

# An Introductory Guide to **HYDRAULIC OIL CONTAMINATION**



*An introductory guide to the types, sources and effects of contamination in hydraulic oils*

A publication from

**ZIMMARK**  
TECHNICAL PROCESS MANAGEMENT



# Background in Contamination of Hydraulic Systems

## Inside This Issue

- ✓ Background into Contamination in Hydraulic Systems
- ✓ Types of Contamination
- ✓ Sources of Contamination
- ✓ Effects of Contamination

## Why is Contamination Harmful?

- Production downtime and costly replacement of key components
- Increases fluid replacement frequency, which in turn drives up disposal costs.

## What Impact Does It Have On A System?

Contamination disrupts the main function of hydraulic fluids:

- Energy Transmission
- Lubrication
- Heat Transfer
- Seal between moving parts

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“Over 85% of all system failures are a direct result of contamination.”

Norvelle, D.F., An Introduction to Fluid Power, West Publishing Company, St. Paul, MN, 1991

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## What Damage Can Contaminants Cause?

- Chemical compound formation
- Depletion of additives
- Orifice blockage and component wear
- Formation of rust and other oxidation



## Types of Contamination

There are a few main types of contamination. This includes the different ways to characterize the contamination. The main categories are shown below:

### Particulate Contamination:

- Silt Particulate
- Chip Particulate

### Water Contamination:

- Dissolved
- Emulsified
- Free

### Air / Oxidation:

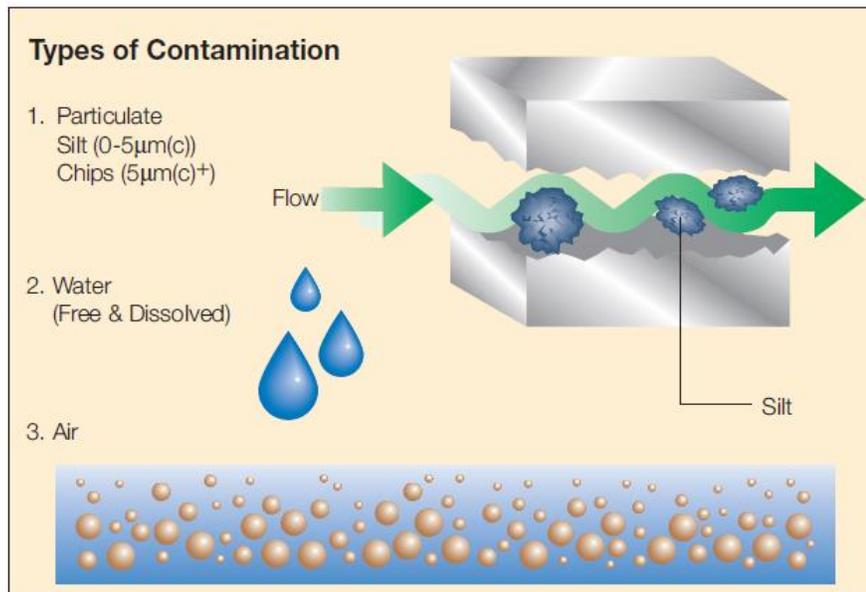


Image -Parker Hannifin, Parker's Filtration's Handbook of Hydraulic Filtration, 2006



# Classification of Particulate Contamination

## Silt Particulates:

- Less than 5 micron
- Cause damage over time

“Most damage is caused by particles under 14 microns which is not visible by the naked eye”

Parker Hannifin, Parker’s Filtration’s Handbook of Hydraulic Filtration, 2006

## Chip Particulates:

- Greater than 5 micron
- Can cause immediate damage to a system
- Can lead to catastrophic failure

### Micrometre Scale

Relative Sizes of Particles		
Substance	Microns	Inches
Grain of table salt	100	.0039
Human hair	70	.0027
Lower limit of visibility	40	.0016
Milled flour	25	.0010
Red blood cells	8	.0003
Bacteria	2	.0001

Both silt and chip contamination can be categorized as “hard” and soft”. Some examples of “hard” particulate are Silica, Carbon and Metal. Some examples of “soft” particulate are rubber, fiber and micro-organisms.

Cleanliness Level Correlation Table						
Code to ISO4406: 1999	Particles per Millilitre (ISO11171 um [c])			NAS 1638 (1964)	Disavowed SAE level (1963)	SAE AS 4059
	>4 Microns	>6 Microns	>14 Microns			
23/21/18	80,000	20,000	2,500	12		-
22/20/17	40,000	10,000	1,300	11		A12 / B12 / C11
21/19/16	20,000	5,000	640	10		A11 / B11 / C10
20/18/15	10,000	2,500	320	9	6	A10 / B10 / C9
19/17/14	5,000	1,300	160	8	5	A9 / B9 / C8
18/16/13	2,500	640	80	7	4	A8 / B8 / C7
17/15/12	1,300	320	40	6	3	A7 / B7 / C6
16/14/11	640	160	20	5	2	A6 / B6 / C5
15/13/10	320	80	10	4	1	A5 / B5 / C4
14/12/09	160	40	5	3	0	A4 / B4 / C3
13/11/08	80	20	2.50	2		A3 / B3 / C2
12/10/07	40	10	1.30	1		A2 / B2 / C1
11/09/06	20	5	0.64	0		A1 / B1 / C0
10/08/05	10	2.50	0.32	00		A0 / B0 / C000

Images -Parker Hannifin, Parker’s Filtration’s Handbook of Hydraulic Filtration, 2006

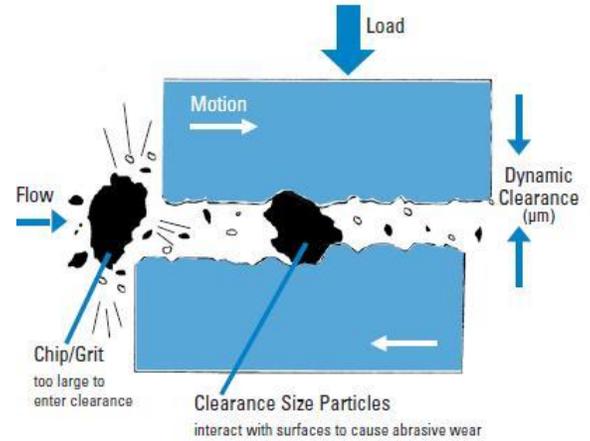


# Sources of Particulate Contamination

## Ingress Contamination

### External Sources

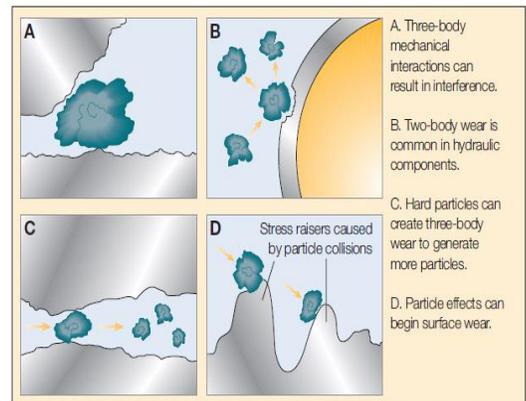
- Old style breather caps
- Piston rod glands
- Hoses and manifold during maintenance
- Worn Seals
- Tanks caps removed / open



## Generated Contamination

### Created from wear inside the systems cavity

- Abrasive Wear
- Cavitation Wear
- Fatigue Wear
- Adhesive Wear
- Erosive Wear



Images -Parker Hannifin, Parker's Filtration's Handbook of Hydraulic Filtration, 2006

# Effects of Particulate Contamination

As you can see in the pictures above, small particles can cause detrimental problems to hydraulic system components such as pumps and valves. Clogging of any hydraulic component can affect performance of the system.



# Classification of Water Contamination

## Dissolved:

- Individual water molecules dispersed in a fluid
- Fluid may contain water with no visual indication. Up to 500 ppm typically

## Emulsified - MORE HARMFUL :

- Water cannot dissolve further, fluid is completely saturated
- Seen as milky discoloration of the oil
- Amount of emulsified water varies based on fluid additives, typically around 10%

## Free Water - MOST HARMFUL :

- Separation can be seen between water and fluid
- Typically water separates to the bottom



Emulsified water creates milky discoloration of oil



# Sources of Water Contamination

## Storage & Handling :

- Outdoor storage tanks may cause water to leak into unsealed lids

## Condensation :

- Water vapor from temperature changes

## Ingression :

- Breathers
- Worn Seals

## Process Side Ingression :

- Leak in heat exchanger or coolers
- Cooling water, wash-down water, steam

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“A new hydraulic fluid can contain 500,000 particles per 100 mL that are 5 µm or larger, which exceeds the level recommended by most manufacturers for normal operation.”

Moore, L.C., The Cleanliness of New Hydraulic Fluids, Basic Fluid Power Research Journal, vol. 11, Oklahoma State University, Stillwater (October 1977)

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## Top 5 Reasons to Outsource Your Lubrication Program

- ✓ When you need to be sure it is getting done
- ✓ When you lack the time, resources or expertise to do it right
- ✓ When you want to keep your high skilled trades focused on high skilled tasks
- ✓ When you want to reduce your overall lubrication costs
- ✓ When you want to use data to drive improvement

Typical Saturation Points		
Fluid Type	PPM	%
Hydraulic Fluid	300	.03%
Lubrication Fluid	400	.04%
Transformer Fluid	50	.005%

Image -Parker Hannifin, Parker’s Filtration’s Handbook of Hydraulic Filtration, 2006



# Effects of Water Contamination

See the table below to help classify the effects each type of water contamination has on the hydraulic system.

Type	Description	Dissolved	Emulsified	Free
Surface Corrosion	Accelerates metal surface fatigue. Decreases component life by factor of 5 or more	✓	✓	✓
Risk of more water ingress	As temperatures of fluid rise, ability to hold more dissolved water increases. This is not a good thing. Once cooled the fluid will either emulsify the water or separate to free water, which is more harmful	✓		✓
Poor Lubrication	The oil film thickness breaks down. This layer creates surface tension between moving parts, helping to keep separated.		✓	✓
Viscosity Change	With an increase in fluid viscosity the lubricant lifetime deteriorates and limits the lubrication and compressibility properties		✓	✓
Decrease Compressibility	Water in an incompressible substance inside a highly compressed hydraulic system	✓	✓	✓
Freezing	At low temps the water begins to form ice crystals, damaging pumps and other mechanical equipment		✓	✓
Hydrogen Embrittlement	Caused by water being trapped at extreme pressures. Flash vaporization causes hydrogen atoms to absorb onto metal surface. This weakens components making them brittle, prone to cracking		✓	✓
Additive Depletion	Some additives are made to react with water for the good of the hydraulic fluid. Excess water causes rapid additive depletion		✓	
Aggressive Corrosion	Standing water under high pressures forces corrosion			✓
Pump Drawing Water	Circulating water through a hydraulic system. Attempting to compress water creates mechanical issues			✓
Thermo-Oxidative Stability	This refers to the amount of oxygen available for oxidation. As high temps/water is introduced, the increase of oxidation rises			✓

@noriacorp. "Water In Oil Contamination." Water In Oil Contamination. N.p., n.d. Web. 16 Sept. 2016.



# Classification of Oxidation Contamination

- Oxidation arises from the presence of other types of contamination
- Metal and dirt are a catalyst for oxidation
- Water and air accelerate the oxidation process
- Temperature increase accelerates oxidation

The oxidation process is a chemical reaction following three steps:

## 1. Initiation

## 2. Propagation

## 3. Termination



Zimmark Service Technician Oil Sampling, Oil Decontaminating and Greasing



# Sources of Oxidation Contamination

## Metal Particles :

- Fine metal particles have large relative surface area
- Oxidation builds off the metal particles

## Temperature :

- Higher temps increase the chemical reaction
- 10 degrees Celsius doubles the reaction which can HALF your oil life

## Air :

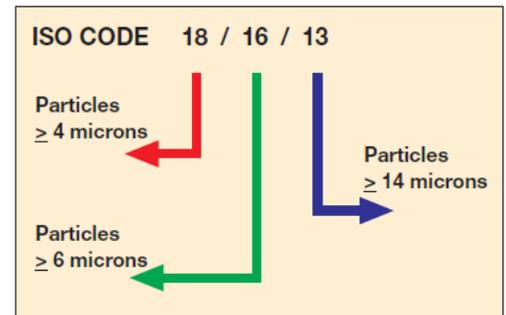
- High compression cause air bubbles to instantly oxidize the surrounding oil

## Water :

- Provides a source of oxygen

## Zimmark's Lubrication Services

- ✓ Onsite Lube & Greasing Services
- ✓ Web Based Oil Analysis, Monitoring & Reporting
- ✓ Visual Factory Identification, Tagging & 5S Services
- ✓ Full Time / Part Time, Trained Lubrication Program for your Facility
- ✓ Onsite Oil Recycling and Decontamination Services



ISO Classification & Definition		
Range number	Micron	Actual Particle Count Range (per ml)
18	4+	1,300 - 2,500
16	6+	320 - 640
13	14+	40 - 80

The ISO codes 4, 6, 14 microns replace the 2 digit 5, 15 microns and 3 digit 2, 5, 15 microns in use prior to the introduction of ISO MTD. Their use continues and the results remain comparable with the 4, 6, 14 micron ISO codes.

Image -Parker Hannifin, Parker's Filtration's Handbook of Hydraulic Filtration, 2006



# Effects of Oxidation Contamination

## Increase in Viscosity :

- Shortens life of oil

### Great Sources For More Info.

- ✓ [www.parker.com](http://www.parker.com)
- ✓ [www.noria.com](http://www.noria.com)
- ✓ [www.worldclasslubrication.com](http://www.worldclasslubrication.com)

## Formation of Sludge and Sediment :

- Creates particulate contamination from chemical reaction

## Varnish :

- Creates particulate contamination

## Additive Depletion :

- Additives are meant to be sacrificial (prevent pre-mature failure)
- Shortens life of oil

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“It is not enough to do your best; you must know what to do, and then do your best.”

W. Edwards Deming

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# Zimmark Technical Process Management

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## About Us

Since 1984, Zimmark has been committed to helping our clients reduce cost and operating risk while improving their productivity and focus. We deliver technical services that provide fully trained and focused on-site personnel/equipment using robust web based KPI Management systems, to deliver data driven process management for non-core technical operations in a manufacturing environment.

We help our clients focus their resources on their core strategic priorities by managing the non-core processes that steal time and expense from their key competitive priorities. This translates into significant operational improvement as our clients are able to concentrate their expertise on the areas of the process that will deliver the greatest net benefit.

## How We Do This

We develop customized condition based management systems that identify and then optimize the Key Process Performance Indicators that impact productivity and total process costs. As a non-contract company, we work hard to justify our services and enjoy tremendous trust and longevity with our clients as we focus on delivering net savings to the plant. Our up-front KPI audits, measure current state and lay out the steps to a future state where savings and benefits are realized.

Zimmark provides complete vendor independence and does not profit from the sale of any consumable associated with the processes we manage. As a result we become a trusted member of our client's team, working to identify lowest total cost alternatives. By applying our specialized expertise and defined evaluation process, we help our clients identify which products will in fact translate into the lowest total cost solution.

