

DENISON HYDRAULICS

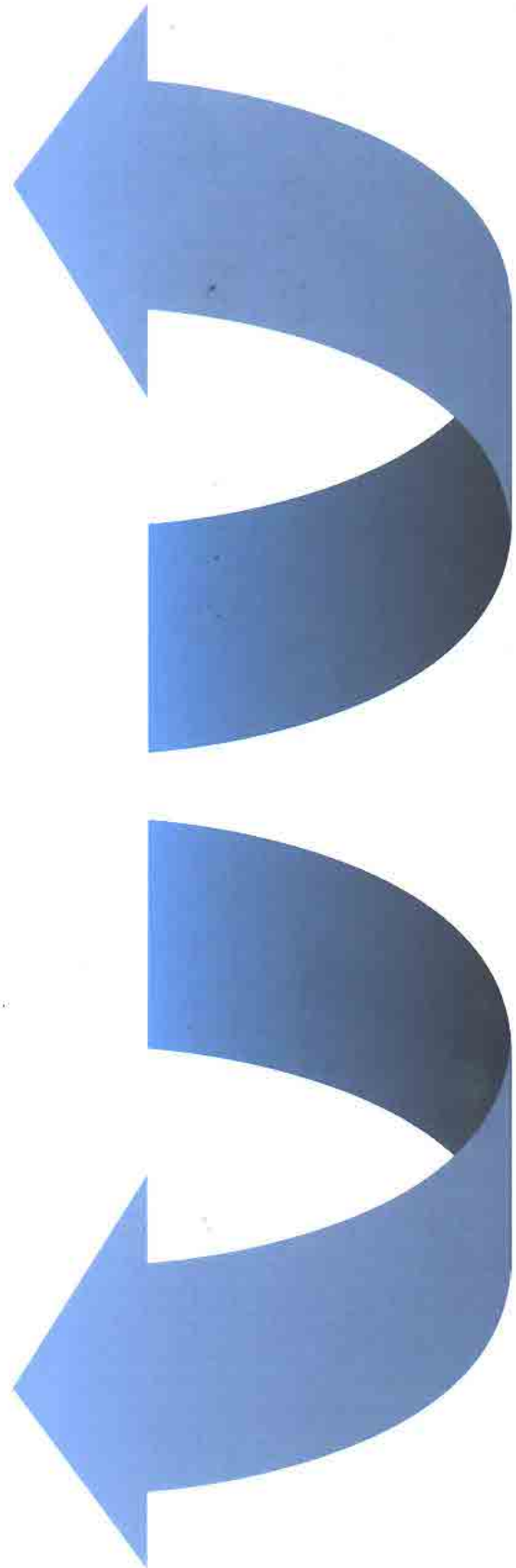
VANE TROUBLESHOOTING GUIDE



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DENISON Hydraulics

VANE TROUBLESHOOTING GUIDE



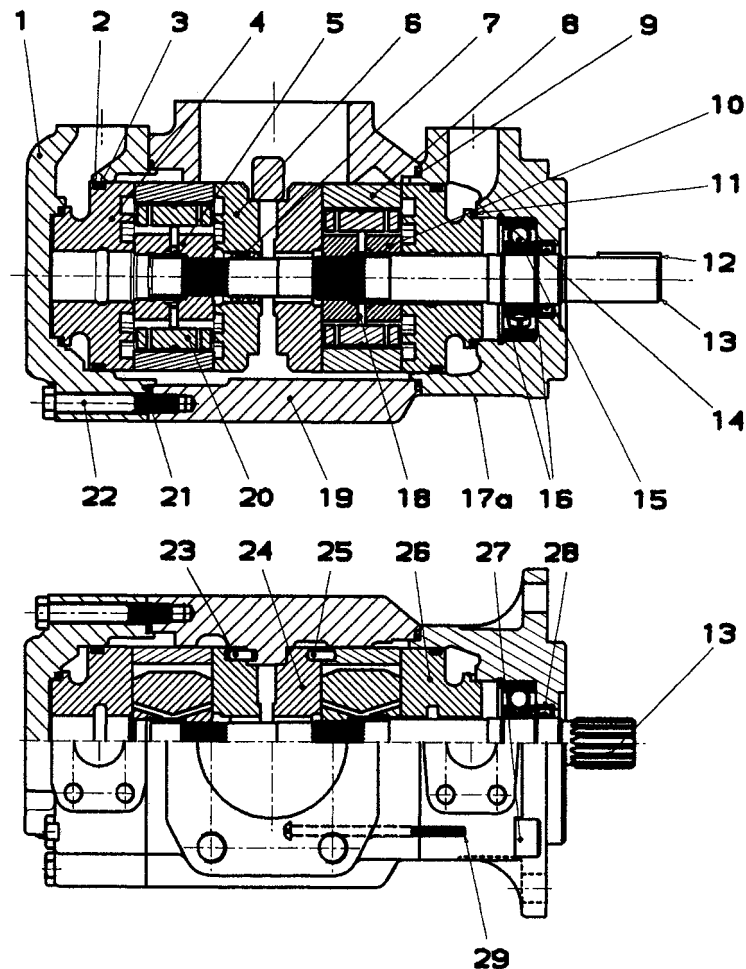
VANE TROUBLESHOOTING GUIDE

V - COMPONENT ANALYSIS CHART

	Pages	bushing	cam ring	pins	rotor	screws	seals	shaft	side plates	vanes	Pages	
PUMP	12							x			12	
	13							x			13	
	14							x			14	
	15		x	x				x	x		15	
	16							x	x		16	
	17						x		x		17	
	18								x		18	
	19			x		x			x	x	19	
	20								x		20	
	21			x							x	21
	22					x			x			22
	23			x		x						23
	24											24
	25											25
	26									x		26
	27			x						x	x	27
	28									x		28
	29											29
	30			x						x		30
	31			x	x	x					x	31
	32					x						32
	33										x	33
	34			x							x	34
	35			x		x				x	x	35
36					x				x	x	36	
37											37	
38			x		x					x	38	
39			x		x						39	
40					x				x		40	
41					x						41	
42											42	
43											43	
44											44	
MOTOR	45							x			45	
	46				x				x		46	
	47						x		x		47	
	48				x				x	x	48	
	49					x					49	

VANE PUMP TROUBLESHOOTING GUIDE

VANE PUMP COMPONENTS DESIGNATION



Part nb.	part designation	Part nb.	part designation
1	End cap	16	Round section ring
2	Square section seal P1 & P2	17	Mounting cap
3	Back-up ring P1 & P2	18	Pin-vane holdout (P1 & P2)
4	Pressure port plate P2	19	Housing
5	Rotor-insert assembly P2	20	Vane P1 & P2
6	Rear port plate P2	21	Square section seal
7	Bush	22	Screw
8	Cam ring P1 & P2	23	Dowel pin
9	O ring	24	Rear port plate P1
10	Rotor-insert assembly P1	25	Dowel pin
11	Square section seal P1 & P2	26	Pressure port plate
12	Key	27	Screw
13	Keyed shaft	28	Shaft seal
14	Splined shaft	29	Screw
15	Ball bearing		

VANE TROUBLESHOOTING GUIDE

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I INTRODUCTION

I-1 Presentation

The main goal of this guide is to help all the DENISON vane pump users to understand the principal causes of destruction of these pumps and motors in service. Our past experience has shown that the failures, occurring in the first 500 hours of service, are premature failures. Failing to follow instructions or ignoring the correct appli-

cation limits and functioning of the units inevitably leads to premature failures. It is important to point out that 80 % of the failures are linked to fluid contamination incidents (chapter II-4).

This guide comes as an addition to the existing "Installation, operation and overhaul instructions" available bulletin S1-EN081.

I-2 How to use this guide

- **"The most common causes", chapter II** (pages 6 to 43): details of the major incidents you may encounter (cavitation, aeration, misalignment...) and their consequences on the vane pumps. While **chapter III** (pages 44 to 49) will concern the **vane motors**.
- **"Fault finding while the pump is running", chapter IV** (pages 50 to 60): the troubleshooting tables for vane pumps and motors. If you have a problem in working conditions, "the troubleshooting table" will help you to find out what is wrong (FAILURE-CAUSE-SOLUTION).
- **"Interpret the physical damages on components", chapter V**: The first page (folded) shows a chart which summarizes all the pictures of failed components. This will enable you to recognize the failed component and to understand the cause of this failure.

I-3 Why a DENISON Vane pump should not break down

Unlike most other hydraulic technologies, the DENISON vane pump design is hydraulically balanced. You cannot calculate the life time of these pumps by calculating the life time of the ball bearing as no internal load (neither axial nor radial) is applied on the shaft. The only purpose of the ball bearing in the Denison vane pump is to

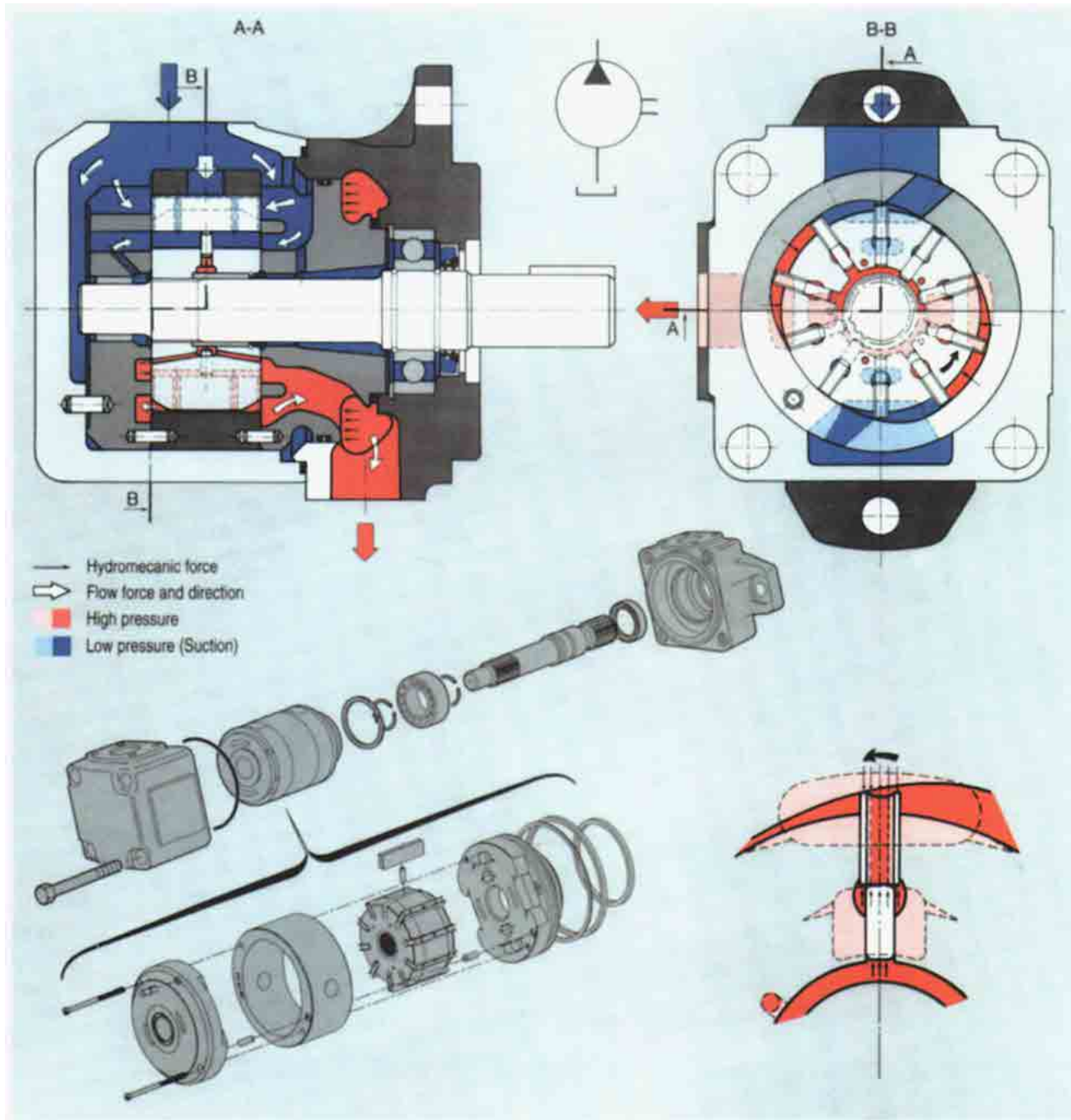
absorb any external shaft misalignment or abnormal coupling loads.

As shown on the drawings hereafter, the two symmetrical high pressure zones have a self centering effect on the rotating components.

This is a hydrostatic balanced pump, axially and radially.

DENISON HYDRAULICS Vane Pumps

Single series T6 - T7 - B-C-D-E sizes



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DENISON | Hydraulics

Each single vane is independently loaded in order to always be maintained on the cam ring contour. The specific Denison pin design reduces the possible internal leakage, reduces the possible vane/cam ring wear (due to a precise balancing of the forces under and over the vanes), lowers considerably the noise level, allowing higher pressure capabilities, extends the life time...

Added to this licensed pin design, Denison has engineered the double vane lip technology. This vane technology combined with the pin design gives unique overall performances. The double lips allow the pressure all around the vane to be the same on the top as on the bottom and as on the sides of it. This is possible because of the double lips and the balancing through the holes in the vanes. Here again, the components are hydrostatically balanced. Another advantage of the double lip design is the fact that the first lip seals the low pressure area and the other one seals the high pressure area. This increases the life time of the pump when working with contaminated oil. The wear, due to the particles of pollution, will have a negative effect, mainly on the first lip. The second lip, working in the high pressure area, keeps its original seal to maintain high volumetric efficiency.

This technology is unique because the wear is compensated. The effect of contamination on the Denison vane design is not a major issue of pump failure as for other pump technologies.

Every port plate and cam ring has a surface treatment to increase the life time capabilities.

On each cam ring, for example, a dry lubricant coating is laid on the cam profile. This coating will assure, even in bad priming conditions, a good start-up minimizing the risk of micro-seizures. With this dry lubricant coating, the deficiency of oil is compensated but not replaced. This is done for short term deficiencies.

Our passed experience shows that the most common failures are linked to the quality of the oil. As soon as there is a lack of lubricity, the failure is imminent. In addition to the pressure and the mechanical failures, all the problems are usually a lack of lubrication (rupture of the film of oil). The followings are some examples of the common causes:

- air in the oil (cavitation, aeration),
- solid large size particles,
- chemical agents (water, wrong additives, tar...),
- too high or too low viscosity,
- overheating (shaft alignment),
- flow of the system coming back to the pump,
- poor quality of oil loosing its main chemical characteristics,

This is why good filtration, good thermal stability, good quality of oil, a good design (hose design, bleeder, tank design ...), correct hydraulic knowledge (...) will always increase the life time of all hydraulic components.

The DENISON vane pump technology is a heavy duty engineering design that will last years if elementary precautions are taken.

I-4 Basic precautions for a long life time:

The Denison vane products are designed for long life. Some minor precautions can help to avoid premature breakdowns:

- have a correct air bleed at start-up,
- always check the oil velocity (inlet & outlet). This should then give the correct sizes of hoses & connectors: maximum velocity of 1,9 m/sec. for the inlet & 6 m/sec. for the outlet,
- no strainer on the inlet line is preferred (250 microns minimum and check the pressure drop when the Viscosity rises),
- always pay attention to the viscosity of the oil versus temperature. Even a small change in temperature can have a big effect on the viscosity. A good quality return line filter is the best solution.
- check the pressure at the inlet port, (position of the tank, shaft rotational speed...),
- ratio flow/tank capacity: is cooling required ?

- good shaft alignment is a classic "weakness", as well as proper coupling with the driving source. The lubrication of these links is also something to look after,
- proper oil selection versus application condition: viscosity index, viscosity grade (ISO 32,46, 68...), environment (biodegradability, fire resistance, normal conditions), pumping temperature range, filterability, deaeration, thermal stability are the basics to consider for a good fluid,
- if the pump is used on a very fast pressure cycling machine, attention should be paid to the relationship between the pressure rise/fall gradient and the inlet pressure in order to avoid cavitation. We recommend maximum limits of 5000 bar per second (72500 PSI/ second) for pressure rise and 6000 bar per second (87000 PSI) for pressure fall.

VANE TROUBLESHOOTING GUIDE

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II ANALYSIS OF FAILURES

The systematic analysis of failures permits the causes to be determined logically, these failures being either distortion, shearing, surface seizure or scoring.

If the failure is shearing, we can almost certainly say it is the consequence of a brutal or a fatigue failure. A brutal failure is due to sudden increase in loads exceeding the material strength limit or its resistance to shocks. A fatigue failure is the

result of the tensile limit of the sensitive point of a component.

Studying the crystalline faces will allow us to determine the mechanical causes that provoked the failure. This troubleshooting guide has been prepared to allow everyone to quickly reach a satisfactory conclusion. A precise and professional analysis to determine the problem is not really the purpose of this guide.

II-1: MECHANICAL FAILURES

Mechanical failures are due to physical external parameters that change the mechanical structure of the materials. The causes of these incidents are

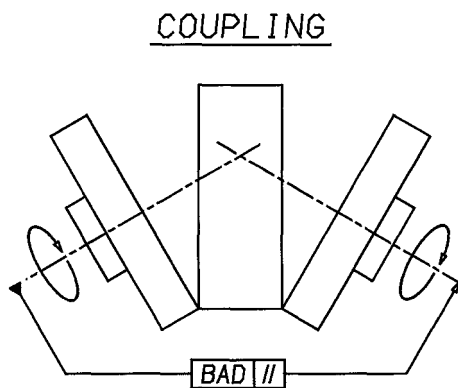
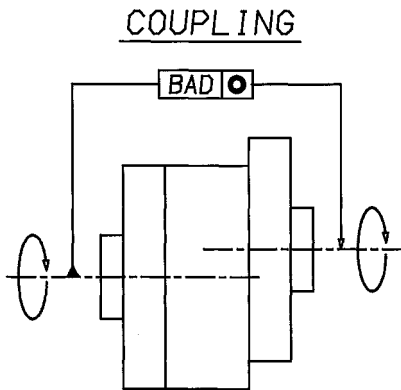
mostly axial and radial shaft overloads. Rotary bending (flexion) and torsion (twisted) fatigue failures.

II-1-1 - Problems on

shafts: bad alignment, bad mechanical link (bracket, chassis deformation, bad bell housing, too loose damping elements...) can create:

a) misalignment

b) out of squareness



consequence page

- Fretting P 12, II-2-1
- Shaft rupture P 12, II-2-2-1
P 13, II-2-2-2
- Rear bushing P 15, II-2-5-1
P 15, II-2-5-2
P 15, II-2-5-3
- Cam ring marked P 15, II-2-6
- Shaft seal problem P 16, II-2-7
- Dissymmetrical wear on port plate P 16, II-2-8
- Ball bearing worn or destroyed

- Fretting P 12, II-2-1
- Shaft rupture P 12, II-2-2-1
P 13, II-2-2-2
- Rear bushing P 15, II-2-5-1
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- Shaft seal problem P 16, II-2-7
- Dissymmetrical wear on port plate P 16, II-2-8
- Ball bearing worn or destroyed

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II-1: MECHANICAL FAILURES (continuation)

II-1-1-1 - Too tight gap between the two coupling flanges (axial loads/radial loads).

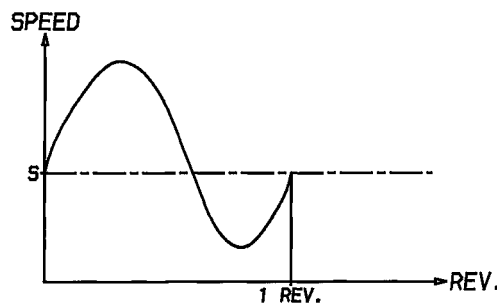
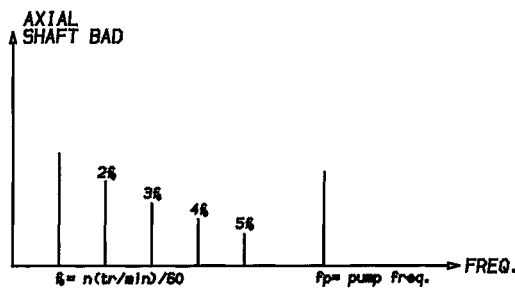
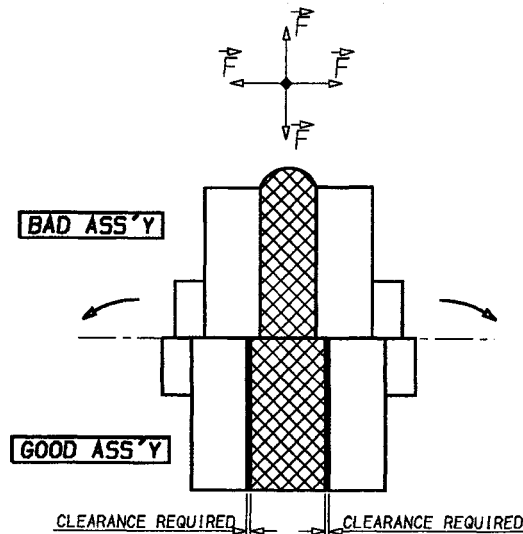
II-1-1-2 - Unbalanced coupling = radial load.

II-1-1-3 - Too high load on a belt driven system (belt drives not recommended).

II-1-1-4 - Non-homokinetic transmission due to unbalanced cardan shaft (or universal joint) means inconstant shaft speed.

II-1-1-5 - Too great moment of inertia due to heavy couplings (like chain couplings) or very large diameter couplings.

COUPLING



consequence page

- Fretting corrosion P 12, II-2-1
- Shaft rupture P 12, II-2-2-1
P 13, II-2-2-2
- Ball bearing worn out
- Rear bushing P 15, II-2-5-1
P 15, II-2-5-2
P 15, II-2-5-3

- Check with the coupling manufacturer to convenient clearance required depending on the torque.

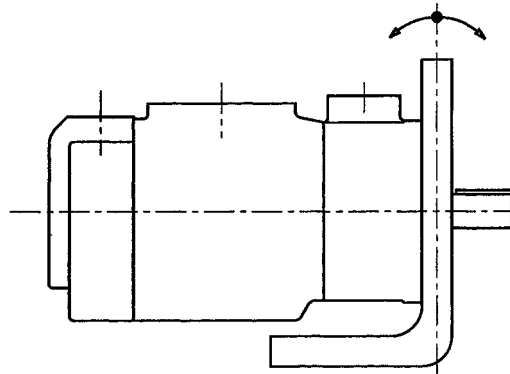
- Shaft rupture P 13, II-2-2-2
- Bushing P 15, II-2-5
- Cam ring marked P 15, II-2-6
- Shaft seal problem P 16, II-2-7
- Dissymmetrical wear on port plate P 16, II-2-8

- Shaft rupture P 13, II-2-2-2
- Bushing P 15, II-2-5
- Cam ring marked P 15, II-2-6
- Shaft seal problem P 16, II-2-7

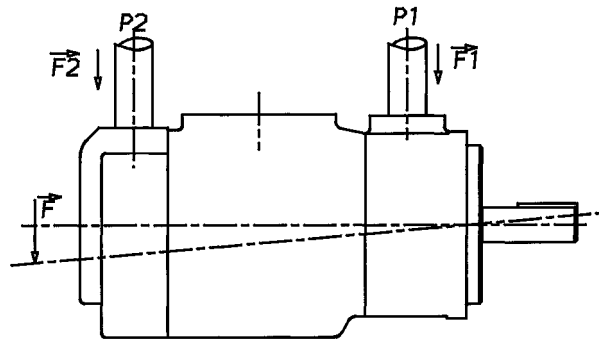
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II-1: MECHANICAL FAILURES (continuation)

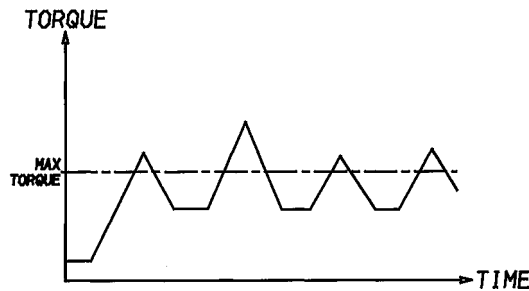
II-1-1-6 - Bracket chassis deformation (when pump under load).



II-1-1-7 - Hose strain (reaction) force (brutal pressure compression / decompression, rigid hoses mounting strain...).

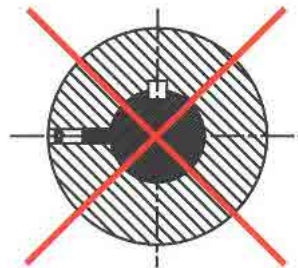


II-1-1-8 - Over torque limits (too high pressure versus displacement for the capacity of the shaft chosen).



II-1-2 - Bad shaft/coupling connection:

II-1-2-1 - "Coupling screw" not properly positioned on the key (keyed shaft).



consequence page

- Shaft rapture P 12, II-2-2-1
P 13, II-2-2-2
- Bushing problems P 15, II-2-5
- Marked cam ring P 15, II-2-6
- Seal problems P 16, II-2-7
- Wear on port plate P 16, II-2-8

- Shaft rapture P 12, II-2-2-1
P 13, II-2-2-2
- Bushing problems P 15, II-2-5
- Marked cam ring P 15, II-2-6
- Seal problems P 16, II-2-7
- Wear on port plate P 16, II-2-8

- Shaft rapture P 13, II-2-2-3
(torsional fatigue)
- Shaft wear P 14, II-2-3
P 14, II-2-4

- Shaft rapture P 12, II-2-2-1
P 13, II-2-2-2
- Rear bushing P 15, II-2-5-1
P 15, II-2-5-2
P 15, II-2-5-3

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II-1: MECHANICAL FAILURES (continuation)

II-1-2-2 - Bad manufacturing (machining) of the couplings:

- bad diameter fit tolerance between the shaft diameter and the coupling diameter

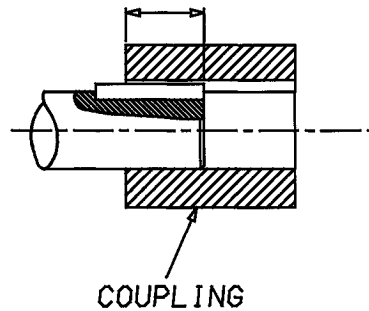
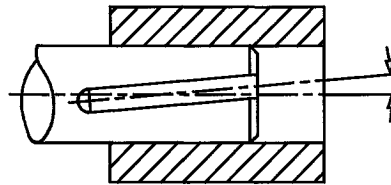
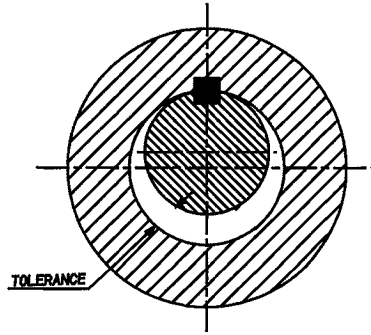
- key way in the coupling is not properly centered with the main bore axis

- bad heat treatment (too high or too low)

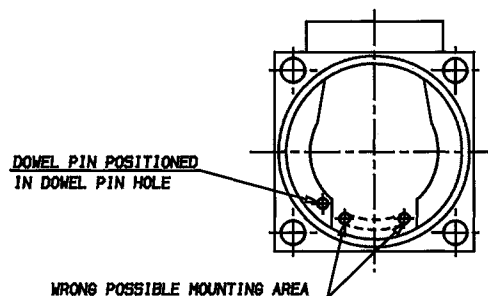
II-1-2-3 - Shaft not properly utilized (too small surface of spline or key used)

II-1-2-4 - Bad (or no) lubrication of splined shafts/coupling.

II-1-3 - Cartridge dowel pin not positioned correctly in the housing.



Denison Hydraulics requires for the lubrication of the shafts a grease with "disulfide of molybdenum" base.



consequence page

- Fretting P 12, II-2-1
- Shaft rupture P 13, II-2-2-3
- Shaft worn out P 14, II-2-4

- Shaft rupture P 14, II-2-3
- P 14, II-2-4

- Wear of the splines P 14, II-2-3
- Wear of the key P 14, II-2-4

- Spline wear P 14, II-2-3

- Dowel pin rupture P 16, II-2-9
- No pressure possible
- Unconstant flow
- Cavitation
- Noisy

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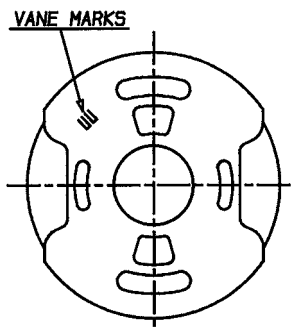
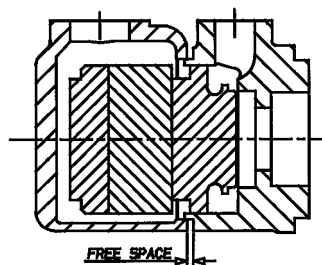
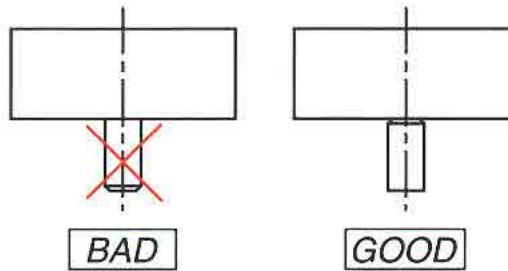
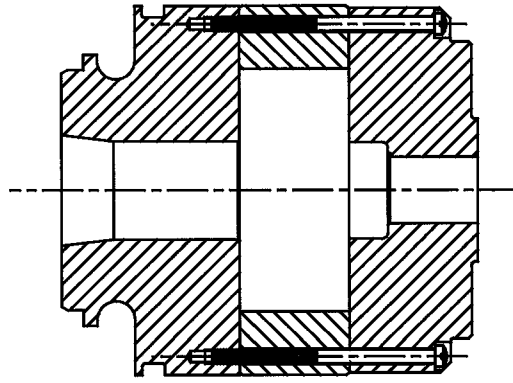
II-1: MECHANICAL FAILURES (continuation)

II-1-4 - Cartridge screws not properly mounted (after a cartridge modification, no precaution has been taken to see if the rotor/vanes could rotate freely in the newly built cartridge. Some vanes can have tilted and therefore be squeezed inbetween the port plates). These screws should be lightly tightened as they just hold pieces together to obtain a cartridge. After reassembling a cartridge, always check if the rotor & vanes can rotate freely in the cartridge.

II-1-5 - Hollow pin-vane hold-out wrongly mounted in the T6*M, Mobile version (pin up side down).

II-1-6 - Loose pump fasteners (after modifying the pump, the screws were not tightened at the proper torque and worked loose).

II-1-7 - Marks on distribution plates that disturb the cycle of the pump. Even a small scratch between the inlet & the pressure area can destabilize the vane.



consequence page

- Vane marks P 11, II-1-7
- Vane marks P 17, II-2-12

- Noisy
- Flow unstable

- Broken screws P 17, II-2-11

- Vane marks P 17, II-2-12
- Noisy
- Pressure limited
- Flow unconstant

II-2: THE CONSEQUENCES OF MECHANICAL FAILURES:

II-2-1 - Fretting corrosion.

This phenomenon appears when the sollicitations are great and when there is a slight vibration movement. These movements will "create" metallic oxides. Being very abrasive, they will weaken the structure of the component and will favour start-up of the fatigue rupture (twisted).

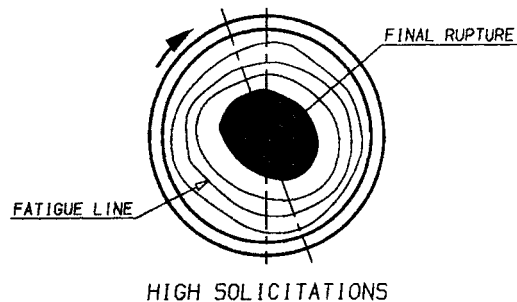
II-2-2 - Fatigue shaft rupture:

II-2-2-1

- Perpendicular, center, rotational bending fatigue rupture.



ROTATIONAL BENDING FATIGUE



incident page

- Bad shaft / coupling link
P 9, II-1-2-1
- Bad coupling manufacturing
P10,II-1-2-2
- Bad grease when assembly

- Bad alignment P 7, II-1-1a
- Out of squareness P 7, II-1-1b
- Unbalanced coupling
P 8, II-1-2
- Too high radial load
P 8, II-1-3
- Non homokinetic P 8, II-1-1-4
- Too great moment of inertia
P 8, II-1-5
- Bracket chassis deformation
P 9, II-1-6
- Hose strain force P 9, II-1-1-7
- Bad shaft / coupling link
P 9, II-1-2-1

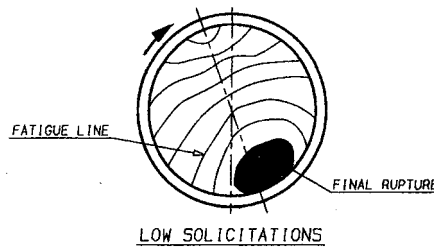
VANE TROUBLESHOOTING GUIDE

II-2: THE CONSEQUENCES OF MECHANICAL FAILURES: (continuation)

II-2-2-2 -
Perpendicular,
over-center rotational
bending fatigue rupture.



ROTATIONAL BENDING FATIGUE



II-2-2-3 - Twisted tor-
sional rupture.



TORSIONAL FATIGUE



incident page

- Bad alignment P 7, II-1-1a
- Out of squareness P 7, II-1-1b
- Unbalanced coupling
P 8, II-1-1-2
- Too high radial load
P 8, II-1-1-3
- Non homokinetic P 8, II-1-1-4
- Too great moment of inertia
P 8, II-1-1-5
- Bracket chassis deformation
P 9, II-1-1-6
- Hose strain force P 9, II-1-1-7
- Bad shaft / coupling link
P 9, II-1-2-1

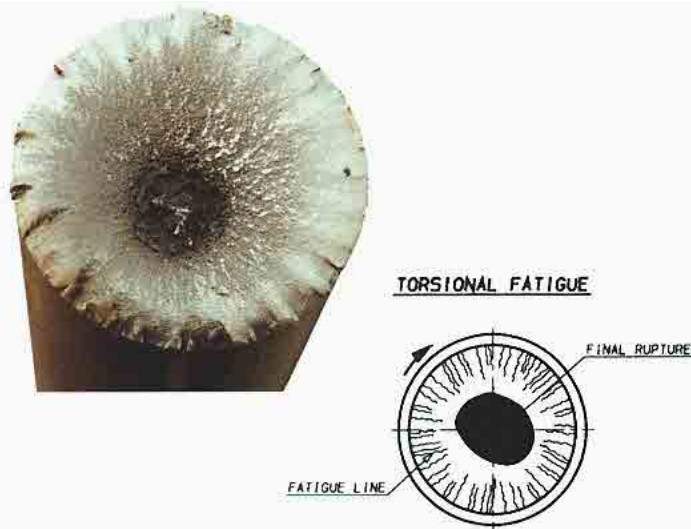
- Fretting corrosion
P 12, II-2-1
- Over torque limits
P 9, II-1-1-8

VANE TROUBLESHOOTING GUIDE

II-2: THE CONSEQUENCES OF MECHANICAL FAILURES:

II-2-2-4

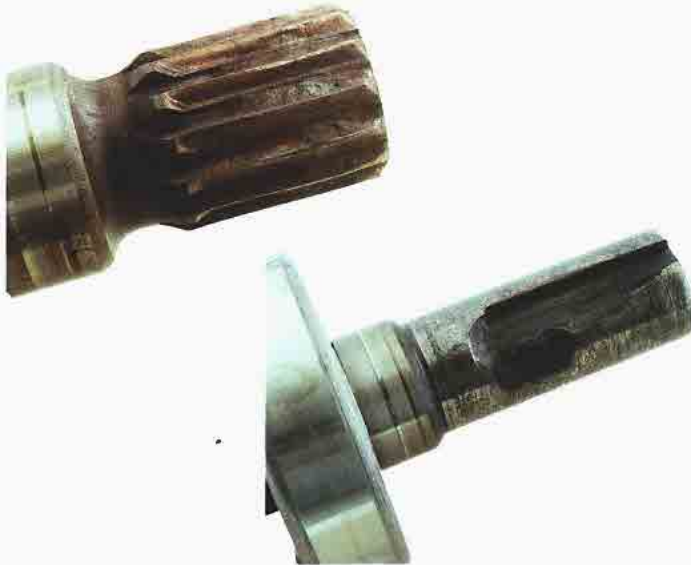
- Perpendicular, torsional fatigue rupture.



incident page

- Torsional fatigue with peak torque values
P 9, II-1-8

**II-2-3 - Shaft splines/
keyed shaft worn
out on total length.**



- Bad shaft / coupling connection
P 10, II-1-2-2
- Bad lubricant (Grease)
- Over torque values
P 9, II-1-8
- Highly cycled

**II-2-4 - Shaft splines/
keyed shaft worn
out on part of the
length.**



- Over torque values
P 9, II-1-8
- Utilized key surface or splined surface too small
P 10, II-1-2-3

II-2: THE CONSEQUENCES OF MECHANICAL FAILURES: (continuation)

II-2-5 - Bushing/bearing problems

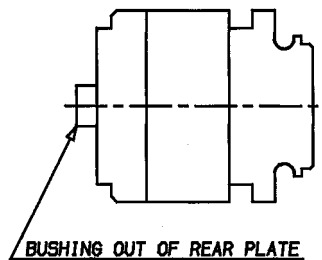
II-2-5-1 - Front or back bearing/bushing with heavy wear



II-2-5-2 - Bushing "welded" on the shaft



II-2-5-3 - Back bushing moving out of the rear port plate



II-2-6 - Cam ring marked by the rotor on the smallest diameter. If the contact between the rotor and the cam ring is important, it will transform the hardness of the cam ring and create local tensions (cracks).



incident page

- Problems on shafts
P 7, 8, 9, II-1
- Bad shaft / coupling connection
P 9, 10, II-1-2

- Problems on shafts
P 7, 8, 9, II-1
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- Problems on shafts
P 7, 8, 9, II-1
- Bad shaft / coupling connection
P 9, 10, II-1-2

VANE TROUBLESHOOTING GUIDE

II-2: THE CONSEQUENCES OF MECHANICAL FAILURES: (continuation)

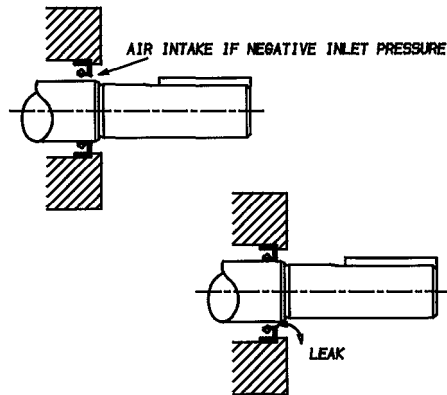
II-2-7 - Seal loosing

contact with the shaft

on one area:

- air intake

- leakage



incident page

- Problems on shafts
P 7, 8, 9, II-1
- Bad shaft / coupling connection
P 9, 10, II-1-2

- Problems on shafts
P 7, 8, 9, II-1
- Bad shaft / coupling connection
P 9, 10, II-2

II-2-8 -

Dissymmetrical
wear on the side
plates



- Problems on shafts
P 7, 8, 9, II-1
- Bad shaft / coupling connection
P 9, 10, II-2

II-2-9 - Dowel pin broken



- Over torque limits
P 9, II-1-8
- Cartridge not properly mounted
in the housing P 10, II-1-3

II-2-10 - Noisy

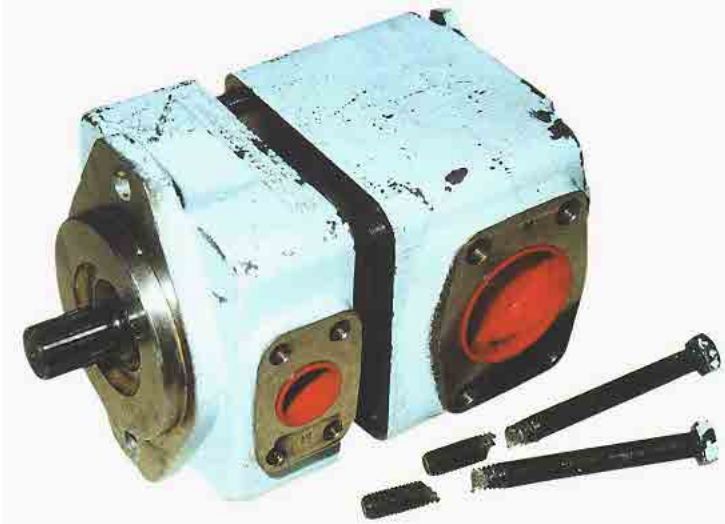


- Hollow pin-vane P 11, II-1-5

VANE TROUBLESHOOTING GUIDE

II-2: THE CONSEQUENCES OF MECHANICAL FAILURES: (continuation)

II-2-11 - Broken screws



incident page

- Loose pump fasteners
P 11, II-1-6

II-2-12 - Parallel marks on the port plate (vane marks)



- Cartridge not properly assembled P 11, II-1-4

- Tilted vanes marked the port plate but the pump did not rotate.

- Tilted vanes but the pump did rotate. The result is scars on the port plate.



- Cartridge not properly assembled P 11, II-1-4

VANE TROUBLESHOOTING GUIDE

II-3 : PRESSURE FAILURES: OVERSHOOT & PRESSURE GRADIENTS

II-3-1 - PRESSURE OVERSHOOT

Although system pressures are rising constantly, the pressure overshoot also rises. The effects on pumps, whichever technology is used, are bad. We have split-up this description into two different categories: "Instant pressure overshoot" and "Cycled overpressurization". The final consequences of these are the same, that is to say the failure of components. We will see that the failing components are damaged differently if it is Instant pressure overshoot or Cycled overpressurization. The valves and the pipes rigidity and length around the pumps have a great impact on these pressure peaks. It can be a system problem

or a valve problem that opens the main security valve. The pump is or is not protected by a check valve. The fact is that the pressure rises over the initial settings or designed settings. This problem is mainly seen when the valves tend to open (or close for a check valve) too slowly. These pressure peaks can reach 2 to 5 times the pressure settings. Not readable with standard manometer, electronic sensors recording traces will show the facts. When the check-valve closes itself too slowly, the flow will come backwards into the pump. This problem will be seen in the cycled overpressurization.

II-3-2 - INSTANT PRESSURE OVERSHOOT:

This a brutal high peak of pressure. The consequence is that the mechanical strength of the material is exceeded.

This will cause some brutal failures of compo-

nents such as the side plates (on the high pressure distribution area), the rotor (split), the cam ring (cracked), the shaft (broken), the dowel pin (cut in two).

II-3-3 - THE CONSEQUENCES OF INSTANT PRESSURE OVERSHOOT:

II-3-3-1 - Cracks or rupture of the pressure plate



VANE TROUBLESHOOTING GUIDE

II-3-3 - THE CONSEQUENCES OF INSTANT PRESSURE OVERSHOOT: (continuation)

II-3-3-2 - Cracks or rupture of the rotor



II-3-3-3 - Cam ring cracked



II-3-3-4 - Shaft broken: perpendicular "clean cut"



VANE TROUBLESHOOTING GUIDE

II-3-3 - THE CONSEQUENCES OF INSTANT PRESSURE OVERSHOOT: (continuation)

II-3-3-5 - Dowel pin cut in two



II-3-4 CYCLED OVERPRESSURIZATION:

The pressure rating of the system is just over the allowed pressure specified.

This will give, on a long term, a fatigue failure. It is the sum of the pressures exceeding limits that will weaken the mechanical strength of the components. These specific failures are seen on the following components: cam ring, vanes, shaft, side plates, rotor splines or the rotor rupture between the two vane slots bulbs of the rotor (as page 19, II-3-3-2).

Another effect is the deflection of the cam rings' external diameter due to this overpressure. The consequence of this expansion is to reduce the space between the rotor OD and the minor diameter of the cam ring. When this gap is too narrow, the rotor may come in contact with the cam ring. If both cam deflection and shaft misalignment happen at the same time, then the contact often arises.

Another distortion effect is this overpressure pushing on the pressure plate. The deflection of the pressure plate will, in its center, reduce the normal clearance between the port plates and the rotor. The film of oil lubricating these components will be reduced. Its temperature will rise

because of the narrow gap and a friction welding will result. The total seizure will then be the consequence if the local temperature rises too high.

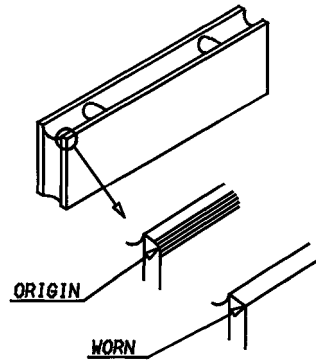
The system is not secured with a check valve or this check valve is too slow to open.

During the opening time of the "slow" relief valve, the flow delivered from actuators or the pump has to go somewhere. Usually, the relief valve opens and this flow goes back to the tank. Here, not being able to go back to the tank, the flow will go back to the pump. If the check valve closes fast enough, the pressure will increase and accelerate the relief valve opening to allow the flow back to the tank. If there is no check valve or if it is too slow, the flow will return to the pump. This flow will then push the rotor forwards, which will wear the rotors' splines. The gap between the rotor & the side plates will then be increased and create a local cavitation. This local cavitation will suck the oil lubricating the sides. Without enough oil, the local overheat will start a pump seizing. The vanes will have marks on both sides, the splines of the shaft and the rotor will be worn (on both splined teeth flanks)...

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II-3-5 THE CONSEQUENCES OF CYCLED OVERPRESSURIZATION:

II-3-5-1 - Vanes



II-3-5-2 - Cam ring:

-rupture/cracks



- rotor/cam ring contact in the "small diameter"

VANE TROUBLESHOOTING GUIDE

II-3-5 THE CONSEQUENCES OF CYCLED OVERPRESSURE: (continuation)

II-3-5-3 - Shaft:

- internal splines worn

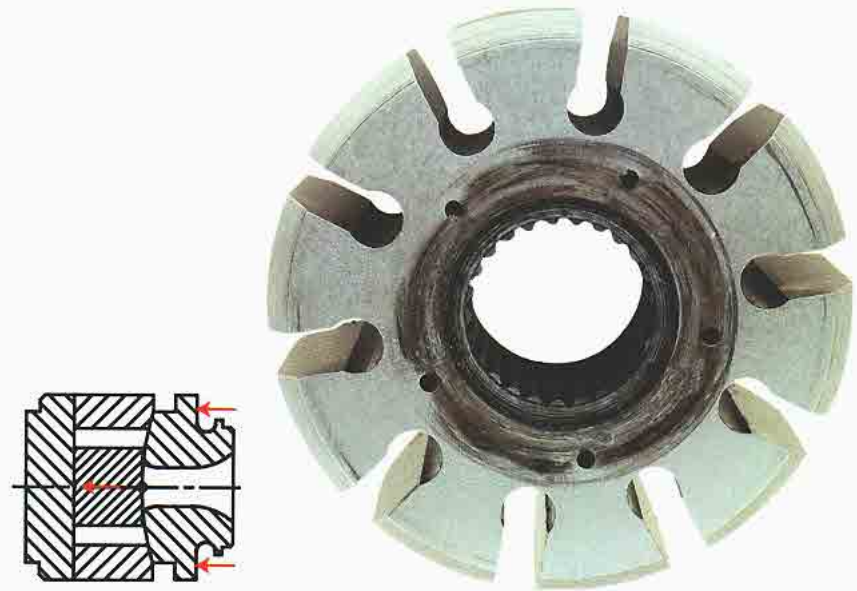
- rupture:

torsional fatigue ruptures

Perpendicular: few cycles but
very high torque

Twisted: often under high
cycling

II-3-5-4 - Side plates deforma-
tions = contact on the smallest
diameter of the rotor.



VANE TROUBLESHOOTING GUIDE

II-3-6 PRESSURE GRADIENTS

This pressure increase/decrease decay, in bar per second, is known by most people but often forgotten in the basic hydraulic systems. The velocity of this increase/decrease is very important. Beyond the fact that it stresses the raw material, it has some big effects on the velocity of the oil. These sudden pressure changes modify the internal leakage of the pumps. Depending on the

pumps' technology, these allowable pressure gradients are more or less important. The Denison vane technology can be used safely up to 6000 bar per second. Over these limits, phenomena such as cavitation, hose decompression effect (...) can appear. A positive inlet pressure and no inlet strainer are recommended to avoid a too high inlet vacuum.

II-3-7 CONSEQUENCES OF TOO HIGH PRESSURE GRADIENTS:

II-3-7-1 - Cam ring fatigue rupture



II-3-7-2 - Rotor/side plates seizure: This is due to a very strong cavitation when the pressure decrease is dramatic. The sudden flow required is so important that the instant local velocity rises and creates the cavitation.



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II-4 PHYSICAL, CHEMICAL OR HYDRAULIC FAILURES

All the following failures are linked, one way or another, to the quality of the lubricant, the poor filtration or the poor inlet conditions. Either there

is some contamination (air, particles, water...), or some temperature problems, or a poor oil edging, or cavitation or fluid aeration problems.

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II-4-1 START-UP WITHOUT A PROPER AIR BLEED.

The vane pumps are designed and manufactured with a dry lubricant capability. The dry graphite lubricant coating on the cam ring and the surface treatment on the distribution plates are done to lubricate during start-ups.

- If the suction column of oil does not build up, the pump will not be lubricated enough and be damaged. The consequence of this bad lubrication is local overheating. Depending on how long this defect lasts, the consequences can go up to the seizure between the port plates and the rotor. The local temperature is so high that the film of oil between the components disappears,

and then the metal to metal contact will create the friction and then the "welding seizure".

- If the column of oil does build up but the air bleed is not complete, the pump will not work properly. The pressure will not build up correctly, the flow could be lower than the one required, the pumping will be erratic and noisy.
- If the inlet velocity is too low, under 0,5 m/sec., the air will stay trapped in the pump and in the inlet pipe.

The consequences of incorrect air bleed are seen in the next paragraph.

II-4-2 AIR CONTAMINATION (creating the foaming of the oil):

When we talk about air in the oil, it is the simplification of a complex chemical transformation. What we will call air is more a mix of different gases than air. This explains why under pressure, these gases will implode and create a very high local temperature.

The pressure creates the ignition and the gases will combust at temperatures as high as 1300°C. The result is the destruction of the fluid giving to it a black color and a "burnt" smell. This phenomenon is also known as the "Lorentz" or "diesel" effect.

II-4-2-1-Aeration:

Description : this phenomenon is the fact that some air is brought into the system and, with the turbulence of the flow, generates a foamed substance.

This new "fluid" has lost all the requirements of the original fluid and, therefore, lost all the capabilities of a standard hydraulic fluid. The consequences of such a transformation are different depending on the quantity of air brought into the system.

This problem could be caused by different external problems, independent or not:

- suction pipe not sealed under vacuum, therefore sucking air,
- deteriorated shaft seal (or high radial load creating an air intake),
- inlet tube in front of the return line (amplifying the foaming),
- turbulence created by a high velocity around the inlet tube (not enough suction surface),
- return line coming back to the reservoir over the oil level. It is required that the lowest point of the return line must always be under the oil level (five times the pipe diameter),

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- oil level of the reservoirs too low compared to the suction level,
- too small tank (high velocity in the tank,)
- fluid in movement (bad tank design on mobile applications),
- bad deaeration capabilities of the fluid and/or the tank. Baffles can help "pushing" the air to the surface. If the "vein flow" is too rapid and if no baffle is there to bring to the surface these bubbles, they will go back to the inlet area. This

- air going to the pump will deteriorate it.
- bad baffle design. If the fluid is to pass over the baffle, the maximum speed has to stay under 0.5 meter per second to avoid turbulence,
- Venturi effect on a return pipe,
- anti-siphon holes drilled in the return pipes,
- water pollution that will create steam due to local overheating. This steam in contact with oil will create foaming (for more details, please go to page 35, chapter II-4-5, water contamination).

II-4-2-2- Consequences of Aeration:

The vanes are going to be completely unbalanced due to the abnormal fluid compressibility (due to quantity of air in the oil). The vanes, usually hydrostatically balanced (without air), will move sideways with such erratic movements that the vanes will destroy their lubricant film of oil that links them to the side plates. Doing so, the vanes,

hardened metal pieces, will start to wear the side plates in die cast or ductile iron.

The marks will start in the discharge area and, depending on the quantity of air, will more or less create a groove.

During all these turbulences, the most noticeable fact is going to be an unusual noise level.

II-4-2-2-1 - If the quantity of air is erratic or not too heavy, the effects are scores only on the port plates in the suction area



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II-4-2-2- Consequences of Aeration: (continuation)

II-4-2-2-2 - If under very severe aeration, this groove can mark deeply the port plates from the suction area to the outlet area. The width of the groove is then the width of the vane.



II-4-2-2-3 - In very heavy air conditions, the vane is so unbalanced that it can even sometimes break (itself).



II-4-2-2-4 - Noisy



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II-4-2-2- Consequences of Aeration: (continuation)

II-4-2-2-4 - Noisy (continuation)



Before obtaining such a disastrous wear, the vanes being so unsteady will make a lot of noise, the flow will not be the one required and/or the

pressure level will not be obtained. The physical aspect of the oil will be "milky" on the surface as the oil and the air create a foam.

II-4-2- AIR CONTAMINATION (continuation)

II-4-2-3 - Cavitation-Deaeration:

Description : When a depression arises in the suction port, the gas (combustible) and aromatic essences dissolved in the fluid (6 to 7 %) will evaporate. Depending on the type of fluid, this deaeration will occur between 100 and 150 mm of HG (around -0.2 bar). Under this depression (or vacuum), small bubbles of a diameter of .2 to .3 mm will be formed. The natural appearance of oil is translucent. Under cavitation and because of these small "bubbles", the fluid will have a "cloudy" appearance. Depending on the value of the vacuum, the quantity of suspended bubbles will be more or less important. As these bubbles have a

small diameter, they will reach the surface of the oil tank very slowly (bad deaeration characteristics). As an example, 100 liters of a foamed oil by cavitation will take 4 hours to become translucent again. When the fluid reaches local hot temperatures and is compressed (at the "critical pressure"), these bubbles implode and create a shock wave, known as the diesel effect, the impact of these "combustion explosions", will create erosion in the shape of the crater (cavities) when located near a metallic surface. These detached metallic particles are very likely to cause, on a medium term base, a seizure between the pumps' moving parts.

II-4-2-3 - Cavitation-Deaeration: (continuation)

This problem can be caused by different external problems (independent or linked):

- suction strainer :
- clogged by a foreign contaminant,
- clogged by a too high viscosity,
- too small in flow rate/pressure drop.
- (Filtration on the return line and no suction strainer is still what we recommend to avoid the above mentioned problems).
- too long inlet hose,
- too small inlet hose (too small section on the whole piping or restricted in one area),
- inlet tube, in the tank, too close from the panel of the tank,
- inlet tube, in the tank, with a too small suction surface creating local turbulence (deaerating the fluid). Cut the tube on a angle to increase this suction surface and avoid local high Velocities,
- too high or too low inlet velocity (0.5 to 1.9 meter per second is the velocity required),
- tank too far away from the pump (horizontally or vertically),
- excessive shaft speed,
- air filter on the tank clogged or not well dimensioned generating a vacuum in the tank.
- reservoirs' oil level too low compared to the suction level (when all cylinders are extended for example),
- inlet tube in front of the return line (amplifying the foaming),
- too small tank (high velocity in the tank),
- bad deaeration capabilities of the oil and of the tank. Baffles can help "pushing" the air to the surface. If the "vein flow" is too rapid and if no baffle is there to bring to the surface these bubbles, they will go back to the inlet area. This air in the pump will deteriorate it.
- bad filtration dimension on return line. Under dimension will increase the velocity and deaerate the oil.

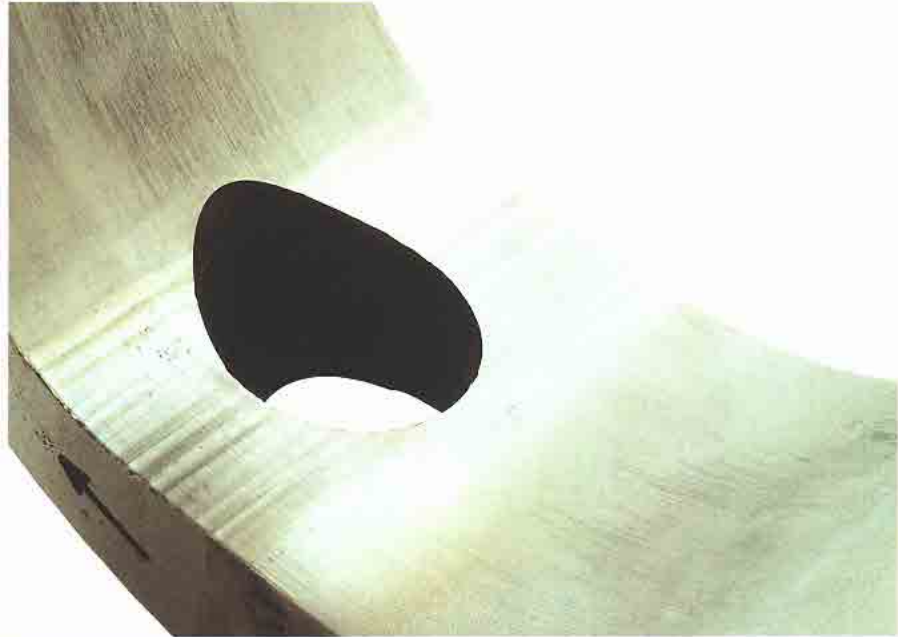
II-4-2-4 - Consequences when the pump is cavitating:

II-4-2-4-1 - Noise level : much higher than usual. Under pressure, this noise level is amplified.



II-4-2-4 - Consequences when the pump is cavitating: (continuation)

II-4-2-4-2 - Ripples on the cam ring: the vanes are hydrostatically balanced to avoid excessive loads on the vane lips. Under suction cycle, the pin compensates the out of balance load due to the cam profile. When the depression is over the design limits, the vane bounces, creating ripples on the cam ring profile. The depth of these marks is proportional to the strength of the depression.



II-4-2-4-3 - Craters: these erosion craters are sometimes difficult to observe as the pump may have already seized. These craters come from erosion, caused either by an explosion/implosion, either by depressurisation.

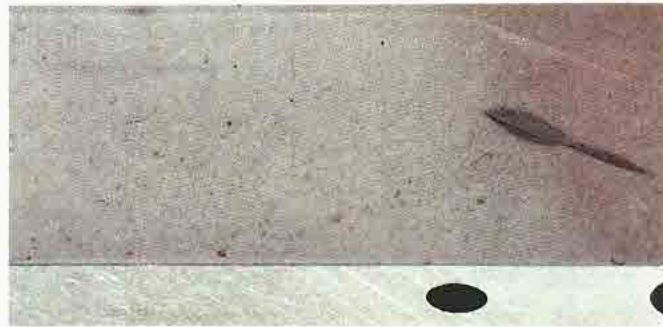
When the fluid trapped between the two vanes is sucked in with a certain percentage of air in suspension, an explosion can occur. When this trapped volume is compressed, these air bubbles explode and create craters in the side plates in the area between the suction port and the pressure port, around the pressure bleed slots.



II-4-2-4 - Consequences when the pump is cavitating: (continuation)

II-4-2-4-3 - Craters (continuation)

- vanes



- pins



II-4-2-4-4 - "Black marks":

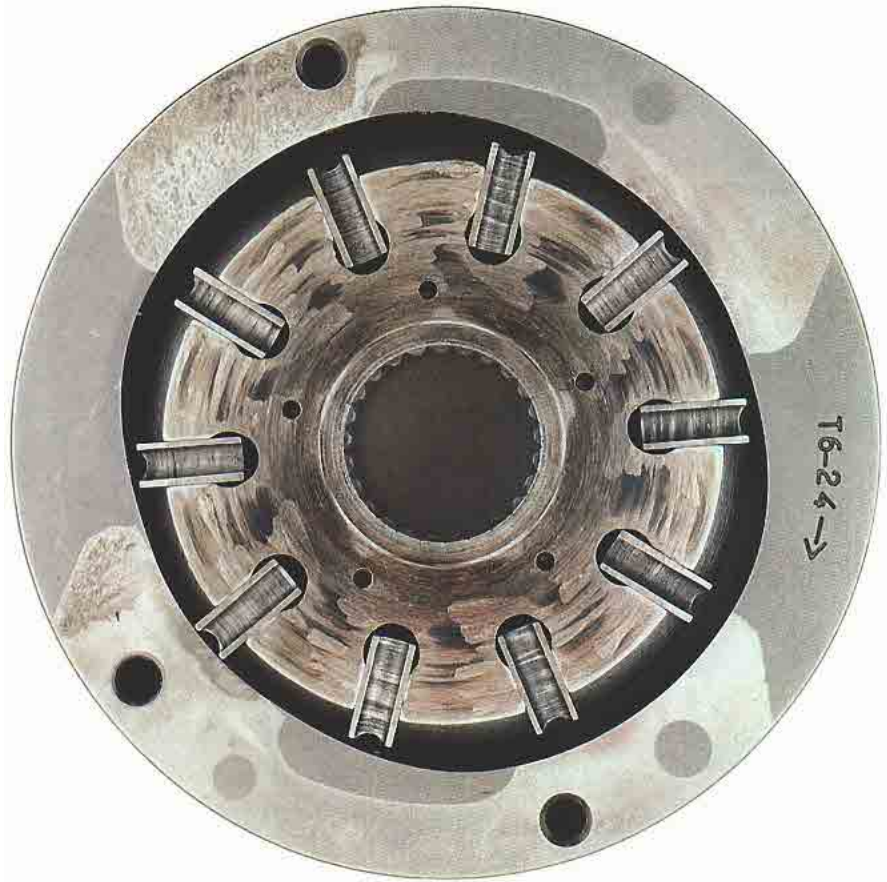
The local depression consequences can be seen on the vanes (top lips and on the center of the vane), on the port plates (in the inlet area) and on the center of the cam ring (just after the inlet "feeding hole"). These "black marks" can be transformed into small craters in the port plates near the outlet bleed slots as the air bubbles explosion occurs.



II-4-2-4 - Consequences when the pump is cavitating: (continuation)

III-4-2-4-5 - Seizure of the pump.

Due to a lack of fluid, the vacuum generated, when really severe, will suck the oil on the side of the pump (between the rotor and the side plates). This will have the effect of breaking the film of oil that lubricates these surfaces. The surfaces will then heat-up and this local over-heat will modify the standard lubricity into a dry friction. The result is a seizure between the rotor and the side plates. (This heavy contamination coming from the digging of craters, the particles can also badly lubricate the pump and lead to the seizure.)



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II-4-3 SOLID PARTICLE CONTAMINATION:

Unlike a lot of different technologies, the Denison vane units do not generate pollution.

Even if this has become an important topic and a lot of education has been done around the cleanliness of the fluid, the pollution by particles stays one of the greatest causes of pumps' destruction. The consequences are either a rapid wear or a premature breakdown (large size particles over 25 μm). In a hydraulic circuit, the pump is the flow/pressure generator. Being so, it becomes the most sensitive unit to pollution and, therefore, will be the first component to fail.

Nature of particles :

The main particles are made up of metallic oxide, silica, carbon and organic materials.

Origin of particles :

- A common large particle is the metallic oxide coming from welding burrs when the welded piping has not been cleaned-up properly.
- The silica comes from the surrounding dust. This dust will enter into the system through cylinders' sealing, through air intakes (absence of air filters), dirty environment and the tank not properly sealed ...

II-4-4 CONSEQUENCES OF SOLID PARTICLE CONTAMINATION:

Depending on the size of the particles, the consequences can go from a gentle ground finish on the vane lips, cam surface, side plates to the total destruction of the cartridge.

It is obvious that under perfect filtration conditions, the rubbing of the vanes in the rotor is reduced to a minimum by the action of the oil under pressure which is located all around the vanes.

II-4-4-1 - Vanes:

a)

- The vane lips edges. The particles in the fluid will have a grinding effect between the top of the lip and the cam ring profile. When the contaminant is too big or too stiff, the vane lip edges can break.



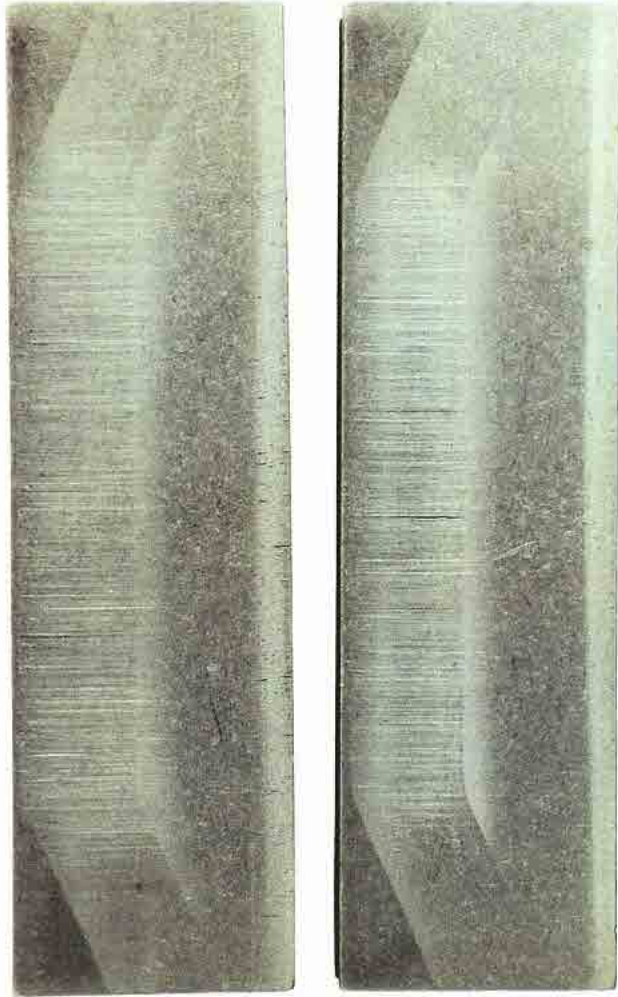
VANE TROUBLESHOOTING GUIDE

II-4-4 CONSEQUENCES OF PARTICLE CONTAMINATION: (continuation)

II-4-4-1 - Vanes (continuation)

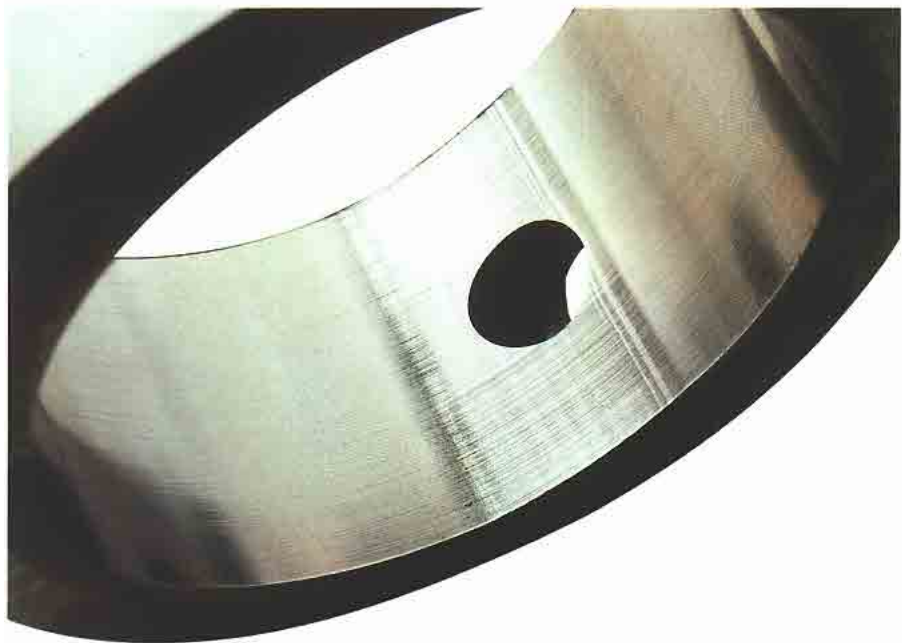
b)

- The vane surface. The film of oil between the vanes and the rotor being contaminated, there will be a rubbing effect in this area. These rubbing marks (pol-
lution marks) will be vertical and of the height of the vanes' translation (displacement).



II-4-4-2 - Cam ring:

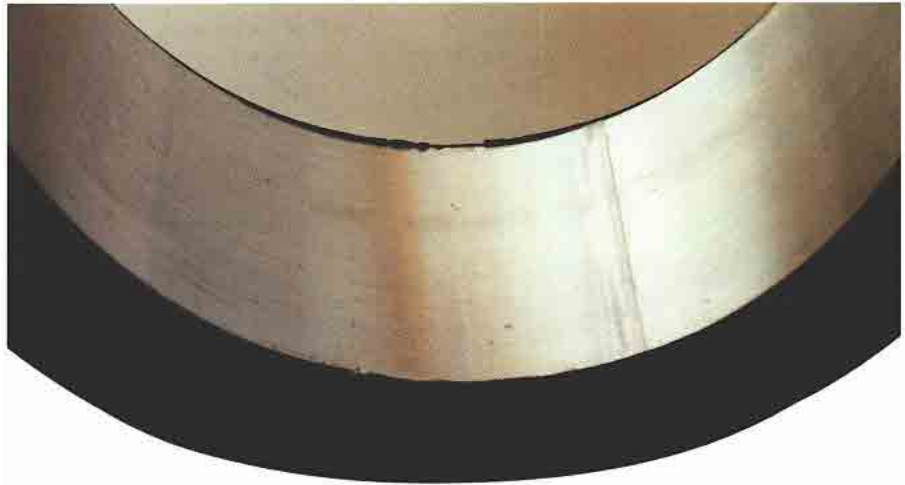
- Between the vane lip and the cam ring, the film of oil is contaminated. This will wear the inner surface of the cam ring.



VANE TROUBLESHOOTING GUIDE

II-4-4 CONSEQUENCES OF PARTICLE CONTAMINATION: (continuation)

- On the edge of the cam ring contour, (with a slight chamfer when new), you will find a sharp angle (edge). If the wear is heavy, the cam ring can have little burrs in this area.



II-4-4-3 - Rotor/vanes:

In the rotors' slots, the rubbing wear between the slots and the vanes will also lead to vertical pollution marks. (P 32 II-4-4-2 b)



II-4-4-4 - Rotor/side plates:

When the particles in suspension in the fluid are greater than half of the clearance between the thickness of the rotor and the thickness of the cam ring, seizure occurs in the peripheral diameter of the rotor and the port plates.



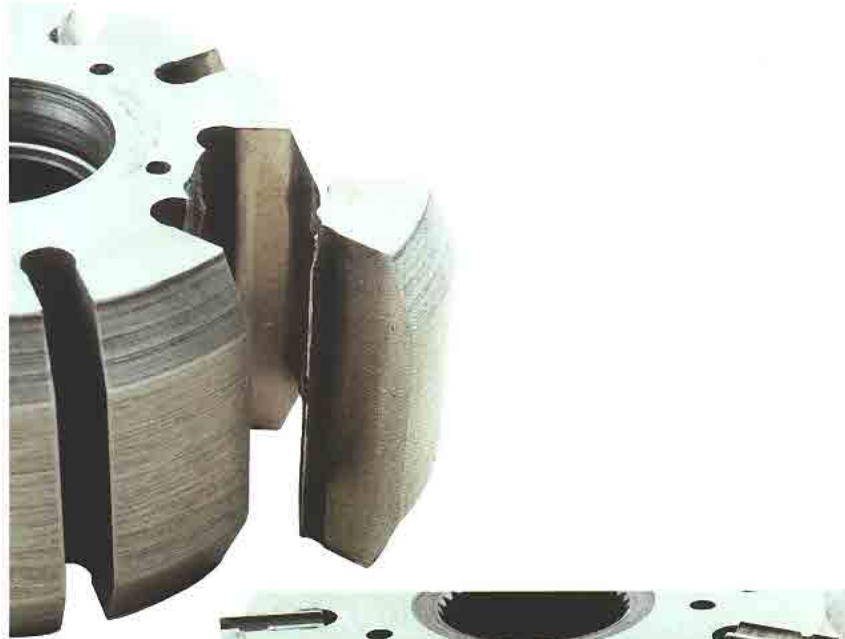
VANE TROUBLESHOOTING GUIDE

II-4-4 CONSEQUENCES OF PARTICLE CONTAMINATION: (continuation)

II-4-4-5 - Rotor - The rubbing effect will also appear in-between the side of the rotor and the side plates. This will create a torque between the two vane slaps. This torque causes a reasonably high level of fatigue in the materials' weakest area, between the two bulb slots of the rotor. If this fatigue level exceeds the design limits, this portion of the rotor will break.

II-4-4-6 - Rotor/side plates/vanes: Big contamination particles damages (like the "carbon" welding balls) are usually seen on the port plates (blocked in the slots) or/and on the top of the vanes/rotor. Each time, they will have an effect on the vane lips, either on the top either on the sides. The "rubbing" action will either destroy the vane lips or weld the vane to the rotor, break the cam ring...

II-4-4-7 - Side plates: Another sign of contaminated oil is some possible erosion craters on the port plates at the inlet/suction bleed slots area. These erosion craters would come from the abrasive fine particles in a local high velocity area.



II-4-5 WATER CONTAMINATION:

Description:

Depending on the type of fluid, the water contamination can be different. For mineral oils, this limit should not exceed 500 ppm (particles per million). This limit for the esters and the vegetable oils is maximum 500 ppm. The water contamination will modify the chemical structure of the fluid (oxidation of the fluid increases the TAN*). Having an excess of water, this water can be transformed into steam under the action of the pressure. Another effect of this excess is the modification of the "compressibility module".

- The fluid will be destroyed and lose its characteristics / performance. The oxidation of the fluid will modify the TAN. The higher acidity of the fluid will destroy the additives. This, added to the local heat created, will transform (or carbonize) the fluid. It will modify the molecular structure. The colour of the fluid will turn creamy (milky).
- Destroying the additives means the lubricity will be worse, the thermic stability very poor...
- The excess of water can also bring in bacteria that can damage the fluid. A gelatinous mass in the tank and in some components is a way to observe this phenomenon.
- The most common consequence is the appearance of rust on all metallic surfaces. This will

modify the nature of the contacts between surfaces. This can lead to start local micro-seizures due to a lack of convenient lubricant.

- When polluted with water, the whole system must be cleaned up and then drained two or three times until obtaining a clean translucent oil when running.

This water pollution can come from various causes:

- condensation coming from a high hydrometric level (big temperature variations),
- a leak in the water exchanger,
- tank not water-tight,
- storage of the oil barrel outside vertically,
- high pressure water cleaning of the machines (water going under the seals of cylinders on off-highway vehicles for example).

*TAN : Total Acid Number.

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II-4-6 CONSEQUENCES OF WATER CONTAMINATION:

II-4-6-1 - Deposit can then be seen on the vanes. This deposit will modify the performances of the pump because of the deterioration of the mechanical efficiency (the varnish will "stick" the vanes in the slots of the rotor).

On the cartridge, it changes the colour of the bronze bushing (due to the modification of the acidity) and leaves a deposit on the external diameter.

II-4-6-2 - The fluid can produce foaming because of the steam. The specificity of the foaming oil due to water is a milky or creamy typical aspect. The consequences are identical to the aerated fluid.



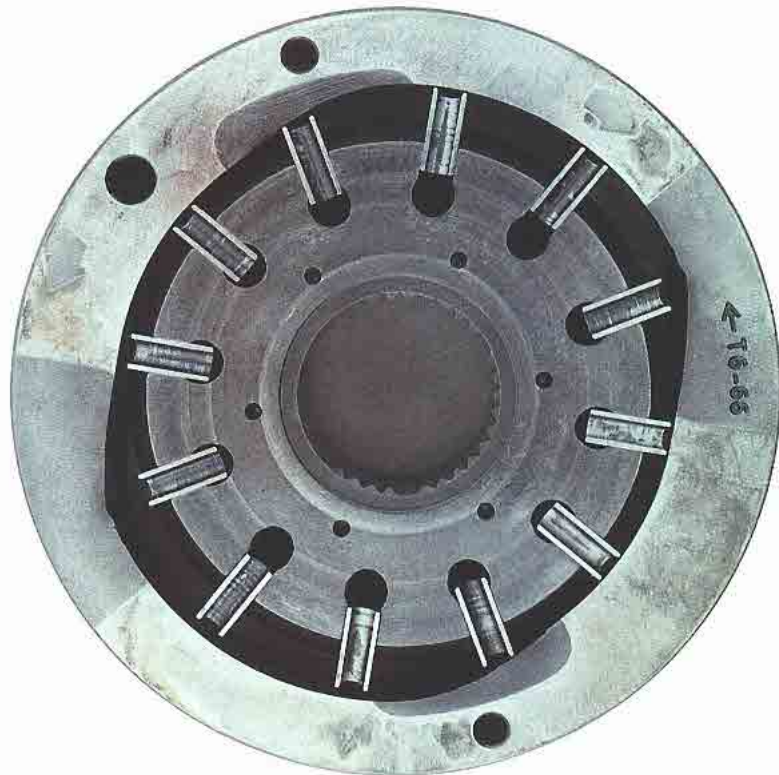
VANE TROUBLESHOOTING GUIDE

II-4-6 CONSEQUENCES OF WATER CONTAMINATION: (continuation)

II-4-6-3 - The fluid compressibility will fluctuate and therefore destabilize the vanes. This will be seen on the cam ring surface full of ripples and on the sharp vane lips edges. In this case, the noise level will be high and the flow & pressure capabilities deteriorated.



II-4-6-4 - Due to these fluid transformations, the mechanical consequences go from performance being deteriorated to the destruction of the pump if the local temperatures are extreme (Here, phosphate oil additive deposit).



II-4-7 VISCOSITY FAILURES.

Depending on the environment, the temperatures can considerably modify the original wanted Viscosity. The influence of the temperature differences on the Viscosity is enormous.

The vane components are designed to work for a wide possible range of Viscosity. When a problem occurs, the Viscosity is either too high or too low.

When the Viscosity is too high, over 2000 cSt

(9240 SSU), the problem is that the fluid has a big resistance and the Velocity will drop. This resistance can create local vacuum, that is to say deaeration of the fluid. This will ruin the lubricity of the pump.

Under heavy Viscosity and low rotation, the vanes can stick and stay stuck in the rotor. The consequence is that there is no flow coming out of the pump.

VANE TROUBLESHOOTING GUIDE

II-4-7 VISCOSITY FAILURES.

When the Viscosity is too low, under 8 cSt (52 SSU), it will decrease the film thickness designed to lubricate all the components in motion. If the Viscosity is very low, it could mean that the temperature is high. Tests carried out have shown that

a tank temperature of 50°C (122°F) could mean a local temperature in the pump of up to 130°C (266°F). If the viscosity is calculated on the tanks temperature, we can easily figure out the very low viscosity when the oil is at 130°C (266°F).

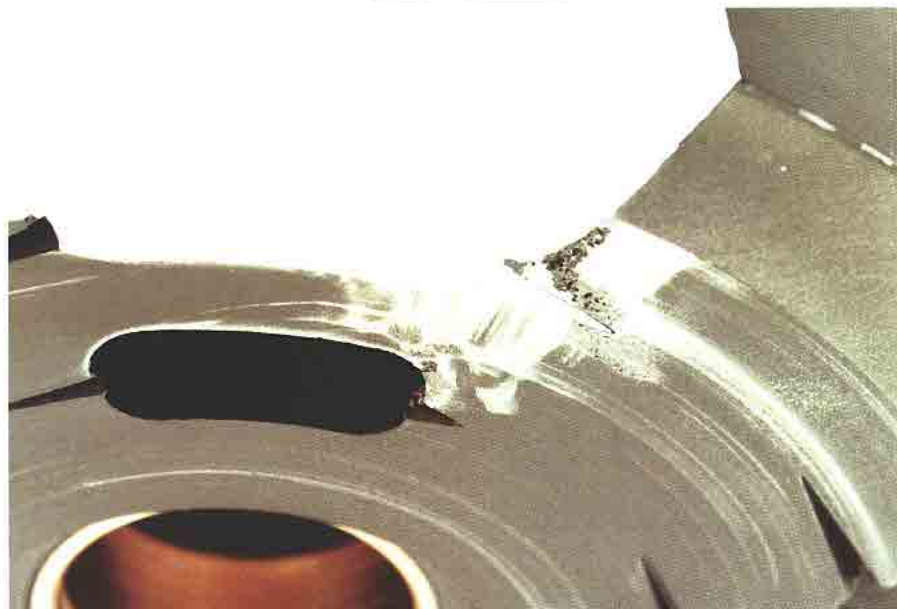
II-4-8 CONSEQUENCES OF VISCOSITY FAILURES.

II-4-8-1 - Too high viscosity:

- Seizure due to the high cavitation not allowing the rotating group to be lubricated.

II-4-8-2 - Too low viscosity:

- Erosion on the port plates.



II-4-8 CONSEQUENCES OF VISCOSITY FAILURES: (continuation)

- Scars on the side plates & rotor due to a bad lubricity.



II-4-9 UNSUITABLE FLUIDS:

Viscosity index choice:

If the fluid was chosen by an OEM in Norway for a local sale but the application is to work in Saudi Arabia, the choice of the fluid will have to take into consideration the specific application environment.

Forgetting this can lead into deep trouble. Too

high Viscosity will probably cause cavitation and a lack of lubrication, too low Viscosity will lead to a too thin film of oil and therefore create a local heat point.

In both extremes, the consequences can be fatal breakdowns.

Filterability:

If the fluid does not have good filterability properties, the filters will be clogged rapidly. The flow will have to go through the by-pass and therefore not be filtrated anymore and will heat-up the system (due to the open by-pass).

Bad filterability can either come from a low quality fluid, or from a fluid sensitive to any contaminant destroying its chemical homogeneity (water, solvents, grease...).

II-4-9 UNSUITABLE FLUIDS: (continuation)

Oxidation resistance:

Contaminants can modify the acidity of the fluid and therefore become very corrosive. Such a modified fluid will corrode the steel components and produce corrosion residues. These residues

will increase the Viscosity. Increased Viscosity will increase the pressure drops. Increased pressure drops will then increase the temperature and cause local overheat.

Deaeration capabilities:

This is another very important topic. If the fluid chosen requires too long time to allow the air to reach the surface of the tank, this can become a big problem. Air in big quantities has a desroying effect on all pump technologies. If the flow versus the size of the tank is small, if the

tank design is incorrect (inlet near return line for example), if the tank is slightly pressurized (due on purpose), the oil will not deaerate fast enough. The air bubbles will then be sucked by the pump. Under pressure, these bubbles will then explode.

Polluted fluid:

This is an important topic and, nowadays, well known at least for the solid particle contamination. The manufacturing clearances becoming tighter and tighter, a good filtration is required. This even though our double lip technology resists fairly well to pollution.

Another pollution is the impact of another fluid creating a reaction between the original fluid and

the contaminant. The fluids are more and more high technical products. They also become more and more sensitive to their environment and any contaminant can destroy the original characteristics. It is common for example to see fluids "desroyed" by a high water content (chemical, other fluid, particles). Refined oils will even be more sensitive than brand new ones.

Density:

It is important to know the specific gravity of the fluid used. Because the density from one fluid to another can vary a lot, the suction head has to be designed with that parameter. The specific gravity of a standard oil (ISO 46) will be around 0.88.

The specific gravity of a water-glycol (60 glycol/40 water) will be around 1.08. Knowing this value, just check the minimum required Absolute pressure in our catalogs to optimize your system.

II-4-9 UNSUITABLE FLUIDS: (continuation)

Conclusion on the fluids:

A common problem is the deterioration of the fluid. This deterioration can come either from the quality of the fluid (low quality or not used as recognized fluid manufacturer), or from an exter-

nal pollution, (solid particles, other fluids, chemical transformations, water), or from air. The consequences always lead to a low performing pump or to a premature breakdown.

II-4-10 Unsuitable grease:

Bad lubricant on the shaft and coupling assembly. We recommend for all grease lubricants to be based with disulfide of molybdenum. The main characteristic of this grease is that it is the

best for heavy duty applications. It has a very good specific load characteristic, avoids stick-slip and fretting corrosion, has a good penetrability and enables easy dismantle.

VANE MOTOR

III SPECIFICS OF VANE MOTOR FAILURES AND CAUSES

Because the motor is a receptor in the hydraulic circuit, the incidents are not very common. It will be much easier to go through the various

typical failures you can possibly be confronted to with vane motors.

III-1 - Torque over the catalog limits:

Front shaft rupture



Internal splines distortion



VANE TROUBLESHOOTING GUIDE

III SPECIFICS OF VANE MOTOR FAILURES AND CAUSES (continuation)

III-2- Bad air bleed

or air intake = incorrect rear cover lubrication. Possible seizure between the rotor and the rear cover.



III-3- Over-pressure on A or B:

Rotor rupture



Port block cracked



VANE MOTOR TROUBLESHOOTING GUIDE

III SPECIFICS OF VANE MOTOR FAILURES AND CAUSES (continuation)

III-4-Over-pressure in the drainline:

shaft seal blow off (extruded).



III-5- Excess of Air in the fluid: coming from the system, coming from an air intake between the pump and the motor or even coming from the front shaft seal.

- Possible seizure between the rotor and the rear cover.
- Possible heavy wear on the port plates.



III-6-Cavitation: the speed of the motor is higher than the flow coming to the motor. Heavy cavitation will lead to seizure.



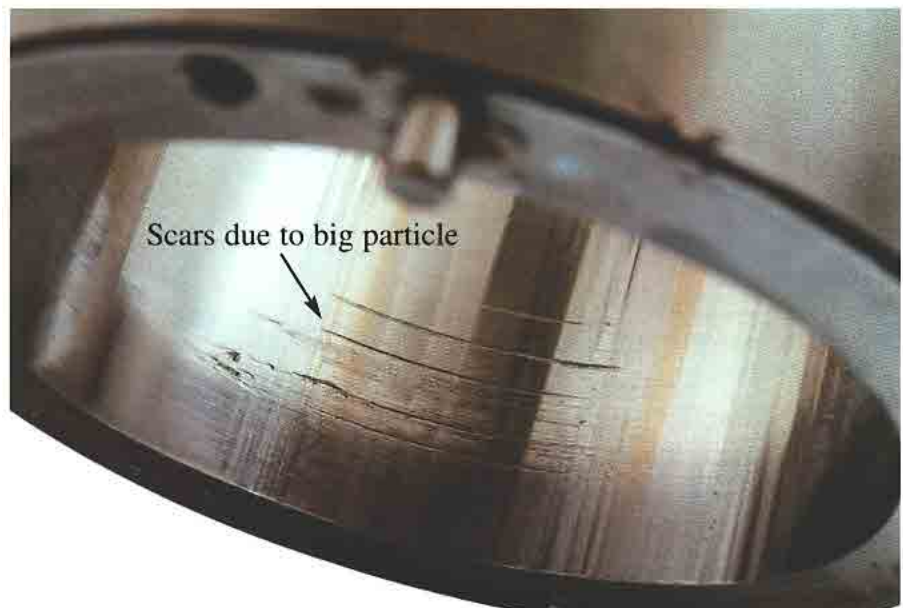
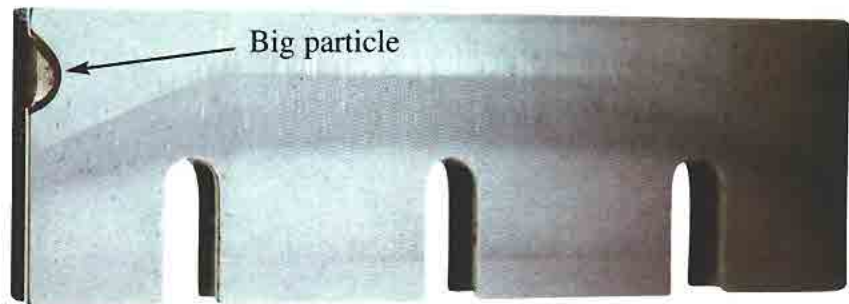
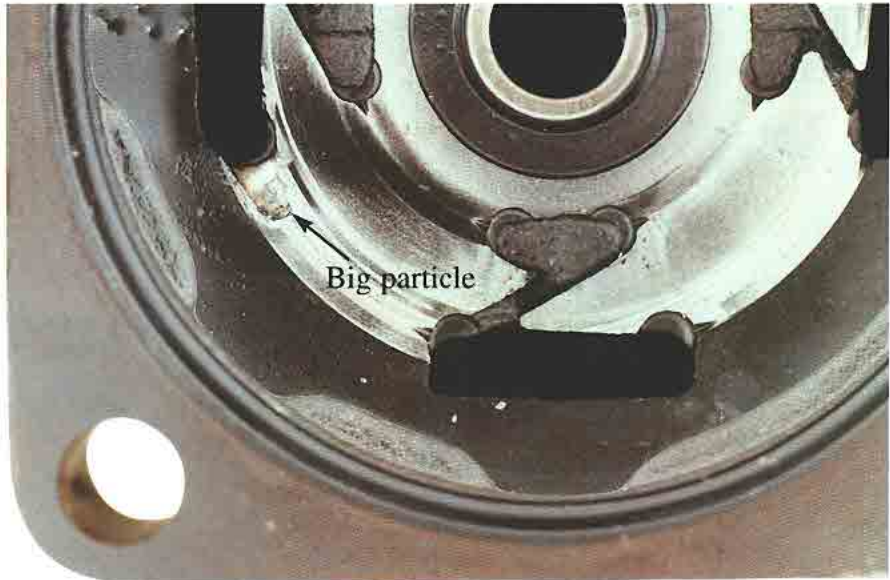
VANE MOTOR TROUBLESHOOTING GUIDE

III SPECIFICS OF VANE MOTOR FAILURES AND CAUSES (continuation)

III-7- Pollution.

The pollution consequences will be seen on various areas:

- In the rotor slots
 - Grinding on both sides of the slots.
 - Traces of the "spring areas" of the vanes digging in.
- On the side of the rotor / port plates.
- On the vanes
 - One big particle (welding ball) and small vertical scars.
- In the came ring
 - (Scars due to big particles).



III SPECIFICS OF VANE MOTOR FAILURES AND CAUSES (continuation)

III-8- Too low viscosity:

If the temperature rises and the fluid becomes very "liquid", the film of oil required to lubricate the components is going to be too thin. This can lead to micro-seizures and to a total seizure if this film of oil is minor.



CONCLUSION:

The DENISON vane technology is hydrostatically balanced, axially and radially. As each and every single pump, motor or cartridge (sold as spare part) is tested in our production plant on test benches before shipment, the quality of these components is certified. Our experience has shown us that if :

- the inlet characteristics,
- the operating limits (pressures, RPM, Viscosity...)

- the mechanical alignment,
 - the fluids' quality (in the time),
- are in the limits given in the Denison Hydraulics catalogue requirements, you are sure to obtain a high and long performing pump/motor.

These few requirements are the major parameters to check when working within the catalogue values.

IV TROUBLESHOOTING TABLE

This following section is there to help you when the hydraulic system or component does not work as required. These solutions are the most common

ones we have seen and experienced in the field. Please always remember that a clean system and a correct air bleed will solve a lot of incidents.

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VANE TROUBLESHOOTING GUIDE

IV -1 TROUBLESHOOTING TABLE FOR PUMPS

IV-1-1 - No flow,
no pressure

a) Is the pump rotating ?

a-1) Check if the coupling is rotating. If not, check the rotation of the electric motor.

a-2) Check the keys of the pump and E motor shaft.

a-3) Check if the shaft is not broken.

b) Is the rotation in the correct direction?

b-1) Check if the rotation of the pump corresponds to the arrow on the name plate.

b-2) Check if the wiring of the electric motor is correct.

c) Is the air bleed-off done?

c-1) Check that no air is still located in the pressure line. Loosen a connector.

d) How are the inlet conditions?

d-1) Check if the inlet gate valve is not closed.

d-2) Check the oil level.

d-3) Check if the inlet hose in the tank is under the oil tank level.

d-4) Check if an air intake is not disturbing the inlet (missing inlet flange seal, air trapped in suction line as examples).

d-5) Check if the pump is not located too high above the oil level.

d-6) Check if the tank is not completely sealed. Then the lack of atmospheric pressure will not allow the pump to prime.

d-7) Check if all connections and seals are air-tight.

e) Is the Viscosity not too high?

e-1) Check if the oil characteristics are not incompatible with the temperature and the pumps requirements. Too high Viscosity will "stick" the vein fluid and enable the pump to suck the oil correctly.

f) Is the pump flow not going somewhere else?

f-1) Check the hydraulic circuit and the main sequences. Doing so, you will check if all the valves are set or work properly.

VANE TROUBLESHOOTING GUIDE

IV -1 TROUBLESHOOTING TABLE FOR PUMPS (continuation)

IV-1-1 - No flow,
no pressure
(continuation)

f) Is the pump flow not
going somewhere else ?
(continuation)

f-2) Check if the main relief valve is not set at an extremely low pressure and therefore bringing all the flow back to the tank.

f-3) Check if in the directional valves the spools are not sticking in a position that brings the flow back to the tank.

f-4) check if the check valve is not mounted "upside down".

g) Is the receptor working correctly?

g-1) Check if the motor does not let all the flow leak internally.

g-2) Check if the cylinder inner seals are not ruined.

h) Is the speed high enough?

h-1) Check if the minimum speed is reached. Mobile pumps require 400 rpm and industrial pumps require 600 rpm.

IV-1-2 -
Not enough flow
(or not the flow required)

a) Are the components OK?

a-1) Check the displacement of the pump.

a-2) Check if the speed of the pump is not too low or too high (E motor or thermic engine sized too small so dropping the speed too low...).

a-3) Check if the main relief valve is not set at an extremely low pressure and therefore venting some flow back to the tank.

a-4) Check if in the directional valves the spools are not sticking in a position that brings part of the flow back to the tank.

a-5) Check if the hydraulic motor is not leaking internally due to a bad efficiency, low viscosity...

a-6) Check if the cylinder inner seals are not ruined and therefore allow internal leakage.

b) Is the connection from the tank to the pump correct?

b-1) Check if there is no air intake between the pump and the inlet pipe (bad seals for example).

b-2) Check if the inlet hose is convenient for the required velocity ($0,5 < V < 1,9$ m/s).

VANE TROUBLESHOOTING GUIDE

IV -1 TROUBLESHOOTING TABLE FOR PUMPS (continuation)

IV-1-2-

Not enough flow
(or not the flow
required)
(continuation)

b) Is the connection from the tank to the pump correct? (continuation)

b-3) Check if the pump is not too high compared to the oil level or if the pump is not too far from the tank (check the inlet absolute pressure with the catalog values).

b-4) Check if the gate valve is not semi-open.

b-5) Check if the inlet strainer is sized correctly (250 mmesh mini.) or not clogged.

c) Is the tank design correct?

c-1) Check if the oil level is correct.

c-2) Check if the suction pipe is under the oil level during the complete cycle of the machine.

c-3) Check if the inlet hose fitted in the tank is cut with an angle wider than 45°.

c-4) Check if this inlet hose is not too close to the tank wall or to the bottom of the tank and therefore limits the "vein flow".

c-5) Check if the suction hose is not located near the return line and therefore sucking a lot of air coming from these turbulences.

c-6) Check if baffles are required to allow correct deaeration of the fluid.

c-7) Check if the air filter is not clogged or under seized (not well dimensioned).

c-8) Check if the tank is not fully tight, not allowing the atmospheric pressure to apply.

d) Is the oil convenient?

d-1) Check if the oil characteristics are not incompatible with the pumps requirements.

d-2) Check if the viscosity is not too high, therefore "sticking" some vanes in the rotor or blocking the vein fluid.

d-3) Check if the high temperature does not destroy the viscosity of the fluid. Doing so, the internal leakage will "consume" the flow.

VANE TROUBLESHOOTING GUIDE

IV -1 TROUBLESHOOTING TABLE FOR PUMPS (continuation)

IV-1-3-
No pressure

a) Is the hydraulic circuit correctly designed?

a-1) Check the hydraulic circuit schematic.

b) Is the circuit correctly piped?

b-1) Compare the schematic to the piped circuit.

c) Are the components working properly?

c-1) Check the main sequences. Doing so, you will check if all the valves are set or work properly.

c-2) Check if the main relief valve is not set at an extremely low pressure and therefore bringing all the flow back to the tank.

c-3) Check if in the directional valves the spools are not sticking in a position that brings the flow back to the tank.

IV-1-4 -
Not enough pressure

a) Check as when "no pressure" IV-1-3.

b) Is the system well dimensioned?

b-1) Check if the flow required is not over the available flow and therefore cannot build-up pressure..

c) Is there an internal leakage somewhere that maintains a certain pressure?

c-1) Check all the possible faulty components, from the pump to all the receptors and intermediates (high pressure seals, mechanical wear...).

IV-1-5 -
Uncommon noise level

a) Is the noise coming from the pump?

a-1) Check the mechanical link of the shaft pump : alignment, balancing of the coupling or Universal joint, key properly fastened, ...

a-2) Check if the air bleed has been done correctly.

a-3) Check if there is no air intake from the tank to the pump (nor through the shaft seal).

VANE TROUBLESHOOTING GUIDE

IV -1 TROUBLESHOOTING TABLE FOR PUMPS (continuation)

IV-1-5 -

Uncommon noise level
(continuation)

a) Is the noise coming from the pump?
(continuation)

- a-5) Check if the hose strain force does not create this noise.
- a-6) Check if the oil level is correct.
- a-7) Check if the oil in the tank is not aerated.
- a-8) Check if the strainer is not clogged or under-dimensioned.
- a-9) Check if the inlet pipe is under the oil level.
- a-10) Check if the air filter is not clogged or too small.
- a-11) Check if the speed is not incompatible with the catalog values.
- a-12) Check if the oil is compatible with the catalog recommendations.
- a-13) Check if the inlet pressure is not higher than the outlet pressure.

b) Is the noise coming from the surroundings?

- b-1) Check the hoses and see if the noise is not coming back to the pump this way.
- b-2) Check the pressure piping and see if its length dumps or amplifies the noise.
- b-3) Check if the structure of the tank is stiff enough to avoid amplification/resonance.
- b-4) Check the E motor fan.
- b-5) Check the balancing of the E motor.
- b-6) Check the water cooler and its theoretical limits.
- b-7) Check the filtration unit, its capacity and if the noise does not come from the opened by-pass valve.

IV-1-6 -

Unusual heat level

a) Does the heat appear when the pump is running without pressure?

- a-1) Check the oil level and the suction pipe. Is the oil coming to the pump (check the length of the pipe, its internal diameter, all that could influence the inlet pressure)?
- a-2) Check if the air bleed has been done correctly.
- a-3) Check if the flow versus the volume of oil in the tank is correct to obtain a good cooling effect.

VANE TROUBLESHOOTING GUIDE

IV -1 TROUBLESHOOTING TABLE FOR PUMPS (continuation)

IV-1-6 -

Unusual heat level
(continuation)

a) Does the heat appear when the pump is running without pressure?
(continuation)

a-4) Check if a cooler is required or, if there is one, if it is well dimensioned.

a-5) If there is a cooler, check if it is working (example for water cooler: is the water flow open or sufficient).

a-6) Check if the hydraulic circuit is not bringing back the flow directly to the inlet port. Doing so, it would create a very small closed circuit not able to cool down the fluid.

a-7) Check the quality of the fluid.

a-8) Check the velocity of the fluid.

a-9) Check the filtration unit, its capacity and if the heat does not come from the open by-pass valve or if it is under-dimensioned (bigger delta P).

b) Does the heat appear when the pump is running with pressure?

b-1) Check the viscosity.

b-2) Check the pressure rating.

b-3) Check if the cooler is working correctly or well dimensioned.

b-4) Check if the relief valve is not creating this heat because always open.

b-5) Check if any other component in the system is not creating this heat due to an internal defect.

b-6) Check if there is a big temperature differential between the inlet and the outlet.

IV-1-7 -

Shaft seal leakage

a) Is the seal destroyed?

a-1) Check the alignment and the correct power transmission (non homokinetic movement, high radial force as examples).

a-2) Check the inlet pressure and compare it to the catalog values.

a-3) Check if the bad suction conditions do not create a vacuum that could even reverse the seal lip.

VANE TROUBLESHOOTING GUIDE

IV -1 TROUBLESHOOTING TABLE FOR PUMPS (continuation)

IV-1-7 -

Shaft seal leakage
(continuation)

a) Is the seal destroyed?
(continuation)

b) Is the seal only leaking?

a-4) Check if the external environment is not too dirty and therefore ruining the seal.

b-1) Check the alignment of the front shaft and check if there is not any radial load.

b-2) Check if seal lip has not been cut during a maintenance operation.

b-3) Check if the inlet pressure is not over or under the catalog values. This has to be done for the whole cycle because the inlet pressure can vary from time to time.

b-4) Check if the seal material has not been modified due to a too warm environment. The seal can vulcanize and stop sealing correctly.

b-5) Check the acidity of the oil that can "burn" the seals material. It will therefore destroy the elasticity of the sealing.

b-6) Check if the chosen seal (high pressure seal for example) is not too stiff for the use. If the environment requires some elasticity due to a gentle misalignment, a high pressure seal will not be able to follow the movement and therefore leak.

VANE TROUBLESHOOTING GUIDE

IV -2 TROUBLESHOOTING TABLE FOR MOTORS

IV-2-1 - No rotation

a) Is the flow coming to the motor?

a-1) Check the circuit and the hydraulic schematic. Is the piping OK?
a-2) Check the setting of the main pressure relief valve. Check if it not settled at an extremely low pressure.
a-3) Check if the pump is giving a flow.
a-4) Check if the directional valve(s) allowing the flow to go to the motor is energized. If it is, check if the spool is in its correct position and not sticking in a position that would deviate the flow somewhere else.
a-5) Check if a check valve would not have been improperly mounted.

b) Is the torque required higher than the system settings?

b-1) Check if the pressure settings are correct.
b-2) Check if the load is not superior to the torque capabilities of the motor.

c) Is the pump OK?

c-1) Check if the pump is working correctly.

d) Are the motors internal drain check valves working properly?

d-1) Check if a failing check valve would not allow some flow to go back to the tank and therefore limit the flow to the motor.

e) How is the motor piped?

e-1) Check the nature of the connectors. If, for example, the "self sealing couplings" type connectors are well fitted into each other.

IV-2-2 - Stalls easily

a) Is the load near the limits of the system?

a-1) Check the relief valve setting and compare it to the theoretical pressure required to deliver the convenient torque.

b) Are the motors internal drain check valves working properly?

b-1) Check if a failing check valve would not allow some flow to go back to the tank and therefore limit the flow to the motor.

c) Is the flow going to the motor sufficient?

c-1) Check the minimum flow required by the motor.
c-2) Check the flow of the pump or the valve feeding the motor.

VANE TROUBLESHOOTING GUIDE

IV -2 TROUBLESHOOTING TABLE FOR MOTORS (continuation)

IV-2-3 - Not enough speed	a) Is the speed lower than desired?	a-1) Check the theoretical displacement of the motor versus the theoretical flow of the pump. a-2) Check that the flow of the pump is really coming to the motor. a-3) Check that the working pressure & speed are not incompatible with the catalog values of the motor. a-4) Check the oil temperature. Check then that the low viscosity of the oil is not having a big effect on the internal leakage of the motor. a-5) Check the air bleed-off.
IV-2-4 - Erratic speed	a) Is the motor loosing speed erratically?	a-1) Check if the limit of the allowable torque is not reached once a while. a-2) Check if the driven load does not transmit some inconstant load (high pressure piston water pumps with an unbalanced technology). a-3) Check if the flow coming from the pump is constant.
IV-2-5 - Unusual noise level	a) Is the motor running? b) When the motor is breaking?	a-1) Check if there is no air intake aerating the motor badly (through the front shaft seal for example). a-2) Check if the motor is not cavitating. It could be that the inertia of the load is such that it drives the motor faster than the flow coming from the pump. a-3) Check if the oil is not proper for the use. a-4) Check if the air bleed has been done properly. b-1) Check the back pressure to see if the replenishment pressure is not too low, leading to cavitation of the motor.
IV-2-6 - Unusual heat	a) Is the oil arriving to the motor already hot?	a-1) Check if a cooler is required or if there is one if it is well dimensioned. a-2) If there is a cooler, check if it is working (example for water cooler: is the water flow opened or sufficient). a-3) Check if the hydraulic circuit is not bringing back the flow directly to the inlet port. Doing so, it would create a very small closed circuit not able to cool down the fluid.

VANE TROUBLESHOOTING GUIDE

IV -2 TROUBLESHOOTING TABLE FOR MOTORS (continuation)

IV-2-6 -
Unusual heat
(continuation)

a) Is the oil arriving to
the motor already hot?
(continuation)

a-4) Check the quality of the fluid.
a-5) Check the velocity of the fluid (5 to 6
meters/second max.).
a-6) Check the filtration unit, its capacity.
a-7) Check if the heat does not come from an open by-
pass valve.

b) Is the oil heating up
when going through the
motor?

b-1) Check the speed of rotation versus the catalog values.
b-2) Check the pressure rating.
b-3) Check the fluid.
b-4) Check the viscosity.

IV-2-7 -
Shaft seal leakage

a) Is the seal leaking
when pressurized?

a-1) Check if the lips of the seal are not ruined (lack
of lubricity leading to vulcanization of the rubber,
external pollution...).

a-2) Check if the shaft is not marked by a groove in
the usual seal lip contact area.

a-3) Check the shuttle valves.

a-4) Check the pressure in the drain line on the motor.
Long piping, elbows, small diameter, too high oil vis-
cosity, other common drain flows in the same pipe can
lead to high drain pressures.

a-5) Check if there is no high overshoot at start-up that
would create a high instant internal leakage.

a-6) Check, when using a "rapid connector", if it is
well locked.

a-7) Check the alignment of the shafts.

a-8) Check if there is no unbalanced driven load that
could create a gap between the shaft and the seal.

a-9) Check if the radial force is not too high (belt
drives for example).

b) Is the seal leaking
when standing still?

a-1) Check if the seal is not damaged.
a-2) Check if the shaft does not have any scratches.
a-3) Check if the ball bearing is not ruined.
a-4) Check if the drain line does not create a back pressure.