## FILTERS

### Function

Filters are an essential component of every hydraulic system. Their function is to remove particle contaminants from the hydraulic fluid, which reduce the service life of system components through abrasive wear.

### Sizing and selection

The primary consideration when sizing a filter is the pressure drop across the element, the magnitude of which should be kept as small as possible. Pressure drop is influenced by: media type and area; particle blocking size and efficiency rating; and fluid viscosity and flow rate. Filter manufacturers publish graphs that plot pressure drop against flow rate at a given viscosity for each filter size (area) and rating.

The fluid cleanliness level required by a particular type of system largely determines the particle blocking size and efficiency rating of the filters chosen. Refer to the table on the following page for guidance.

Before confirming filter selection, check that the pressure developed by the system at the chosen filter location is within the manufacturer's maximum permissible working pressure.

### Rating

Hydraulic filters are rated according to the size of the particles they remove and the efficiency with which they remove them.

Beta ratio

Filter efficiency is defined according to international standard ISO 4572, commonly referred to as the 'multi-pass test' and expressed as the Beta ratio or rating ($\beta$) for a given particle size ($\chi$). The Beta ratio value is derived as follows:

$$\beta\chi = \frac{\text{number of particles of size } \chi \text{ upstream of the filter}}{\text{number of particles of size } \chi \text{ downstream of the filter}}$$

Beta efficiency is derived as follows:

$$\% = \frac{\text{number of particles of size } \chi \text{ upstream} - \text{number of particles of size } \chi \text{ downstream}}{\text{number of particles of size } \chi \text{ upstream}}$$

| EFFICIENCIES OF BETA RATIO VALUES | | | | | |
|---|---|---|---|---|---|
| β | % | β | % | β | % |
| 2.0 | 50.00 | 5.8 | 82.76 | 52.2 | 98.084 |
| 2.4 | 58.33 | 16.0 | 93.75 | 75.0 | 98.67 |
| 3.0 | 66.66 | 17.4 | 94.25 | 100.0 | 99.0 |
| 4.0 | 75.00 | 32.0 | 96.875 | 173.0 | 99.42 |

Absolute and nominal ratings

A filter that is rated as *absolute* has an efficiency of 98% or better at the specified micron size. A filter that is rated as *nominal* has an efficiency of between 50% and 95% at the specified micron size.

**Fluid cleanliness level**

Fluid cleanliness can be defined according ISO, NAS or SAE standards. ISO 4406 defines contamination levels using a dual scale numbering system. The first number refers to the quantity of particles over 5 micron per 100 millilitres of fluid and the second number refers to the number of particles over 15 micron per 100 millilitres of fluid. For example, a cleanliness level of 15/12 indicates that there are between $2^{14}$ and $2^{15}$ particles over 5 micron and between $2^{11}$ and $2^{12}$ particles over 15 micron, per 100 millilitres of fluid.

| **TYPE OF SYSTEM** | **MINIMUM RECOMMENDED CLEANLINESS LEVEL** | | | **MINIMUM RECOMMENDED FILTRATION LEVEL $\beta\chi \geq 75$** |
|---|---|---|---|---|
| | **ISO 4406** | **NAS 1638** | **SAE 749** | |
| SILT SENSITIVE | 13/10 | 4 | 1 | 2 µ |
| SERVO | 14/11 | 5 | 2 | 3 – 5 µ |
| HIGH PRESSURE (250 – 400 bar) | 15/12 | 6 | 3 | 5 -10 µ |
| NORMAL PRESSURE (150 - 250 bar) | 16/13 | 7 | 4 | 10-12 µ |
| MEDIUM PRESSURE (50 - 150 bar) | 18/15 | 9 | 6 | 12-15 µ |
| LOW PRESSURE (< 50 bar) | 19/16 | 10 | - | 15-25 µ |
| LARGE CLEARANCE | 21/18 | 12 | - | 25-40 µ |

| **CONTAMINATION CODE COMPARISON TABLE** | | | |
|---|---|---|---|
| ISO 4406 | NAS 1638 | SAE 749 | DEF STAN 05/42 |
| 11/8 | 2 | | |
| 12/9 | 3 | 0 | |
| 13/10 | 4 | 1 | |
| 14/11 | 5 | 2 | |
| 15/9 | | | 400 |
| 15/12 | 6 | 3 | |
| 16/10 | | | 800 |
| 16/13 | 7 | 4 | |
| 17/11 | | | 1300 |
| 17/14 | 8 | 5 | |
| 18/12 | | | 2000 |
| 18/15 | 9 | 6 | |
| 19/13 | | | 4400 |
| 19/16 | 10 | | |
| 20/13 | | | 6300 |
| 20/17 | 11 | | |
| 21/14 | | | 15000 |
| 21/18 | 12 | | |
| 22/15 | | | 21000 |
| 23/17 | | | 100000 |

**Fluid condition analysis**

Monitoring of fluid condition and contamination levels should be an essential part of every hydraulic system's maintenance program. A typical fluid condition report should include the following data:

| CONDITION CATEGORY | RECOMMENDED TARGETS OR ALARM LIMITS |
|---|---|
| Fluid cleanliness level | Within targeted range chosen for the system or recommended by the manufacturer |
| Wear debris level | (Al) 5 ppm, (Cr) 9 ppm, (Cu) 12 ppm, (Fe) 26 ppm, (Si) 15 ppm |
| Viscosity | ± 10 % of new oil |
| Water content | < 100 ppm |
| Total Acid Number (TAN) value | + 25% of new oil |
| Additive level | – 10% of new oil |