# INTRODUCTION

Contamination Control in the hydraulic systems is a very wide and complex matter; the following is just a short summary.
Our Customer Service is at your disposal for any further information.
**The function of the fluid in the hydraulic systems is transmitting forces and motion.**
In view of a reliable and efficient operation of the system, it is very important to select the fluid considering the requirements of the system and the specific working conditions (working pressure, environment temperature, location of the system, etc.).
Depending on the required features (viscosity, lubricant capacity, anti-wear protection, density, resistance to ageing and to thermal solicitations, materials compatibility, etc.), the proper oil can be selected among a number of mineral oils (the most popular), synthetic fluids, water based fluids, environmental friendly fluids, etc.
All the hydraulic fluids are classified according to international standards.
**Solid contamination is recognized as the main reason for misfunctioning**, failures and early decay in hydraulic systems;
**it is impossible to eliminate completely it, but it can be well kept under control with proper devices (filters).**
No matter which fluid is used, it must be kept at the contamination level required by the most sensitive component used on the system.

# HOW THE CONTAMINATION IS MEASURED

**The contamination level is measured by counting the number of particles of a certain dimension per unit of volume of the fluid; this number is then classified in Contamination Classes, according to international standards.**
Measuring is made with Automatic Particle Counters that can make the analysis on line (through sampling connectors put on the system for this purpose) or from sampling bottles.
Measurations and sampling of the fluid must be done according to the specific ISO norms, to attest their validity.
**The most popular standard for Contamination Classes in the hydraulic systems is ISO 4406:1999**; the standard NAS 1638 (under revision) is also quite used.

# CONTAMINATION CLASSES ACCORDING TO ISO 4406:1999

**The Contamination Class according to this standard is described by 3 numbers indicating the number of particles per 100 ml of fluid having bigger size than 4, 6 e 14 $\mu m_{(c)}$ respectively.**

| ISO Code | Number of particles per 100 ml | |
|---|---|---|
| | more than | up to |
| 22 | 2.000.000 | 4.000.000 |
| 21 | 1.000.000 | 2.000.000 |
| 20 | 500.000 | 1.000.000 |
| 19 | 250.000 | 500.000 |
| 18 | 130.000 | 250.000 |
| 17 | 64.000 | 130.000 |
| 16 | 32.000 | 64.000 |
| 15 | 16.000 | 32.000 |
| 14 | 8.000 | 16.000 |
| 13 | 4.000 | 8.000 |
| 12 | 2.000 | 4.000 |
| 11 | 1.000 | 2.000 |
| 10 | 500 | 1.000 |
| 9 | 250 | 500 |
| 8 | 130 | 250 |

| ISO Code 21/18/15: 21 → $\geq 4\ \mu m_{(c)}$ | 18 → $\geq 6\ \mu m_{(c)}$ | 15 → $\geq 14\ \mu m_{(c)}$ |
|---|---|---|

The above Contamination Class describes a fluid containing:
- between 1.000.000 and 2.000.000 particles $\geq$ 4 $\mu m_{(c)}$ per 100 ml
- between 130.000 and 250.000 particles $\geq$ 6 $\mu m_{(c)}$ per 100 ml
- between 16.000 and 32.000 particles $\geq$ 14 $\mu m_{(c)}$ per 100 ml

## FILTERS AND FILTER MEDIA

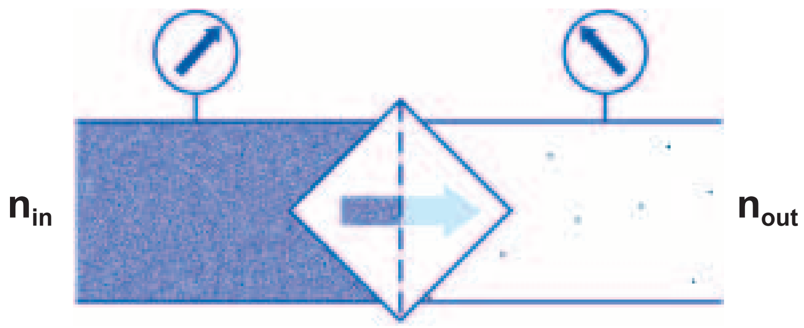
All the hydraulic systems have an initial solid contamination, tending to increase during operation due to components wear, ingression from seals, etc. For this reason it is necessary to use filters that retain the contaminant and allow to reach and maintain the required contamination class.

Depending on their location into the system, the most common filter types are:

- **return filters**, downstream from all the components, filtering the oil before it returns into the tank. Their function is keeping the required contamination level inside the tank (indirect protection of the components) and must be sized to have a high dirt holding capacity (i.e. a long life). They usually have filter elements by glassfiber (absolute filtration, $ßx \geq 75$) or by cellulose (nominal filtration, $ßx \geq 2$)
- **in line filters**, on the pressure line, protecting directly one or more components,ensuring they are fed with oil having the proper contamination class. They usually have filter elements by glassfiber (absolute filtration, $ßx \geq 75$) sometime by cellulose (nominal filtration, $ßx \geq 2$)
- **suction filters**, on the suction line, protecting the pump from possible coarse contamination. They usually have filter elements by metal wire mesh (geometric filtration) and must be sized properly, to avoid any possible pump cavitation.

Good **air filters** (breathers), filtering the air sucked into the tank when the oil goes to the actuators, must be used to avoid contaminant ingression from the environment. When a very low contamination class is required (i.e. very good cleanliness) it can be necessary to use a **off-line filter**, that operates at steady flow rate and pressure, thus getting the highest filtration efficiency. Even the new oil has always a certain solid contamination, so it is a good rule to make any filling or refilling of the system by using a **filtration unit**.

## HOW TO MEASURE THE FILTRATION EFFICIENCY




**Beta ratio:**

**$ß_x = (n_{in} = X\ \mu m) : (n_{out} = X\ \mu m)$**

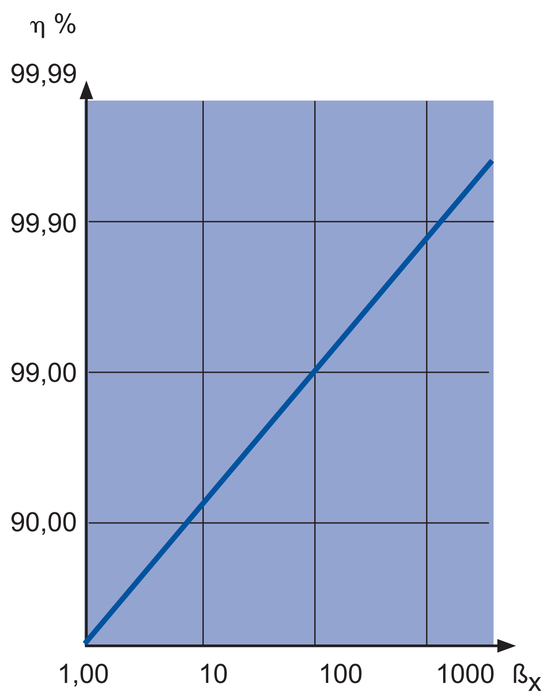
where "n" is the number of particles = x µm upstream and downstream from the filter.

E.g. if you have 100.000 particles = 10µm upstream and 1.000 particles downstream:
$ß_{10} = 100.000 : 1.000 = 100$

**Filtration efficiency $\eta$(%):**

**$\eta = 100 - (100 : ß)$**

i.e.
$ß_x$ = 2 means $\eta$ = 50,00 %
$ß_x$ = 20 means $\eta$ = 95,00 %
$ß_x$ = 75 means $\eta$ = 98,67 %
$ß_x$ = 100 means $\eta$ = 99,00 %
$ß_x$ = 200 means $\eta$ = 99,50 %
$ß_x$ = 1.000 means $\eta$ = 99,90 %



# FILTER MEDIA AND CONTAMINATION CLASSES

Each hydraulic components manufacturer specifies the contamination class required for the best performance and life of their components.
**To achieve the required contamination class, the proper UFI filter media must be chosen according to this table:**

| **Typical application** | Aeronautic, test rigs. | Aeronautic, ind. robotics | Ind. robotics, precision machine tools | High reliability ind. machines, Hydrostatic transmissions | Industrial machines, earth moving machines | Mobile machines | Machines for heavy industry | Machines for agriculture systems not continuos service |
|---|---|---|---|---|---|---|---|---|
| **Pumps and/or motors** | - | Piston, variable > 21 MPa | Piston, variable < 21 MPa Vane, variable > 14 MPa | Pist./vane, variable < 14 MPa Pist./vane, fixed > 14 Mpa | Pistons, fixed < 14 Mpa Vane, fixed > 14 MPa | Vane, fixed gear > 14 MPa | Vane, fixed gear < 14 MPa | Vane, fixed gear < 14 MPa |
| **Valves** | Servovalves > 21 MPa | Servovalves < 21 MPa Proportional > 21 MPa | Proportional < 21 MPa Cartridge > 14 MPa | Cartridge < 14 MPa | Solenoid > 21 MPa | Solenoid < 21 MPa | Solenoid > 14 MPa | Solenoid > 14 MPa |
| **Contamination class NAS 1638** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
| **Contamination class ISO 4406-1999** | **15/13/10** | **16/14/11** | **17/15/12** | **18/16/13** | **19/17/14** | **20/18/15** | **21/19/16** | **22/20/17** |
| **Reccommended UFI filter media** | **FA** $\beta_{5(c)} > 1.000$ | **FA - FB** $\beta_{5(c)} > 1.000$ $\beta_{7(c)} > 1.000$ | **FB** $\beta_{7(c)} > 1.000$ | **FB - FC** $\beta_{7(c)} > 1.000$ $\beta_{12(c)} > 1.000$ | **FC - FD** $\beta_{12(c)} > 1.000$ $\beta_{21(c)} > 1.000$ | **FD** $\beta_{21(c)} > 1.000$ | **FD - CC** $\beta_{21(c)} > 1.000$ $\beta_{10} > 2$ | **CC** $\beta_{10} > 2$ |

# NEW REFERENCES FOR THE “BETA” RATIO

Since 1999 the new standard ISO 16889 has replaced the former ISO 4572 concerning the Multi-Pass test, measuring the Beta value of a filter element.
**The new standard uses the new test dust ISO MTD instead of the ACFTD formerly used, both in the Multi-Pass test rigs both for the calibration of the automatic particle counters.**
In the ISO 16889 the particles sizes are measured in a different way than in the ISO 4572.
To avoid any confusion, when micron are measured according to ISO 11171 they are indicated as **$\mu m_{(c)}$**.

The 3 reference sizes to state the contamination class (according to ISO 4406-1999) are now :

- **4 $\mu m_{(c)}$** (it was 2 µm in the former standard)
- **6 $\mu m_{(c)}$** (it was 5 µm in the former standard)
- **14 $\mu m_{(c)}$** (it was 15 µm in the former standard)

**Depending on the measuring method, the reference Beta values of the UFI filter media are as follows:**

| UFI Media | $\beta_x > 200$ (ISO 4572) | $\beta_{x(c)} > 1000$ (ISO 16889) |
|---|---|---|
| **FA** | 3 µm | 5 µm $_{(c)}$ |
| **FB** | 6 µm | 7 µm $_{(c)}$ |
| **FC** | 12 µm | 12 µm $_{(c)}$ |
| **FD** | 25 µm | 21 µm $_{(c)}$ |

**N.B.**
**The contamination classes achieved**
(i.e. the performances on the field) as well as the pressure drop values **remain unchanged**.

**The technical data reported on our catalogue still refer to the ISO 4572 standard, while waiting for all the new test reports according to the ISO 16889.**

# REAL FLOW RATE THROUGH THE FILTER

In order to size properly the filter, it is essential to calculate the REAL flow rate of the oil passing through it:

- in **suction and pressure filters** the flow rate is usually the same than the pump delivery (with the exception of the FPD01 and 12 series, where the flow rate is just the one required by the pilot valve)

- in **return filters** it is necessary to calculate the maximum possible flow rate, taking in account any possible additional return line, cylinder and accumulator. If such data are unknown, as a good rule a flow rate at least 2 ÷ 2,5 times the pump delivery should be considered.

Filter element life is significantly effected by the pollution level at the machine location and by the maintenance level of the machine. Considering these parameters the actual flow rate should be multiplied by the following "Environmental Factor":

| ENVIRONMENTAL FACTOR | | | |
|---|---|---|---|
| **System maintenance level** | **Environment contamination level** | | |
| | LOW | MEDIUM | HIGH |
| • tank with good protection, efficient air breathers<br>• few actuators, with very good protection from contaminant ingression<br>• frequent monitoring of filter conditions | 1,0 | 1,0 | 1,3 |
| • tank with protection, good air breathers<br>• many actuators, with good protection from contaminant ingression<br>• scheduled monitoring of filter conditions | 1,0 | 1,5 | 1,7 |
| • tank with poor protection<br>• many actuators, with low protection from contaminant ingressions<br>• random monitoring of filter conditions | 1,3 | 2,0 | 2,3 |
| | F. i. system located in climatized room | F. i. system located in industrial building | F. i. system located in hostile environment (foudry, wood working machines, mobile machines) |

## PRESSURE DROP ($\Delta p$) - according to ISO 3968:2005

After having stated the filter media and the REAL flow rate, the filter must be chosen from the "flow rate tables" on the catalogue. The values shown there take in account the pressure drop $\Delta p$ met by the fluid passing through the filter, that must be within a certain value. In practice, the "assembly $\Delta p$" ($\Delta p$ filter housing + $\Delta p$ filter element) with clean filter element should be

- **3 kPa** (0,03 bar)
  max for suction filters
- **35 ÷ 50 kPa** (0,35 ÷ 0,5 bar)
  max for return filters
- **35 ÷ 50 kPa** (0,35 ÷ 0,5 bar)
  max for pressure filters < 11 MPa (110 bar)
- **80 ÷120 kPa** (0,80 ÷1,2 bar)
  max for pressure filters > 11 MPa (110 bar)

Lower is the initial pressure drop, better is the filter efficiency and longer filter element service life.

**N.B.** The flow rate values given in the tables are referred to mineral oil with viscosity "V" di 30 cSt and density "ps" = 0,9.
When using oils with different features, the following correction factors must be applied at the $\Delta p_0$ values obtained on the curves:

**FILTER HOUSING**: the pressure drop is directly proportional to the oil density "ps", so in case you have $ps_1 \neq 0{,}9$ $\longrightarrow$ $\Delta p_1 = (\Delta p_0 \times ps_1) : 0{,}9$

**FILTER ELEMENT**: the pressure drop through the filter element varies in function of the oil viscosity, so in case you have a viscosity $V_1$ (cSt) different from cSt:
· for oil viscosity ≤ 150 cSt $\longrightarrow$ $\Delta p_1 = \Delta p_0 \times (V_1 : 30)$
· for oil viscosity > 150 cSt $\longrightarrow$ $\Delta p_1 = \Delta p_0 \times [V_1 : 30 + \sqrt{(V_1 : 30)}] : 2$

Some fluids have **filterability problems** (difficulty in passing through a "multilayer" (glassfiber) filter media).
In such cases a **correction factor** must be considered when sizing the filter: this factor must be verified with the filter manufacturing, specifying all the features of the fluid.

## CLOGGING INDICATOR

During the system operation, the pressure drop through the filter increases as the element clogs, due to the contaminant retained.
The filter element must be replaced when clogged and anyway before the pressure drop reaches the bypass valve set value.
For this reason it **is recommended a clogging indicator on the filter. It gives a visual or electrical indication and must have a set value lower than the bypass valve set value**, to get an exact indication of the right time for filter element replacement.

On **return** and **low pressure filters** the clogging indicator can be a **pressure gauge** or a **pressure switch**, measuring the pressure upstream the filter. On some return filters and on **high pressure filters**, the clogging indicator can be of **differential** type: measuring the pressure upstream and downstream the filter and activating a signal when the differential pressure reaches the set value.

On **suction filters** the clogging indicator is a **vacuum gauge** or a **vacuum switch**, measuring the depressure downstream the filter.

All the **UFI** filters have the port for the indicator as a standard feature; if the filter is ordered without indicator the port is plugged with a removeable plug allowing the indicator to be added easily at any time.