CONTAMINANTS AND SYSTEM CLEANLINESS

CONTAMINATION

General:

Contaminates in a hydraulic fluid can best be described as undesirable additives which take the form of solids, liquids or gases.

Solids;

Solid contaminant particles come from three main sources:

Inbuilt – All new systems will contain some contaminant left during manufacture and assembly. This normally consists of fibrous material from cleaning rags, casting sand, pipescale, cast iron and other metal particles, jointing material and loose paint.

Generated – Normally, when a new system has been run for a reasonable period, the majority of solid contamination is in the form of small ferrous platelets, created by "bedding in" and the normal wear process. The bulk of these are in the size range between 5 and 15 Microns and are thus only visible with the aid of a microscope. Because of their size and shape, they can take a long time to settle, and it is has been shown that even large sized particles may remain in suspension in the hydraulic fluid for many hours.

Added – Unless extreme care is taken in filling and topping up a system, considerable quantities of contaminant can be added during these processes and much of this contamination is likely to be abrasive. Systems can also be contaminated by the ingression through the oil film on piston rods. Worn seals will increase this possibility. Contamination will be added if all reservoir openings are not fitted with correct air breather filters.

The presence of solid contaminants is the main cause of failure in the majority of hydraulic systems. The sensitivity of components to these particles, depends on the internal working clearances, the system pressure levels and the quantity, size and composition of the contaminant particles.

Failures arising from contamination, fall into three main categories:

Sudden or catastrophic failure occurs when a few large particles or a very large number of small particles enter a component and cause seizure of the pumping elements or jamming of valve tools.

Intermittent failure is caused by contamination momentarily interfering with the function of a component, but it may be washed away during the next cycle of operation. For example, it can be caused by particles preventing a valve spool from moving freely but which may be washed away when the valve spool is moved to a new position, or a particle of dirt may stop a poppet valve from closing properly but is likely to be washed clear during the next operation.

Degradation failure is generally long term and shows up as a gradual loss of performance. The main causes are normal wear inside a component, cavitation erosion and erosion resulting from contaminated fluid at high velocity, all of which can cause increased internal leakage. If degradation failure is allowed to continue, it may eventually lead to catastrophic failure.

Liquids;
In system using mineral oil or synthetic fluid, water is the most usual liquid contaminant. This can result from condensation and may eventually settle in the bottom of the reservoir. The presence of “free” water in the hydraulic fluid, can have a serious effect on the fatigue life or the roller bearings. It can also cause rusting and may deplete or precipitate the fluid additive package and thus reduce the lubricating properties of the fluid. The presence of water in mineral oils provides, in most cases, a breeding ground for bacteria which can be a health hazard to personnel directly in contact with the oil. e.g. Dermatitis of the skin etc.

Gases;
Nearly all hydraulic fluids contain some dissolved gases and at atmospheric pressure, hydraulic oils can contain up to 8% of their volume in dissolved air. Whilst in this state, no problems are caused, increasing the pressure in the hydraulic fluid will increase the volume of air that can be dissolved whilst in low pressure areas, some of this dissolved air will be liberated in the form of bubbles, a state frequently found downstream of relief valves. It is the presence of these air bubbles that will cause erratic operation and damage to pumps especially if present in suction lines. Air bubbles can also cause degradation failure by increasing oxidation and corrosion rates, thus reducing the life of both the fluid and the components.

SYSTEM CLEANLINESS
To ascertain the cleanliness level and the condition of the hydraulic fluid, it is necessary to obtain a representative sample. This can be achieved by extracting a sample of the hydraulic fluid, either manually or by the use of a Fluid Condition Monitor, from strategic points in the system via specially designed sampling valves and /or appropriately approved sampling equipment.

The preferred method of establishing the number of solid contaminant particles in a sample, is by the use of ISO4406. The code is constructed from the combination of three range numbers selected from the table on Sht3. The first range number represents the number of particles in a millilitre sample of fluid that are larger than 4 Microns, the second number represents the number of particles that are larger than 6 Microns and the third number represents the number of particles that are larger than 14 Microns.

Number of particles per mL		Range Number
More than	Up to and including	
2500000		>28
1300000	2500000	28
640000	1300000	27
320000	640000	26
160000	320000	25
80000	160000	24
40000	80000	23
20000	40000	22
10000	20000	21
5000	10000	20
2500	5000	19
1300	2500	18
640	1300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9
1.3	2.5	8
0.64	1.3	7
0.32	0.64	6
0.16	0.32	5
0.08	0.16	4
0.04	0.08	3
0.02	0.04	2
0.01	0.02	1
0	0.01	0

For example, code 22/18/13 indicates that there are between 20,000 and 40,000 particles larger than 4 Microns, between 1300 and 2500 particles larger than 6 Microns and between 40 and 80 particles larger than 14 Microns.

Comparison of ISO Contamination codes against other commonly used cleanliness classes are given on the next page.

ISO 4406 CODE	Def. Std 05/42		NAS1683 ISO11218 Class	SAE749 Class
	Table (A)	Table (B)		
13/11/08	-	-	2	-
14/12/09	-	-	3	0
15/13/10	-	-	4	1
16/14/09	-	400F	-	-
16/14/11	-	-	5	2
17/15/09	400	-	-	-
17/15/10	-	800F	-	-
17/15/12	-	-	6	3
18/16/10	800	-	-	-
18/16/11	-	1300F	-	-
18/16/13	-	-	7	4
19/17/11	1300	2000F	-	-
19/17/14	-	-	8	5
20/18/12	2000	-	-	-
20/18/13	-	4400F	-	-
20/18/15	-	-	9	6
21/19/13	4400	6300F	-	-
21/19/16	-	-	10	-
22/20/13	6300	-	-	-
22/20/17	-	-	11	-
23/21/14	15000	-	-	-
23/21/18	-	-	12	-
24/22/15	21000	-	-	-
24/23/17	100000	-	-	-

Appropriate Equivalents of Contamination Classes