY MAINT;

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

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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.

- Gear Joints

  Only recommended when gear joints are disassembled.

  (example; when replace rotor)

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Lubrication Suppliers

MOYNO® PROGRESSING CAVITY PUMPS USE TWO LUBRICANT FOR MOST INDUSTRIAL APPLICATIONS. (TEMPERATURES 400º F OR LESS) DuBOISE CHEMICAL *ACG – 2* , AND MOBIL-1 NLGI Grade 2

DuBOISE CHEMICAL. *ACG – 2* and **MOBIL-1 *NLGI Grade 2***
ARE RECOMMENDED FOR:
GEAR JOINTS
PIN JOINTS
BEARINGS
INDUSTRIAL PACKINGS

THE FOLLOWING LUBRICANTS ARE ACCEPTABLE FOR:
PIN JOINTS
BEARINGS
INDUSTRIAL PACKINGS

1. ACG-2	DuBOISE CHEMICAL (FACTORY INSTALLED)
2. MOBIL 1 NLGI Grade 2	MOBIL CHEMICAL (RECOMMENDED)
3. MOBILUX EP2	MOBIL CHEMICAL
4. ALVANIA EP2	SHELL OIL
5. MYTILUS 2	SHELL OIL
6. SUNAPLEX 992 EP	SUN OIL
7. ACL-2	FISKE BROTHERS
8. TRIBOL 823-2	CASTROL
9. STARPLEX SERIES	TEXACO

FOR **MOYNO®** ***SANITARY PUMPS***, THE RECOMMENDED PACKING LUBRICATION IS **FGG - 2** from **DuBoise Chemical** or **Accrolube – 2** from **Accro-Sea**l or equivalent.

NOTE: THE ABOVE LUBRICANTS ARE ALL NLGI Grade 2 Greases

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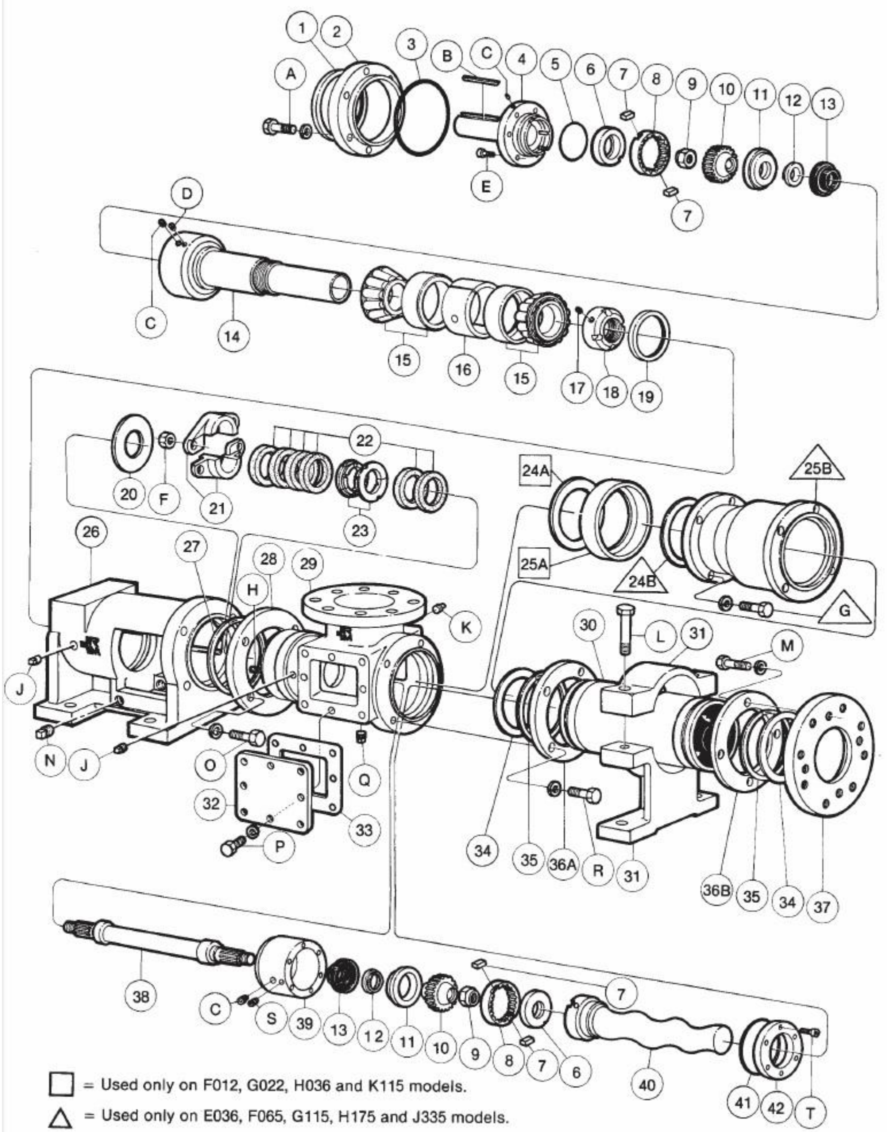
Manual Diagrams



		DRIVE END SIZE					
	DESCRIPTION	E	F	G	H	J	K
1	Radial Grease Seal	AG0611	PF0611	PG0611	PH0611	PJ0611	PK0611
2	Bearing Cover Plate	PE0341	PF0341	PG0341	PH0341	PJ0341	PK0341
3	O-Ring	PE110Q	BJ112Q	BK113Q	PH110Q	BH114Q	PK110Q
4	Drive Shaft Head	PE0971	PF0971	PG0971	PH0971	PJ0971	PK0971
5	O-Ring Shaft Head:	BE111Q	BE113Q	BG114Q	BH111Q	TJ111Q	BK114Q
6	Primary Thrust Plate	PE0981	PF0981	PG0981	PH0981	PJ0981	PK0981
7	Key	RE0761	RF0761	RG0761	RH0761	RJ0761	RK0761
8	Ring Gear	AE0952	AF0952	AG0952	AH0952	AJ0952	AK0952
9	Lock Nut	RE0581	RF0581	RG0581	RH0581	RJ0581	RK0581
10	Gear Ball	AE0951	AF0951	AG0951	AH0951	AJ0951	AK0951
	Gear Joint Kit (See Note C)	KPE951	KPF951	KPG951	KPH951	KPJ951	KPK951
11	Secondary Thrust Plate	PE0982	PF0982	PG0982	PH0982	PJ0982	PK0982
12	Seal Support	PE0891	PF0891	PG0891	PH0891	PJ0891	PK0891
13	Gear Joint Seal:						
	CDQ, CSQ, SSQ, CDR, CSR, SSR	PE087Q	PF087Q	PG087Q	PH087Q	PJ087Q	PK087Q
	CDB, CSB, SSB, CDF, CSF, SSF	PE087F	PF087F	PG087F	PH087F	PJ087F	PK087F
	Gear Joint Seal Kit (See Note D):						
	CDQ, CSQ, SSQ, CDR, CSR, SSR	KPE87Q	KPF87Q	KPG87Q	KPH87Q	KPJ87Q	KPK87Q
	CDB, CSB, SSB, CDF, CSF, SSF	KPE87F	KPF87F	KPG87F	KPH87F	KPJ87F	KPK87F
14	Drive Shaft:						
	CDQ, CDR, CDB, CDF	PE0261	PF0261	PG0261	PH0261	PJ0261	PK0261
	CSQ, CSR, CSB, CSF, SSQ, SSR, SSB, SSF	PE0266	PF0266	PG0266	PH0266	PJ0266	PK0266
15	Tapered Roller Bearing	PE0311	PF0311	PG0311	PH0311	PJ0311	PK0311
	Bearing Kit (See Note B)	KPE291	KPF291	KPG291	KPH291	KPJ291	KPK291
16	Bearing Spacer	PE0331	PF0331	PG0331	PH0331	PJ0331	PK0331
17	Bearing Lock Plug	P10762	P10762	P10762	P10762	P10762	P10762
18	Bearing Lock Nut	PE0581	PF0581	PG0581	PH0581	PJ0581	PK0581
19	Thrust Grease Seal	AK0621	XK0621	PG0621	PH0621	AI4611	PK0621
20	Slinger Ring	PE0771	PF0771	PG0771	PH0771	PJ0771	PK0771
21	Packing Gland Half (See Note A):						
	CDQ, CDR, CDB, CDF, CSQ, CSR, CSB, CSF	PE041D	PF041D	PG041D	PH041D	PJ041D	PK041D
	SSQ, SSR, SSB, SSF	PE041S	PF041S	PG041S	PH041S	PJ041S	PK041S
22	Packing (See Note A)	PE0423	PF0423	PG0423	PH0423	PJ0423	PK0423
23	Lantern Ring Half (See Note A)	AE0571	PF0571	PG0571	PH0571	AJ0571	PK0571
24A	Adapter Gasket:						
	CDB, CSB, SSB	---	BF085B	BG085B	BH085B	---	BK085B
	CDQ, CDR, CSQ, CSR, SSQ, SSR	---	BF085Q	BG085Q	BH085Q	---	BK085Q
	CDF, CSF, SSF	---	BF085F	BG085F	BH085F	---	BK085F
24B	Adapter Gasket:						
	CDB, CSB, SSB	----	---	---	----	BK085B	---
	CDQ, CDR, CSQ, CSR, SSQ, SSR	---	----	---	----	BK0B5Q	----
	CDF,CSF,SSF	---	----	---	----	BK085F	---
25A	Adapter Bushing—See Tables 4-2 and 4-3						
25B	Adapter Bushing—See Tables 4-2 and 4-3						
26	Bearing Housing	PE0051	PF0051	PG0051	PH0051	PJ0051	PK0051
27	Retaining Ring	AF0085	AG0085	PG0085	AH0085	PJ0085	PK0085
28	Clamp Ring	AF0932	AG0932	PG0932	AH0932	PJ0932	PK0932
29	Suction Housing—See Tables 4-2 and 4-3						
30	Stator—See Table 4-4						
31	Stator Support—See Tables 4-2 and 4-3						
32	Inspection Plate:						
	CDQ, CDR, CDB, CDF, CSQ, CSR, CSB, CSF	BE0171	BF0171	BF0171	BF0171	BH0171	BJ0171
	SSQ, SSR, SSB, SSF	BE0176	BF0176	BF0176	BF0176	BH0176	BJ0176
	-K800 CDQ, CDR, CDB, CDF, CSQ, CSR, CSB, CSF	---	----	---	----	---	BJ0172
	SSQ, SSR, SSB, SSF	---	----	---	----	---	BJ0177
33	Inspection Plate Gasket:						
	CDB, CSB, SSB	BE079B	BF079B	BF079B	BF079B	BH079B	BJ079B
	CDQ, CDR, CSQ, CSR, SSQ, SSR	BE079Q	BF079Q	BF079Q	BF079Q	BH079Q	BH079Q
	CDF, CSF, SSF	BE079F	BF079F	BF079F	BF079F	BH079F	BH079F
34	Stator Gasket—See Table 4-5						
35	Retaining Ring—See Tables 4-2 and 4-3						

Remember…

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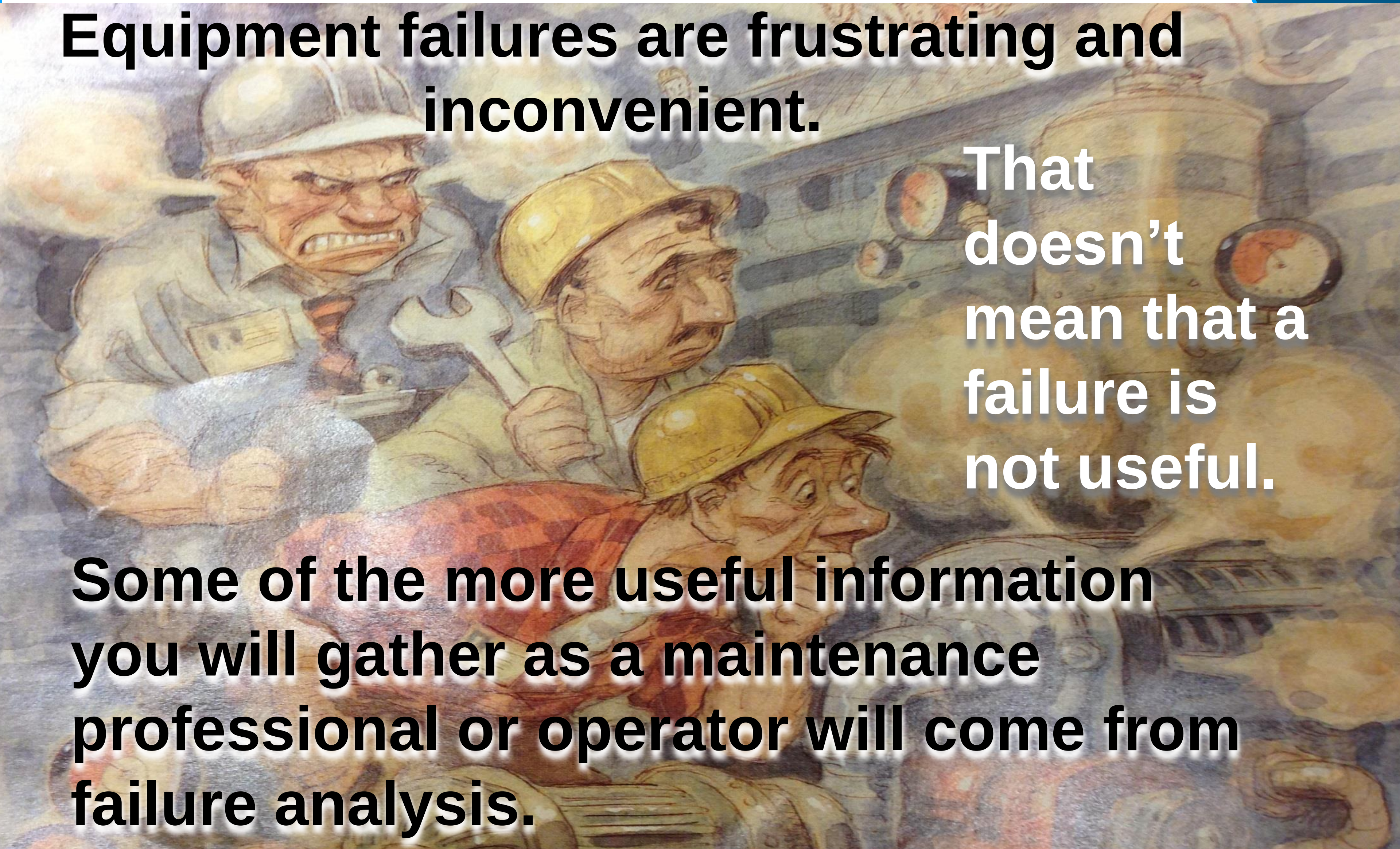
FAILURE ANALYSIS
AND
EXAMPLES OF WORN & FAILED MOYNO PARTS

Failure Analysis



Equipment failures are frustrating and inconvenient.

That doesn't mean that a failure is not useful.

Some of the more useful information you will gather as a maintenance professional or operator will come from failure analysis.

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.

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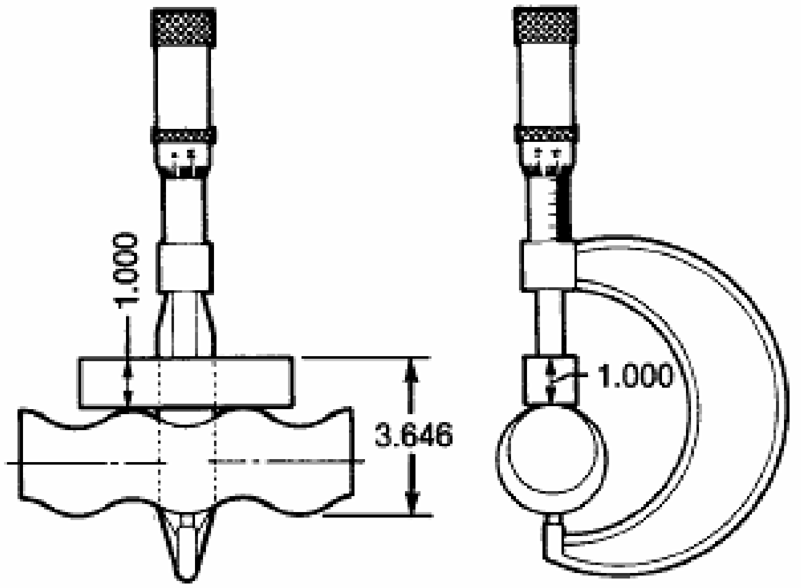
Failure Analysis

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

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Failure Analysis

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 **MOYNO** sales representative.

Failure Analysis

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 **MOYNO** 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.

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Failure Analysis

- TYPICAL ROTOR ABRASIVE WEAR PATTERN
- NOTE THE TELLTALE RIDGES

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Failure Analysis

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

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Failure Analysis

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

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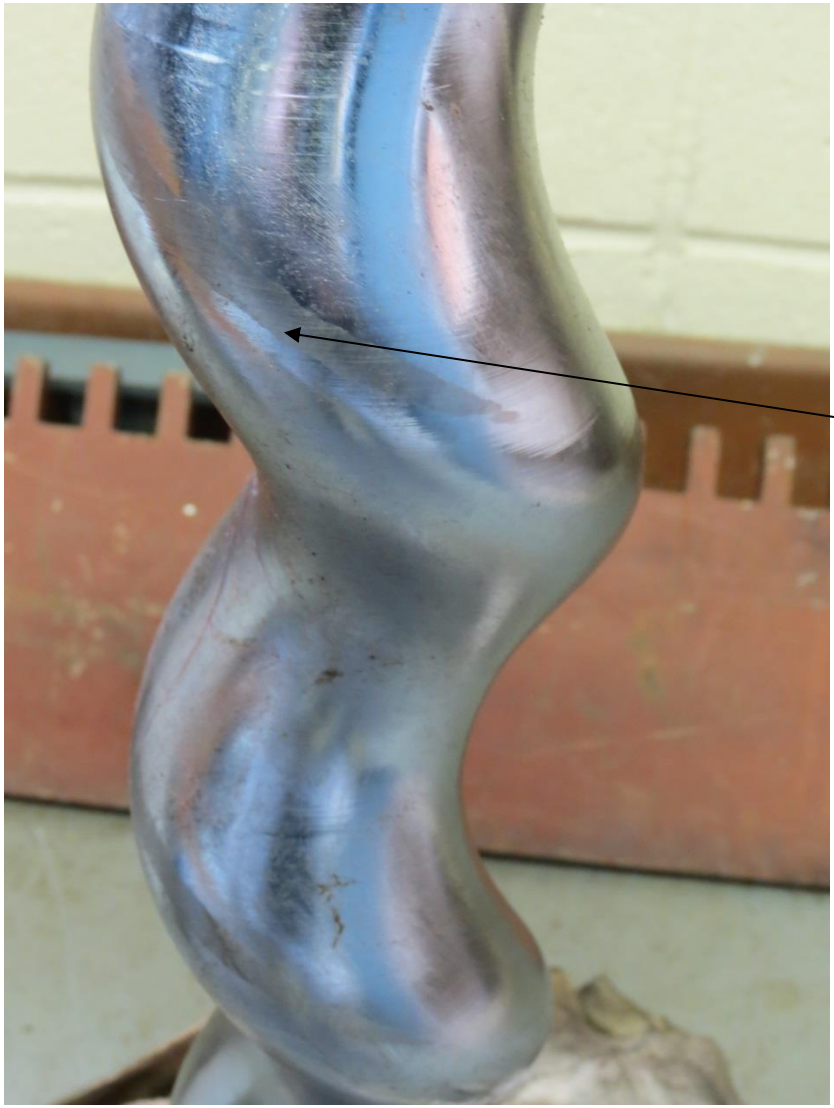
Failure Analysis



- TYPICAL ROTOR EVEN WEAR PATTERN
- A LITTLE TOO WORN TO RE-PLATE
- ADJUSTING THE MAINTENANCE INTERVAL MAY LOWER COSTS

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Failure Analysis

- 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

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Failure Analysis

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

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Failure Analysis

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

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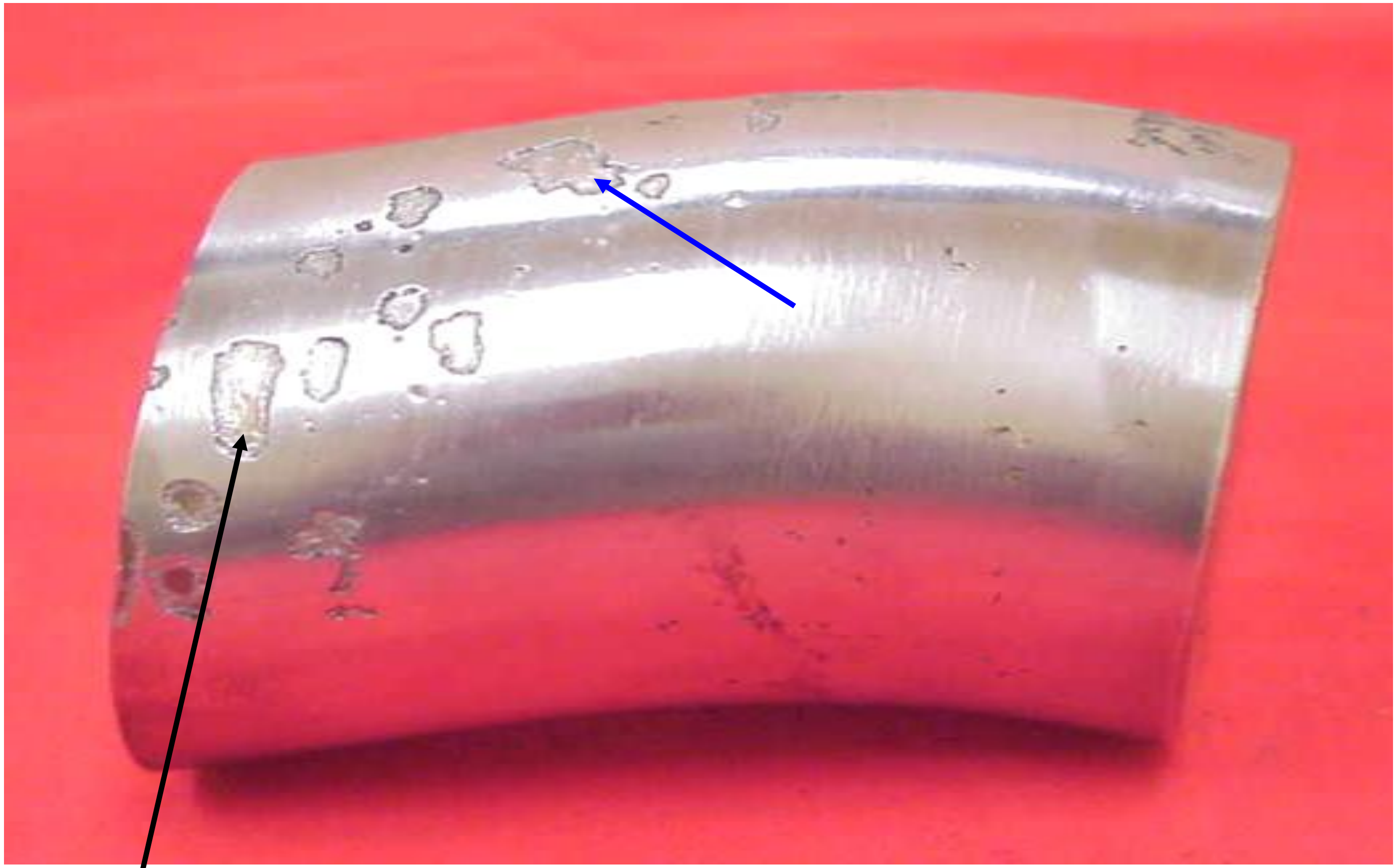
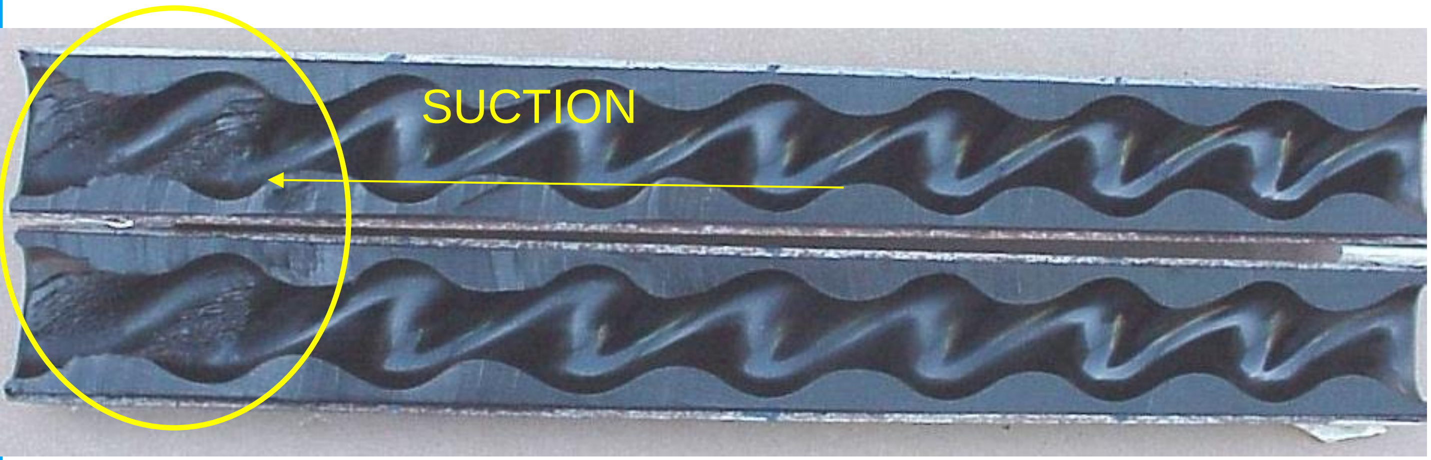
Failure Analysis



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

Failure Analysis



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.

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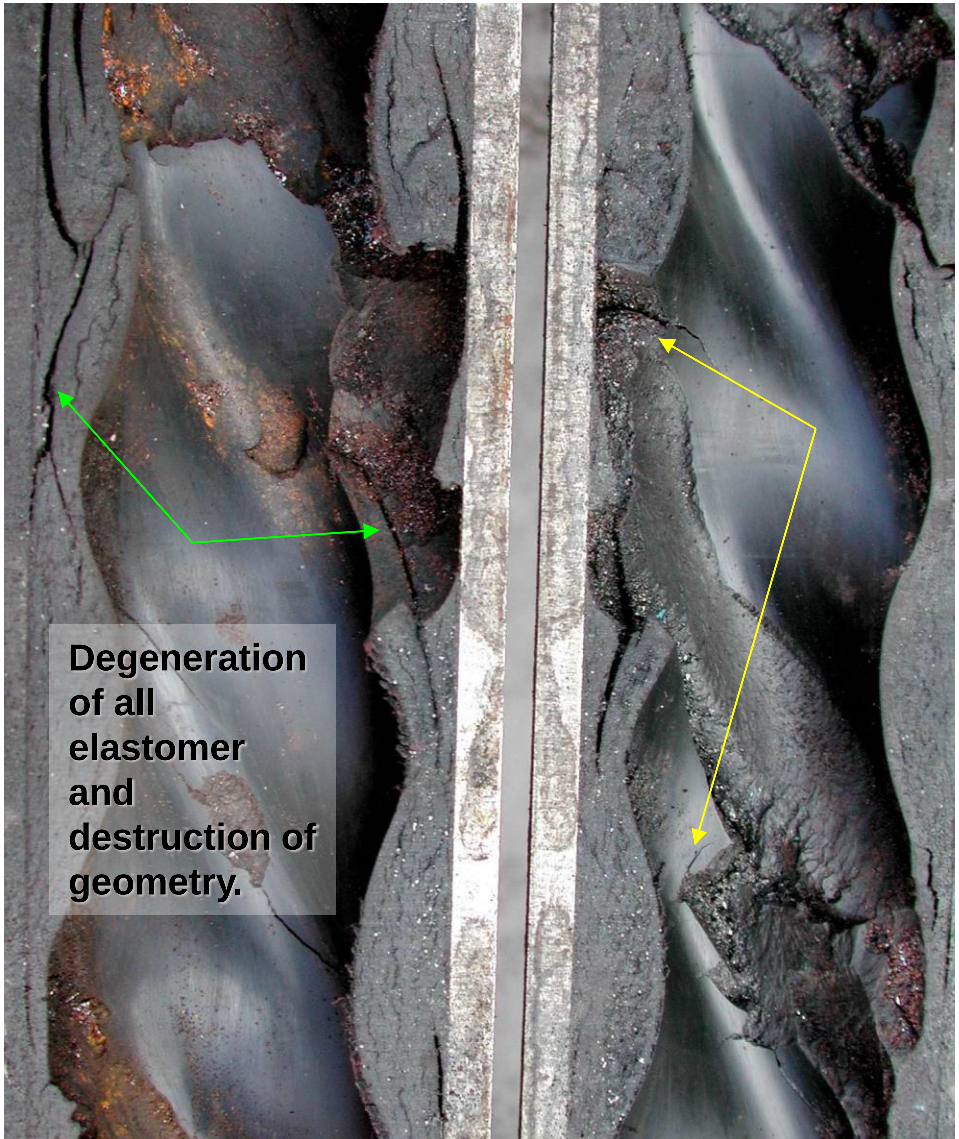
Failure Analysis



- 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.

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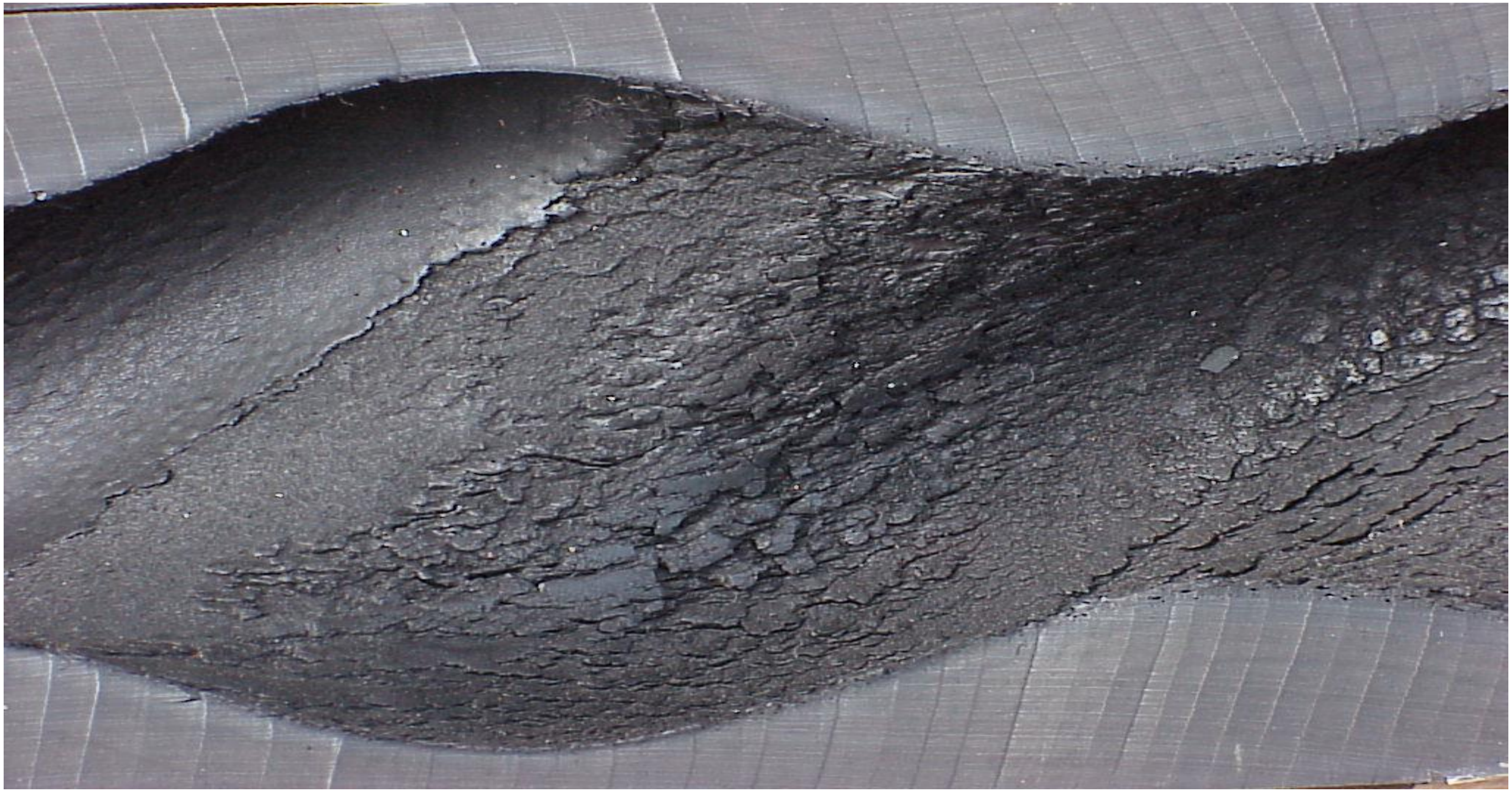
Failure Analysis

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 Analysis



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 Analysis

- 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.

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Failure Analysis

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

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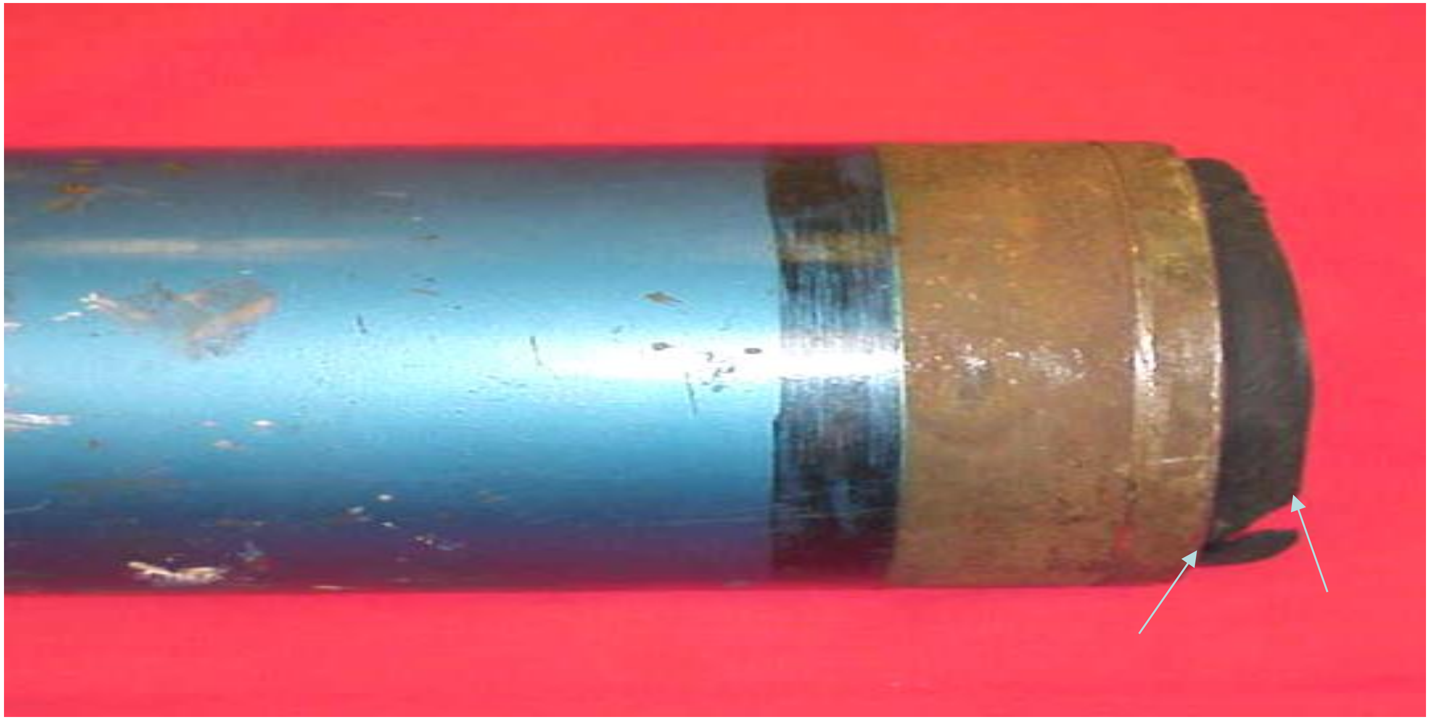
Failure Analysis



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.

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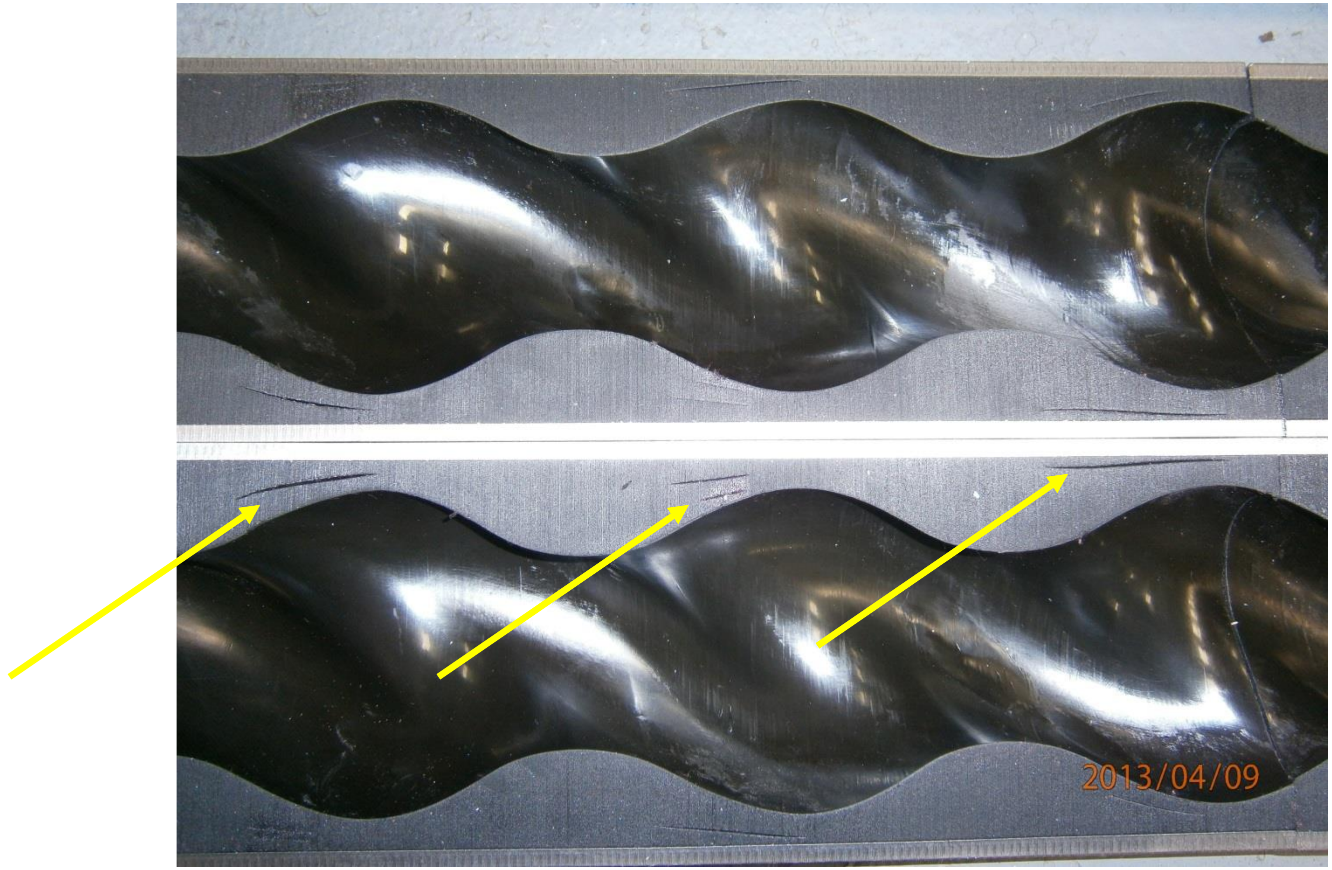

<u>DELAMINATION</u> IS THE RESULT OF THE ELASTOMER MOLECULES NOT KNITTING PROPERLY DURING THE MANUFACTURING PROCESS. THE ELASTOMER MAY THEN COME LOOSE IN LAYERS WHILE PUMPING AGAINST HIGH DISCHARGE PRESSURE.

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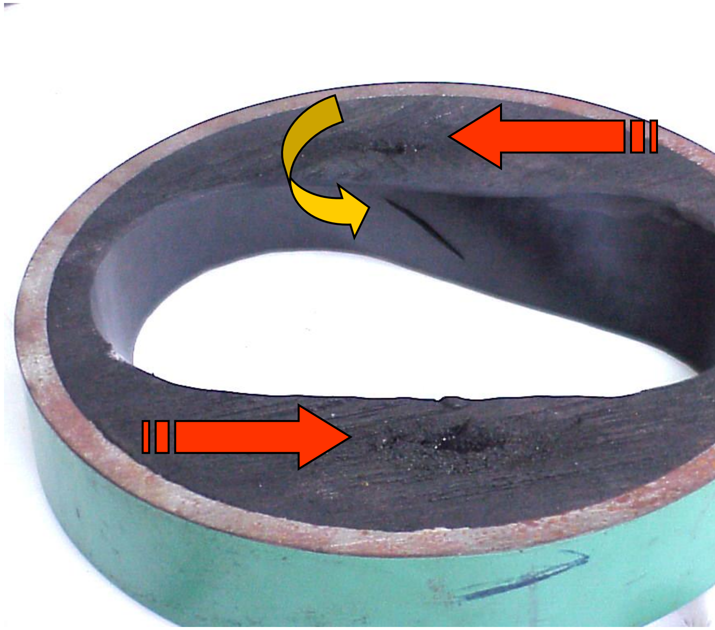

Hysteresis (fatigue)

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

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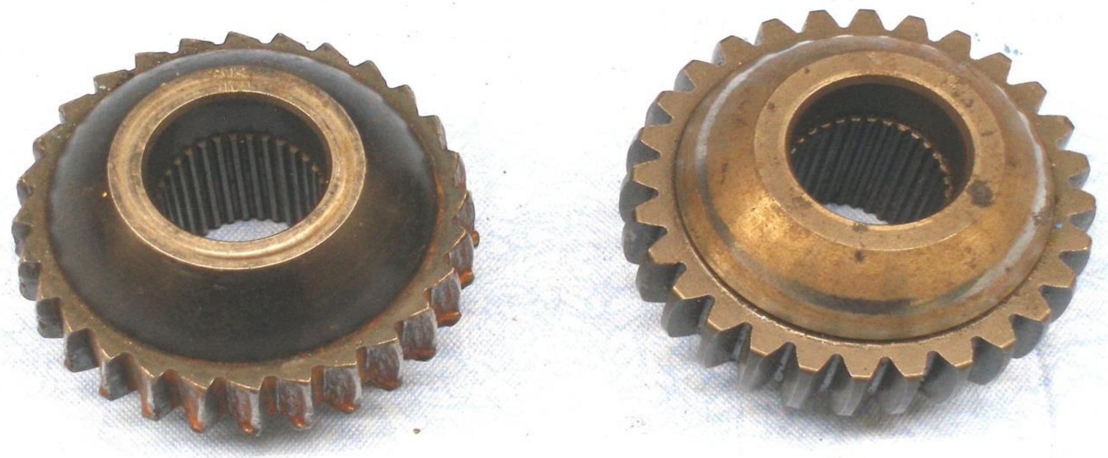
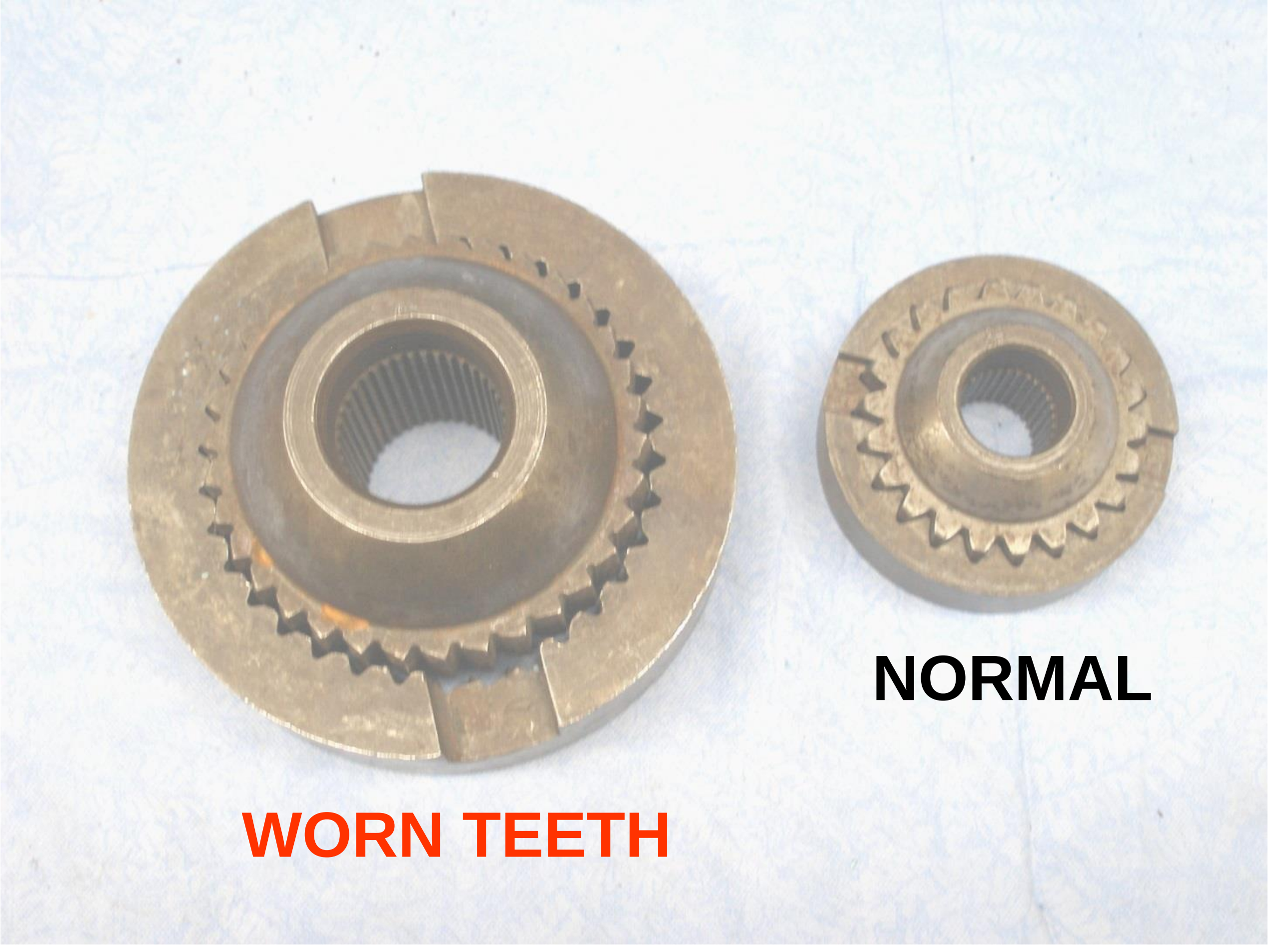
Failure Analysis



WORN TEETH

NORMAL

Failure Analysis



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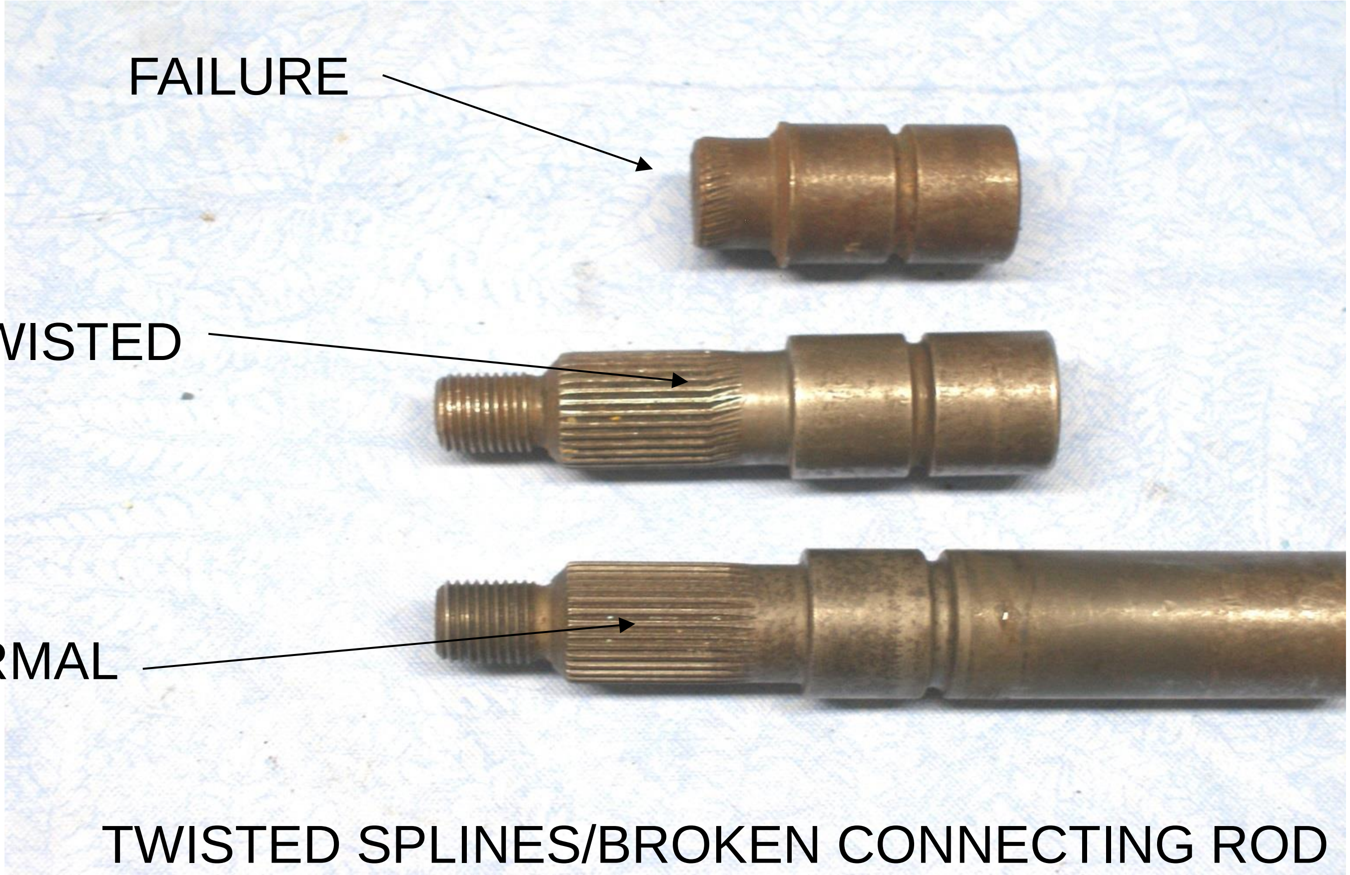
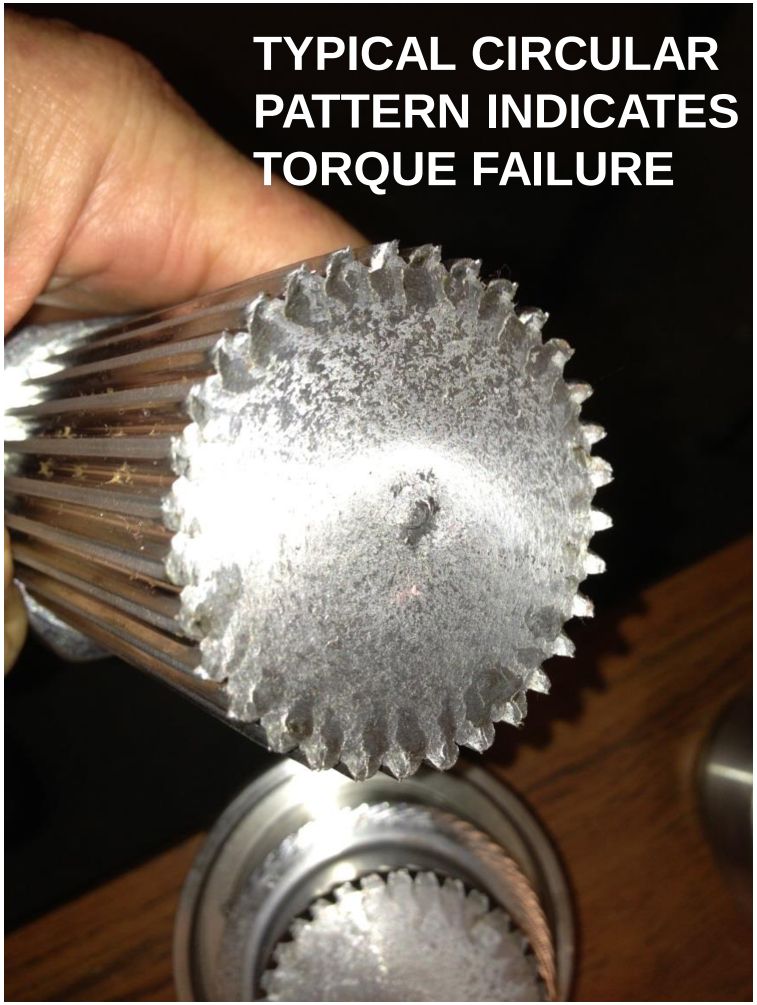
Failure Analysis



TWISTED SPLINES/BROKEN CONNECTING ROD TYPICALLY INDICATE HIGH TORQUE

Failure Analysis



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Failure Analysis

BAD SEAL

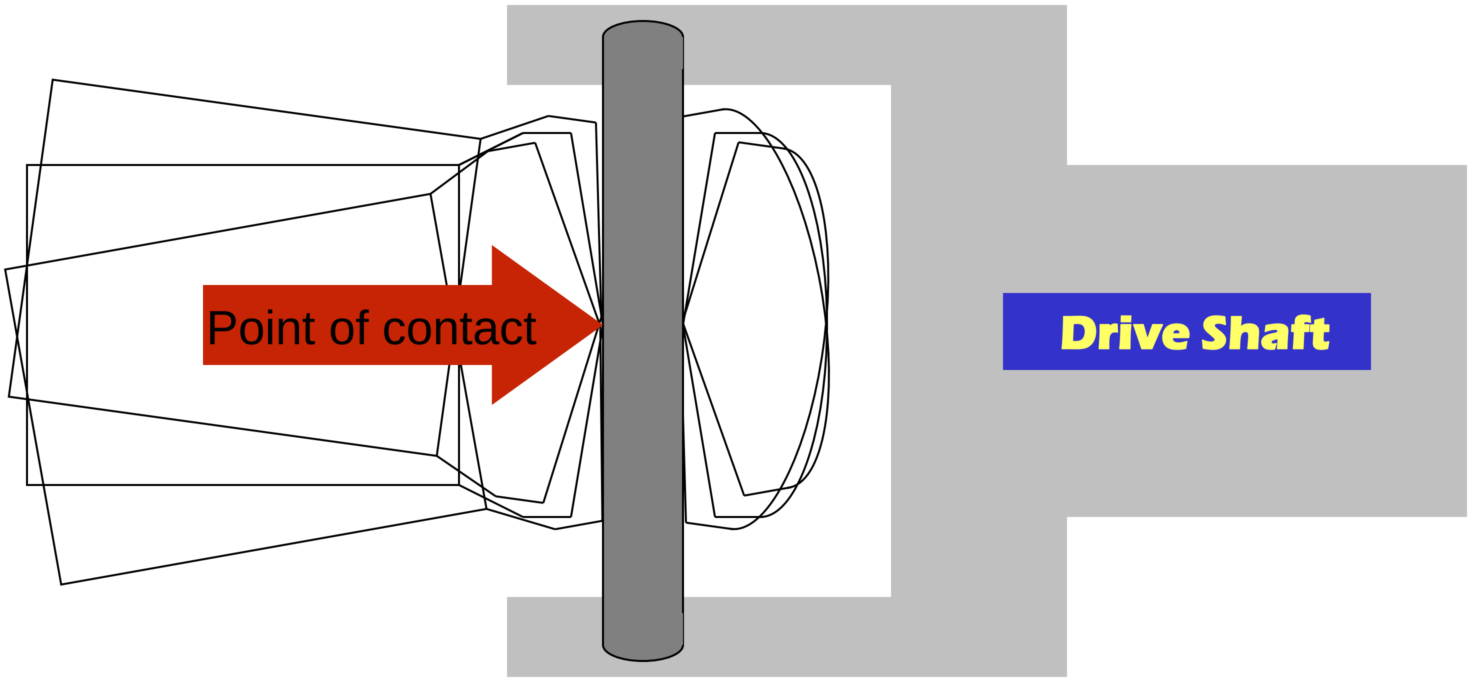
NORMAL

- **Gear joint seals should be inspected for damage when the pump is serviced**

Failure Analysis

<u>Pin Joint Dynamics</u> – 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 Analysis

- **Typical pin wear patterns**

Failure Analysis

- **Typical connecting rod wear pattern**

Failure Analysis

- Excessive rotor head wear

Failure Analysis

Questions?

Failure Analysis Case

A customer reported repeated failures of a connecting rod.
Application is a G2 (open throat housing) pumping 7% solids from a filter press.

MOYNO replaced the 1st connecting rod under warranty.
Then the 2nd connecting rod.

When the customer had a 3rd failure, and using customer supplied information concerning the failed parts, engineering changed the material to 17-4 ph (heat treated stainless) with a strength of 145,000 psi.

Engineering also developed a hollow tube version of the connecting rod to withstand higher torsional loads, without the higher expense associated with 17-4.

When the 17-4 con-rod broke Moyno sent a team to investigate the issue.

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Failure Analysis Case

We looked at the broken parts

Noted an irregular break pattern.
Noted no twist in the splines.

Failure Analysis Case

We looked at and evaluated the normal wear parts for damage or anything that could cause binding.

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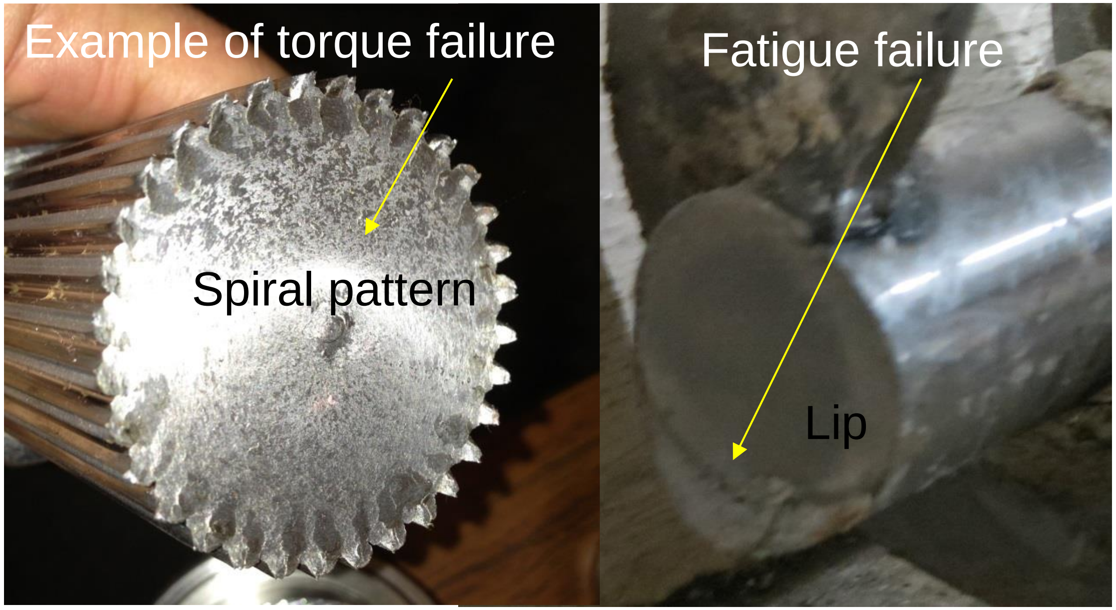
Failure Analysis Case

When nothing was obvious we further evaluated the type of failure
And began to carefully review the operational information.

The type of failure pattern is not consistent with a torque failure and is consistent with a fatigue failure



Then the operational information; how the system operates and conditions when operating were closely reviewed.

The system has high levels of whey from a cheese producer, which results in significant pipe build up.

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Failure Analysis Case

The system is run by the flow rate (maintain a certain flow), so if the pipe buildup results in restriction the pump speeds up. The max speed by design is 419 rpm, which is faster than we would prefer for a 2 meter open throat.

The system is protected from high pressure using a pressure ring switch assembly and analog gauge.

Spool piece with one week of build up

Plant maintenance reported that pipe buildup regularly restricted the internal pipe dimension to 2” or less.

High pressure safeguard is set to shut off at 80psi, but heavy buildup can stop the switch and the pressure gauge from properly reading = malfunctioning. The restriction would also lower the flow rate resulting in faster, and faster pump speeds to keep up.

Failure Analysis Case

Review of the VFD settings revealed the system is enabled to run over the design speed at a max 78Hz which translates to 544rpm max.

The system failures/breakages generally occurred on third shift when the system was not closely monitored.

The conclusion after reviewing all the information was the pipe internal buildup needed to be addressed by more frequent maintenance or a process change.

But more importantly the <u>speed needed to be restricted</u> to at or below the original design speed.

Failure Analysis Case

Questions?