STAUFF ®

FILTRATION TECHNOLOGY

STAUFF

Guideline

Hydraulic Filtration That Meets Requirements

Local solutions for individual customers worldwide

That's STAUFF

Originating and located in Werdohl in the German Sauerland region, we have become an internationally leading developer, manufacturer and supplier of pipework components, measuring equipment and hydraulic accessories.

More than 5 decades of experience, highly-motivated and qualified staff, state-of-the-art manufacturing technologies and a foresighted management give us the reputation of being a competitive partner.

Many of our products have been successfully tested and approved by several international organisations and institutes.
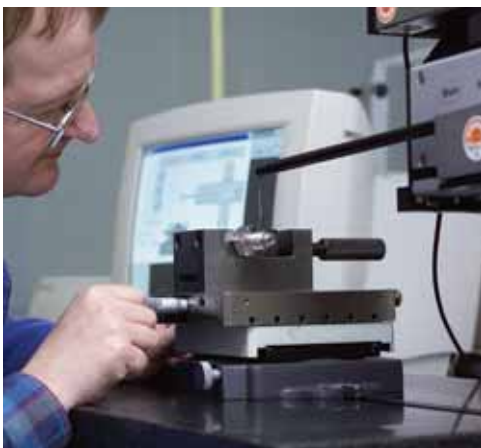
Our in-house laboratories carry out constant tests in line with international standards on all products. Certified in accordance with EN ISO 9001:2000, DIN EN ISO 14001:2005 and OHSAS 18001:2007, our management system continually strives for perfection.

Our well-stocked warehouses and flexible production lines ensure prompt reactions and short delivery times.

Represented by a tight network of distributors and wholly-owned manufacturing facilities, distribution bases and warehouses in 15 countries worldwide, we are also close to you.

Our subsidiaries also supply additional retail products related to the hydraulics industry, thereby offering a near-complete range of industry-specific key products.

Local solutions for individual customers worldwide

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Figures: ThyssenKrupp Marine Systems AG, VoithPaper GmbH & Co. KG, Nordex AG, Terex GmbH

Selection of STAUFF Replacement Filter Elements

Filtration – Why?

Good hydraulic filtration is gaining more and more importance in the use of hydraulic systems.

Besides reducing the wear resulting in extension of the service life of the machine, the prevention of production stoppages and the cost reduction due to this are in the foreground.

Right from the beginning, there is contamination in a new hydraulic system, which reduces the service life of the system and its components such as valves and cylinders without any or with inadequate filtration.

This so-called original dirt is created during the manufacturing of the components and mainly consists of coarse particles.

Besides contamination that arises during operation of the system, e.g. abrasive wear, dirt particles can also get into the system when it is filled with hydraulic oil.

Choosing the right filter contributes significantly to prevent the dangers mentioned above thereby ensuring efficient operation even after many years.
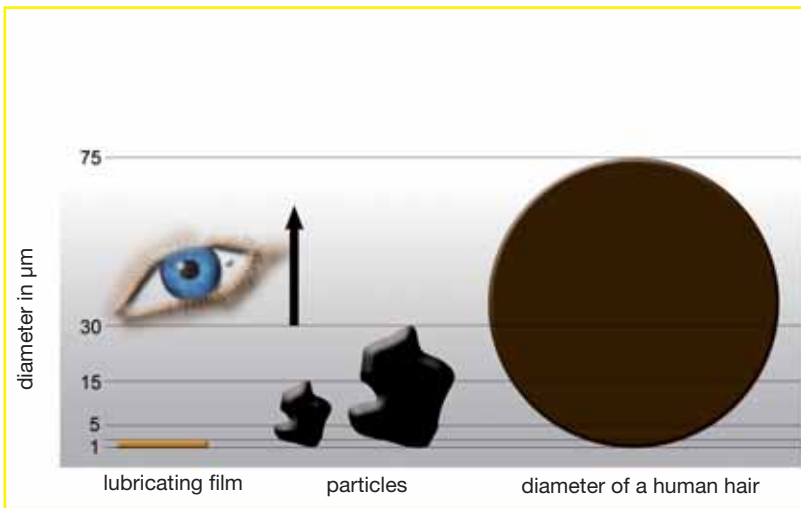
Reduction of contamination

- extension of service life
- extension of maintenance intervals
- reduction of machine downtime
- reduction of environmental pollution
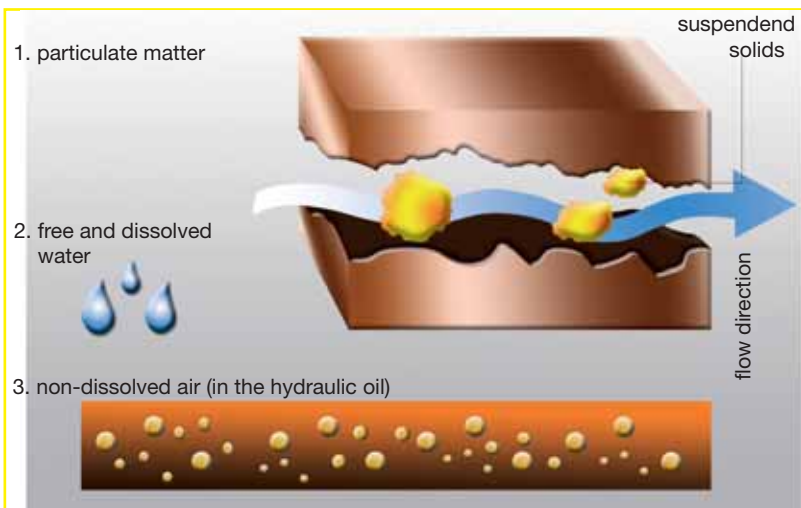
▶ cost savings for the user

Multipass Test Bench

Contamination – Types of Contamination

lubricating film   particles   diameter of a human hair

Examples of particle sizes:

- 100 µm   table salt, fine sand
- 75 µm   diameter of a human hair
- 60 µm   flower pollen
- 50 µm   fog
- **30 µm   (from approx.) resolution
  of the human eye**
- 15 µm   fine particles
- 7 µm   red blood cells
- 2 µm   bacteria
- 1 µm   layer of lubricating film

1. particulate matter

2. free and dissolved water

3. non-dissolved air (in the hydraulic oil)

suspendend solids

flow direction

**There can be different
types of contamination
in a hydraulic system**

The most frequent ones are:

- particulate matter
- free and dissolved water
- non-dissolved air

A majority of the contamination
can be removed through filtration.

STAUFF Laser Particle Counter LasPaC-II and Bottle Sampler

Contamination

Origin of contamination:

The main cause of failures and stoppages is dirt in the hydraulic system.

Failure analyses indicate that 70% of the failures are caused by faults in the hydraulic system.
90% of them are caused by impurities in the hydraulic oil.

Contamination that gets in from the outside comes from:

▪ filling and refilling the hydraulic tank
▪ inadequately dimensioned breathers
▪ damaged tank seal
▪ replacement of hydraulic lines and components (pumps, cylinders)
▪ impurities in the air

Contamination found in the hydraulic system:

▪ contamination on/in the components caused by the manufacturing process (e.g. chips)
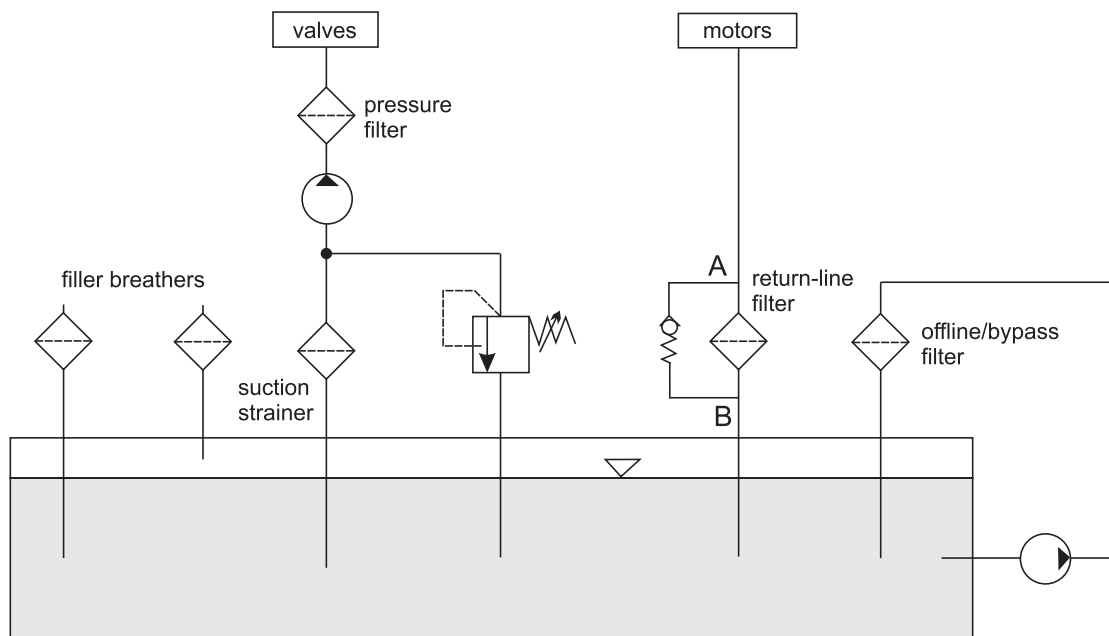▪ contamination on the components caused by the installation of the components

Contamination arising in the hydraulic system:

▪ disintegration of particles from high pressure changes and tension on the surface of hydraulic components
▪ material erosion that occurs at places in the hydraulic units due to the impact of pressurised liquid at high speeds (erosion wear)
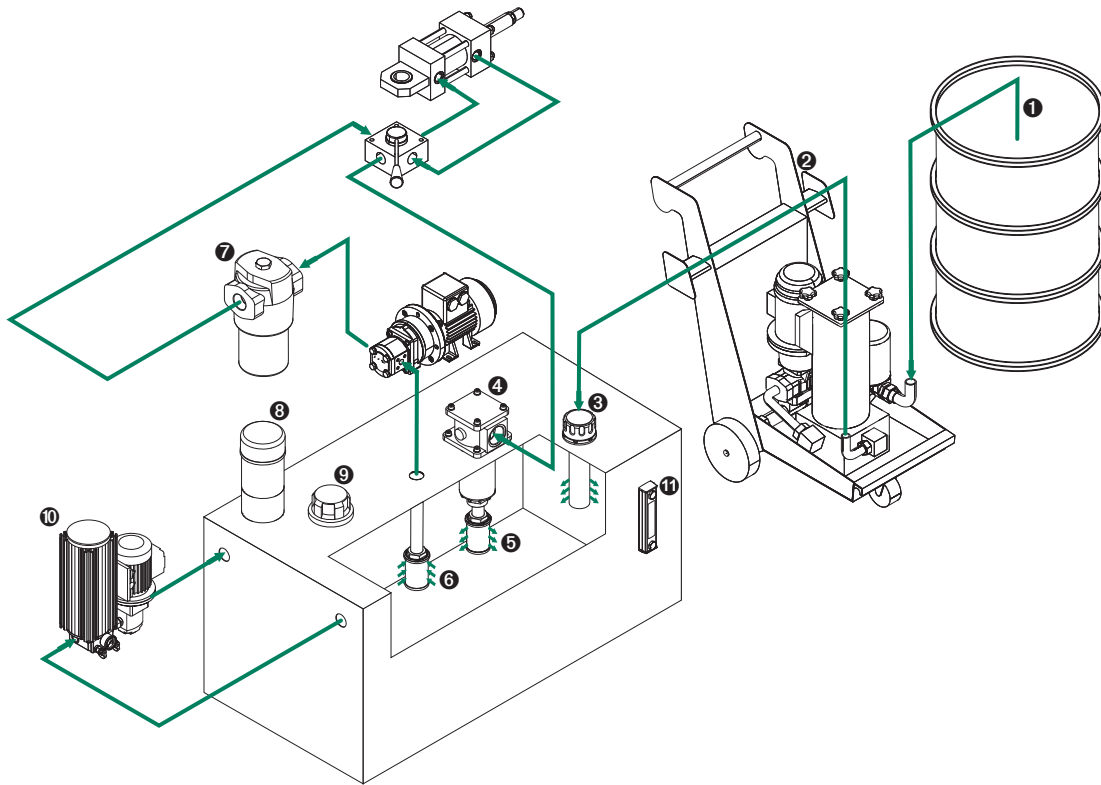
❶ Oil tank
❷ STAUFF Mobile Filter-System SMFS-U
❸ STAUFF Metal Filler Breather SMBB

❹ STAUFF Return-Line Filter RF
❺ STAUFF Diffusor SRV
❻ STAUFF Suction Strainer SUS
❼ STAUFF Pressure Filter SF

❽ STAUFF Desiccant Air Breather SDB
❾ STAUFF Plastic Filler Breather SPB
❿ STAUFF Offline Filter OLS
⓫ STAUFF Level Gauge SNA

valves

pressure
filter

filler breathers

suction
strainer

motors

A
return-line
filter

B

offline/bypass
filter

Hydraulic diagram: Installation variants for filters

| Pressure Filter | Return-Line Filter | Diffusor | Suction Strainer | Desiccant Air Breather | Plastic Filler Breather | Offline Filter |

STAUFF Filter Components

Pressure filters (7) are placed behind the pump and clean the hydraulic oil before it flows through downstream components like valves, cylinders and so on. The main reason for pressure filtration is for the protection of downstream, sensitive components. Eroded particles from the pump are immediately filtered out of the hydraulic oil. Besides working as a protection filter, pressure filters also help to maintain the required purity class.

Because it is placed right behind the pump, a pressure filter must withstand the maximum system pressure. The filter element in the pressure filter must also withstand the loads and is intricately constructed, for example as a return-line filter element.

Return-line filters (4) are installed on top of or within the oil tank. They filter the hydraulic oil before it flows back into the reservoir. This ensures that contamination arising in the components does not get into the tank. Return-line filters maintain the targeted purity class like pressure filters. However, because of their arrangement, they do not fulfil the additional function of a protection filter. In contrast to a pressure filter, it only has to withstand low pressure levels.

Diffusers (5) are used in combination with return-line filters and ensure that the returning oil flow is settled before it reaches the oil tank thereby preventing foaming and re-suspension of deposited dirt.

The job of **suction strainers (6)** is mainly to provide functional protection of the downstream pumps in the circulation. Suction filters must always be provided if the risk of pump damage from coarse impurities is particularly high. This risk exists if impurities collect in the tank and they cannot be cleaned out. This is a coarse filter with a micron rating that is usually 125 µm.

Filler breathers (3 + 9) are mounted on the oil tank and prevent the entry of dirt from the surroundings during tank breathing. They should be chosen with a filter unit that is similar to the working filter (pressure filter, return-line filter).

The replacement cycles of filter inserts is highly dependent on the surrounding conditions of the hydraulic system.

Another variant of the breather is the **desiccant air breather (8)**. The additional function of this filter is dehumidification of the inflowing air through silicate gel.

Offline / bypass filters (10) are not part of the actual hydraulic system. They are supplementary to achieve the best possible filtration results. Because of the high efficiency of the offline / bypass filters, purity levels are reached that cannot be achieved with conventional main filter systems.

Offline filters work with an integrated motor/pump unit that draws in the fluid from the system, filters it and then feeds it back into the tank. Because the offline filter is independent, i.e. it can still be operated if the hydraulic system is switched off, it is used in practice for continuous cleaning of the tank.

Bypass filters on the other hand use the existing system pressure to draw a small volumetric flow out of the hydraulic system for filtration. They are only active while the unit is in operation.

Another mobile variant of the bypass filter is the **mobile filter system (2)** dar.

Multipass Test Bench

Test Standards and Oil Purity

Definition of the required micron rating:

Essentially, the components found in the hydraulic system are decisive for determining the micron rating.

To guarantee a reliable mode of operation over the years, it is mandatory to maintain a stipulated oil purity class for specific components.

The most sensitive component determines the choice of filter material and micron rating.

To determine the oil purity, a laser particle counter is used to count particles that are >4 µm, >6 µm and >14 µm in 100 ml of hydraulic oil. The number of particles is then assigned a classification number (e.g. 20/18/15) that then corresponds to the ISO purity class. Please note here that the number of particles doubles for the next higher class. The oil purity class that must be achieved is an important criterion for choosing the right filtration.

## STAUFF filter elements are subject to the following test methods:

▪ ISO 294	Compatibility with hydraulic media
▪ ISO 3968	Flow characteristics
▪ ISO/DIS 3724	Flow fatigue characteristics
▪ ISO 16889	Filtration performance test (multi-pass method)
▪ ISO 2942	Verification of fabrication integrity (bubble point test)
▪ ISO 3723	End load test
▪ ISO 2941	Collapse / burst resistance

Number of particles in 100 ml		Classification numbers		
More than	Less than	> 4 µm(c)	> 6 µm(c)	> 14 µm(c)
8.000.000	16.000.000	24	24	24
4.000.000	8.000.000	23	23	23
2.000.000	4.000.000	22	22	22
1.000.000	2.000.000	21	21	21
500.000	1.000.000	20	20	20
250.000	500.000	19	19	19
130.000	250.000	18	18	18
64 000	130.000	17	17	17
32 000	64 000	16	16	16
16 000	32 000	15	15	15
8 000	16 000	14	14	14
4 000	8 000	13	13	13
2 000	4 000	12	12	12

Recommended purity classes for hydraulic applications

Hydraulic components	Purity class ISO 4406 4 µm / 6 µm / 14 µm	Recommended filter fineness (µm)
Gear pump	19 / 17 / 15	20
Cylinder	20 / 18 / 15	20
Valves	20 / 18 / 15	20
Logic valves	20 / 18 / 15	20
Control valves	19 / 17 / 14	10
Standard hydraulic < 100 bar	19 / 17 / 14	10
Proportional valves	18 / 16 / 13	5
Piston pump	17 / 15 / 13	5
Servo valves < 210 bar	16 / 14 / 11	3
Servo valves > 210 bar	15 / 13 / 10	3

The component manufacturer's specifications must be observed.
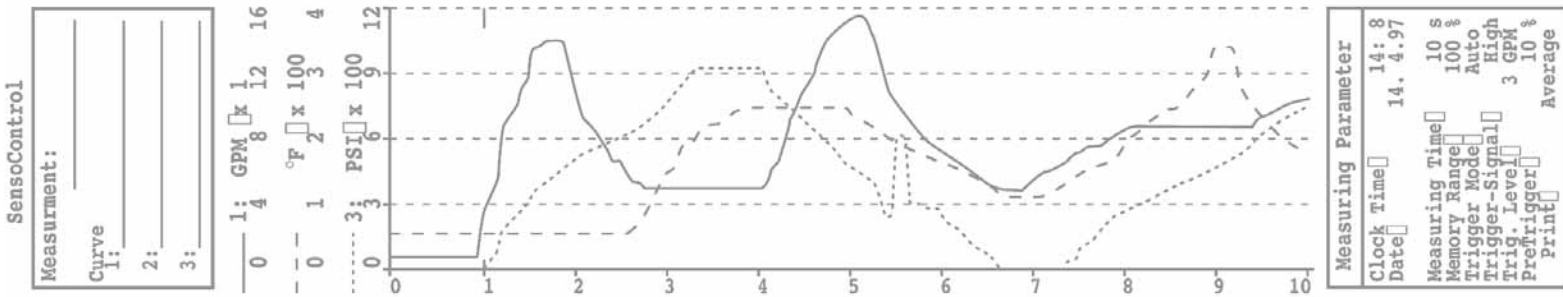
β-Value and Separation Efficiency

To choose filtration that meets requirements, performance characteristics like the filter fineness, the separation efficiency, the dirt retention, and the pressure loss must be observed.

The β-value as per ISO 16889 is the relevant characteristic value for separation efficiency. The β-value gives the ratio of particles before (N_x) and after (N_h) the filter.

$$\beta_x = N_x / N_h$$

$\beta_{10} > 200$ means that of 1000 particles that are 10 μm in size, only five particles can pass through the filter.

995 particles will be trapped by the filter element. Popular filters with inorganic glass fibre medium must achieve a β-value of at least 200 in order to meet the demands placed on hydraulic filtration today.

The **separation efficiency**, also called the retention rate, is directly related to the β-value and is calculated as follows:

$$\varepsilon = (\beta_x - 1) / \beta_x$$

$\beta_{10} > 200$ corresponds to separation efficiency of 99,5%.

Comparison of β-value and efficiency η
(each related to a defined particle size)

β-value	separation efficiency η
1	0,00 %
2	50,00 %
10	90,00 %
25	96,00 %
50	98,00 %
75	98,67 %
100	99,00 %
200	99,50 %
1.000	99,90 %
9.999	99,99 %

The **dirt-hold capacity** (DHC) shows how much solid dirt a filter element can hold before it has to be replaced. The dirt retention capacity is therefore the most important parameter in the filter service life.

The **pressure differential** (ΔP) is another important criterion for the configuration of the filter. Ensure that the physical size of the filter is chosen such that the initial pressure differential is as low as possible.

To guarantee optimum filtration, the β-value, the dirt-hold capacity (DHC) and the pressure differential (ΔP) must be carefully matched.

11

Filter material

Filter Material – Quality and Properties

The choice of the right filter material is dependent on different criteria. Among others, this includes the type of application, the filter function, degree of contamination or alternatively the required dirt retention capacity as well as requirements of chemical or physical resistance.

Inorganic glass fibre, polyester, cellulose, metal fibre material and stainless steel wire mesh are used for hydraulic applications.

The following list gives you an overview of how these five filter materials differ with regard to specific properties:

Inorganic Glass Fibre

- inorganic glass fibre based on synthetic fibres with acrylic resin binding
- large dirt retention capacity
- excellent separation efficiency of the finest particles due to the three-dimensional labyrinth structure with deep-bed filtration
- outstanding price/performance ratio

4PRO **Latest generation of inorganic glass fibre filter elements: Increasing the service life of your hydraulic systems by up to 60%**

- high dirt-hold capacity
- improved filtering capacity
- extended maintenance intervals
- reduced operating costs
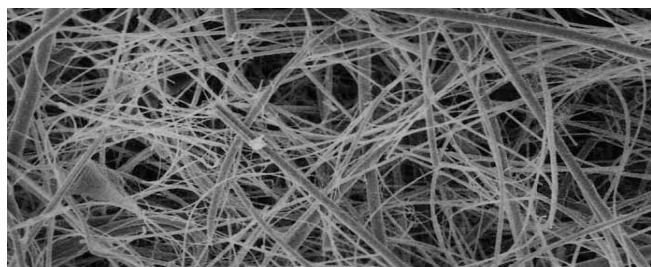
Laser labelling of return-line filter element

Polyester

- 100% polyester fibre with thermal binding
- high pressure differential resistance
- high dirt-hold capacity due to deep-bed filtration with low flow resistance
- good chemical resistance
- high separation efficiency of the finest particles
- tear-proof structure
- no static charging

Cellulose

- filter material made of cellulose fibres with special impregnation
- variants with the lowest price with good dirt retention capacity
- not suitable for hydrous media
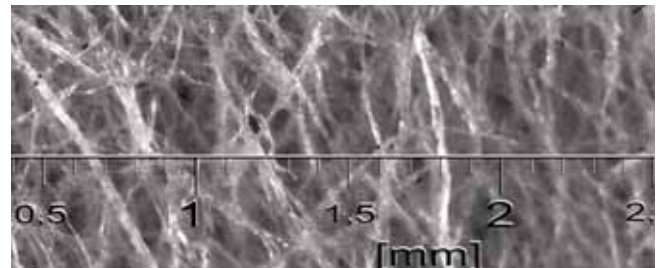
Metal Fibre

- sintered metal fibres with three-dimensional labyrinth structure for deep-bed filtration
- low flow resistance with high dirt-hold capacity
- excellent chemical and thermal resistance
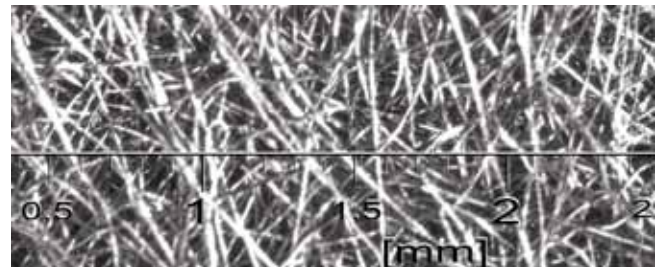
Stainless Steel Wire Mesh

- wire mesh fabric made of material 1.4301 for surface filtration
- type of weave: square weave or Dutch weave
- low flow resistance due to large-pored screening surface
- excellent chemical and thermal resistance
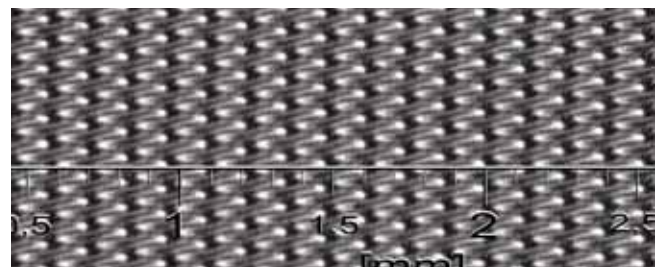
STAUFF Replacement Filter Elements

STAUFF manufactures one of the most comprehensive ranges of replacement filter elements for hydraulic and lubrication applications which are compatible with most of the common competitor products.

The STAUFF replacement element program includes replacement elements for over 10,000 part numbers covering almost every major international brands of filter elements. The majority of these are avaliable from stock.

Continuous improvement of the materials used as well as strict quality controls which take into consideration international standards guarantee the consistently high performance data of the filter elements.

STAUFF impresses in particular with its:

· innovative research, design and development
· modern production lines with complete
· certified work processes in accordance with ISO 9001:2000 (quality management), DIN EN ISO 14001:2005 (environmental protection) as well as OHSAS 18001: 2007 (occupational health and safety)
· comprehensive stocks and quick delivery
· customised products in accordance with customer drawings or on the basis of STAUFF designs
· comprehensive worldwide network of wholly-owned subsidiaries and sales partners

Cross Reference of STAUFF Filter Elements

Pressure Filter Element		Return-Line Filter Element		Pressure Filter Element		Return-Line Filter Element	
Series	NL	Series	NR	Series	SD	Series	RD
replacing	DIN	replacing	DIN	replacing	ARGO	replacing	ARGO

Pressure Filter Element		Return-Line Filter Element		Pressure Filter Element		Return-Line Filter Element	
Series	SE	Series	RE	Series	SL	Series	RL
replacing	HYDAC	replacing	HYDAC	replacing	Mahle	replacing	Mahle

Pressure Filter Element		Return-Line Filter Element		Pressure Filter Element		Return-Line Filter Element	
Series	SN	Series	RN	Series	SP	Series	RP
replacing	Internormen	replacing	Internormen	replacing	Pall	replacing	Pall

Pressure Filter Element		Return-Line Filter Element		Return-Line Filter Element		Special Filter Elements
Series	SS	Series	RS	Series	RA	Besides a multitude of standard elements, STAUFF is able to develop and manufacture special filter elements in accordance with customer requirements.
replacing	Eppensteiner	replacing	Eppensteiner	replacing	Fairey-Arlon	

Visit our online database to cross-reference replacement filter elements for hydraulic and lubrication oil applications with more than 65,000 stored datasets: **www.filterinterchange.com**

Filtration terminology

Bypass Valve

A bypass valve is a valve that is integrated in a filter and allows the oil to bypass the filter element if a defined pressure differential is exceeded. Bypass valves are used to protect the filter element.

Cavitation Damage

Cavitation is defined to be the cavity formation in liquids. Cavity formation occurs if the local static pressure of a liquid drops below a critical value. This critical value usually corresponds to the vapour pressure of the liquid. Critical effects of cavitation are:

- cavitation wear
- undissolved gas in the hydraulic system
- loud high-frequency noises
- local high temperatures in the liquid
- changes to the resistance characteristics of the hydraulic resistance

Clogging Indicator

Another way to make sure that no unfiltered oil gets into the hydraulic circuit is to use clogging indicators. They work with differential pressure and back pressure. Clogging indicators are available in optical, electrical and optical/electrical versions. While it is the responsibility of the installation or maintenance personnel to check the degree of clogging of the filter element with optical clogging indicators, a signal contact (switch) can be connected to the machine controller with an electrical or optical/electrical clogging indicator.

Collapse Pressure

The permissible collapse pressure according to ISO 2941 is understood to be the pressure difference that a filter element can withstand with the stipulated direction of flow. Exceeding the collapse pressure results in the destruction of the filter element.

Deep-Bed Filter

Impurities penetrate into the filter fabric and are retained by the structure of the filter fabric. Mainly cellulose and inorganic glass fibre media are used in hydraulic filters. For special applications, plastic media (high-strength) and metal fibre media are also used. The design of the deep-bed filter combines the highest micron rating with a high dirt retention capacity. Due to the fleece-like structure of deep-bed filters, particles are not only separated on the surface of the filter material, but they can penetrate into the filter material, which leads to a considerable increase of the effective filter area. In contrast to sieves, there are no "holes" in fleece, rather they practically consist of labyrinths in which the particles are trapped. Hence, there is no sharply defined "screening", rather a wide range of particles are trapped. Deep-bed filters are replaced at the end of the service life and are not to be cleaned.

Dirt-Hold Capacity (DHC)

The dirt-hold capacity(DHC), shows how much solid dirt a filter element can hold.

EPDM

Ethylene-propylene-rubber is used as a material for O-rings because of its chemical resistance.

Filter
A filter (hydraulic filter) has the job of keeping solids out of a liquid (oil). A filter is usually made of a filter housing and a filter element.

Filter Area
The filter area is the size of the theoretically spread-out filter element. The larger the filter area, the lower the flow resistance of the filter element. Simultaneously, the dirt retention capacity increases. The following applies in general: the larger the filter area, the longer the service life of the element.

Filter Cake
A filter cake is made up of the particles trapped on the surface of a filter medium.

Filter Design
Essentially depends on the following factors: volumetric flow rate, desired oil purity, amount of contamination and the required filter service life.

Filter Element
The filter element is located in the filter housing and performs the actual filtering task. The filter medium can be made of cellulose, inorganic glass fibre, plastic or metal mesh and is available in different micron ratings.

Filter Housing
Depending on the application, the filter housing is built into the pressure or return line and must be designed for the specific operating or system pressure and the volumetric flow rate (flow). The filter element is located in the filter housing. Depending on the application, the filter housing may be equipped with a bypass valve, a reversing valve, a clogging indicator and other options.

FKM
Fluorinated rubber is used as a material for O-rings and is characterised by its outstanding resistance to high temperatures, mineral oils, synthetic hydraulic fluids, fuels and chemicals.

Inorganic glass fibre medium
Inorganic glass fibre media are among the most important materials in modern filtration. During production, selected fibres (1mm – 5mm long and 3 μm - 10 μm in diameter) are processed into a specific mix. The manufacturing process is very similar to paper production. The fibres are bound with a resin and impregnated. The benefit compared to cellulose paper is a fibre structure that is considerably more homogenous and consequently has larger open pored surfaces. As a result, lower flow resistance is achieved.

Hydraulic Fluid
A pressure liquid is defined to be a fluid used in a hydraulic system for power transmission. According to ISO 6743, the fluids are divided into mineral oil based, flame resistant and environmentally friendly liquids.

Line Filter
Filter for installation in pipelines and hoses.

Micron Rating
Regarding micron rating, we must differentiate between the filter materials that are used. To define the micron rating for deep-bed filter elements, the β-value as per ISO 16889 is commonly used. Typical micron ratings in hydraulics are 3 μm, 5 μm, 10 μm, 15 μm, 20 μm and 25 μm.

Multi-Function Valve
A combination of bypass, reversing and non-return valve.

Multi-Pass Test
Defined in ISO 4548-12 and calibration as per ISO 16889. Here, mineral oil contaminated with quartz sand (ISO-MTD dust) of different grain sizes is passed multiple times through the filter to be tested. The β-value is used as a measure of the retention rate as the ratio of the number of particles of a specific size before the filter. As a result, you get the development of the separation efficiency over time, the β-value and the filter service life. The multi-pass test is standardised in ISO 16889.

Nominal Flow Rate
The nominal flow rate describes the flow rate or the volumetric flow rate for which the respective filter has been designed. It is usually given in litres per minute and is an important parameter in the filter design. The actual flow rate is determined by the viscosity, filter fineness, temperature and the medium.

Nominal Pressure (bar)
Pressure for which the filter is designed and with which it can be identified.

Non-Return Valve
Variant of the cartridge valve. It prevents the continuation line from draining while the filter element is changed.
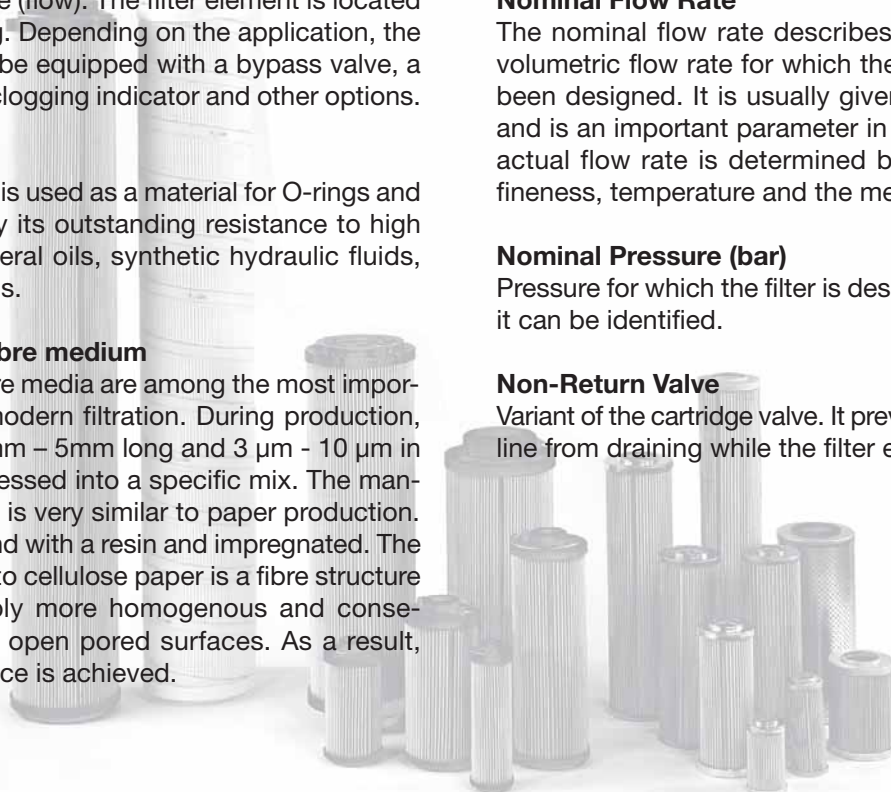
Oil Purity

The purity of a hydraulic fluid is defined by the number of solid particles per ml of fluid. The number of particles is usually measured with an automatic particle counter. The purity class code is determined from the number of particles of different sizes.

Particle counting as well as the coding of the purity class for hydraulic oils are described in the ISO 4406 (1999) standard.

Operating Pressure / System Pressure (bar)

Maximum pressure with which the filter may be used.

Particulate Matter

Particles that are suspended in the liquid as solids and do not chemically bond with the liquid are considered to be particulate matter. Particles that are approx. 1 µm in size are of interest in hydraulics. Particulate matter includes metals, elastomers, silicon or slag.

Pressure Differential

The pressure differential ($\Delta\rho$) is defined as the pressure difference between the filter input and the filter output, or alternatively before and after the filter element. Exceeding the maximum permissible pressure differential leads to the destruction of the filter element. A bypass valve integrated in the filter prevents destruction of the filter element by opening if the pressure is too high. The oil is then passed into the hydraulic circuit unfiltered. For applications in which no unfiltered oil is allowed to pass into the hydraulic circuit, there is the possibility of using filters without bypass valves with filter elements that can withstand a high pressure differential. The filter elements must be designed such that they can withstand the maximum expected pressure differential.

Reversing Valve

Variant of the cartridge valve. It is used to bypass the filter element for reversible oil flow so that the fluid does not pass through the filter element in the reverse direction.

Separation Efficiency

Separation efficiency is a measure of the effectiveness of a filter element for separating particulate matter. It is given in percent (see page 11).

Surface Filter

Impurities are separated on the surface of the filter element. Surface filters are designed to have uniform pores (gaps), therefore they can almost completely retain specific particle sizes. Surface filters are made of thin fabrics in which mainly metal threads are used (screen filter). Other surface filters are metal-edge filters.

Viscosity

The dynamic viscosity is a measure of the viscosity of the medium that is to be filtered. It is highly temperature dependent.

Volumetric Flow Rate

This is the amount of fluid that flows past a specific cross-section per unit time. It is given in litres per minute (l/min).

Wire Mesh

Filter elements with a metal wire mesh are often used as a low-cost and conditionally reusable solution in protection filters, suction filters or return-line filters. Depending on the requirements (micron rating, pressure, dynamics), different types of mesh are used like twill, linen, or also Dutch weave.

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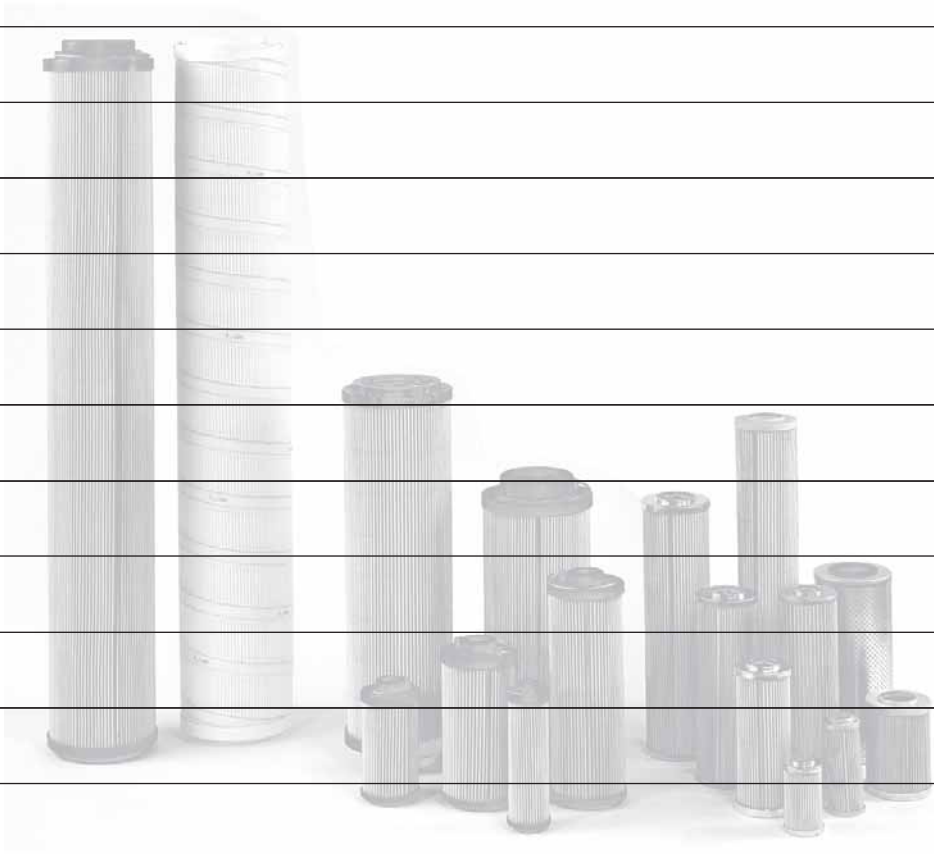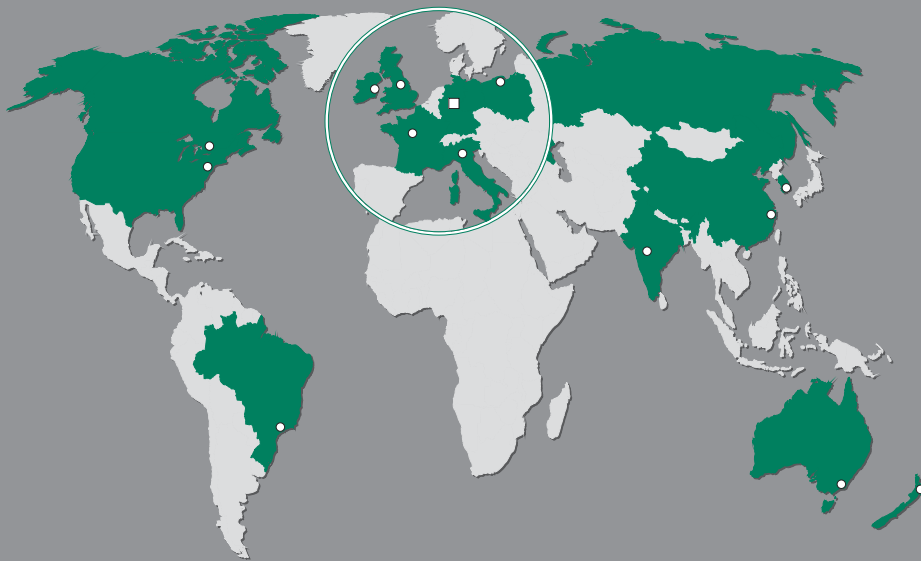
AUSTRALIA
STAUFF Corporation Pty. Ltd.
P. O. Box 227
Unanderra, NSW, 2526
24-26 Doyle Avenue
Unanderra, Wollongong, NSW, 2526
Tel.: +61 2 4271 18 77
Fax: +61 2 4271 84 32
sales@stauff.com.au

BRAZIL
STAUFF Brasil Ltda.
Avenida Gupê 10767
Galpão 2 - Bloco A
Barueri - São Paulo
CEP 06422-120
Tel.: +55 11 47 72 72 00
Fax: +55 11 47 72 72 10
stauff@stauffbrasil.com

CANADA
STAUFF Canada Ltd.
866 Milner Avenue
Scarborough
Ontario M1B 5N7
Tel.: +1 416 282 46 08
Fax: +1 416 282 30 39
sales@stauffcanada.com

CHINA
STAUFF International Trading
(Shanghai) Co., Ltd.
No. 41-42, Lane 369, Chuang Ye Road
Jushuo Industrial Zone, Kang Qiao
Shanghai, 201319
Tel.: +86 21 68 18 70 00
Fax: +86 21 68 18 71 36
info@stauff.com.cn

FRANCE
STAUFF S.A.S.
230, Avenue du Grain d'Or
Z.I. de Vineuil - Blois Sud
41354 Vineuil-cedex
Tel.: +33 2 54 50 55 50
Fax: +33 2 54 42 29 19
direction@stauffsa.com

INDIA
STAUFF India Pvt. Ltd.
Gat. No. 2340
Pune Nagar Road, Wagholi
Pune, 412207
Tel.: +91 20 6620 2473
Fax: +91 20 2705 1567
sales@stauffindia.com

ITALY
STAUFF Italia s.r.l.
Viale Nuova Valassina 78
angolo Via Baragiola sn
20033 Desio (MI)
Tel.: +39 0362 63 80 70
Fax: +39 0362 63 80 69
sales@stauff.it

IRELAND
STAUFF Ireland Ltd.
Unit B3
Weatherwell Business Park
Clondalkin
Dublin 22
Tel.: +353 1457 4936
Fax: +353 1467 0687
sales@stauff.ie

KOREA
STAUFF Korea Ltd.
1500-12, Dadae-Dong
Saha-Ku
Pusan, 604-826
Tel.: +82 51 266 6666
Fax.: +82 51 266 8866
info@stauff.co.kr

NEW ZEALAND
STAUFF Corporation (NZ) Ltd.
P. O. Box 58517
Greenmount, Auckland
Unit D, 103 Harris Road
East Tamaki, Auckland
Tel.: + 64 9 271 48 12
Fax: + 64 9 271 48 32
info@stauff.co.nz

POLAND
STAUFF Polska Sp. z o.o.
Miszewko 43 A
80-297 Banino
Tel.: +48 58 660 11 60
Fax: +48 58 629 79 52
sales@stauff.pl

RUSSIAN FEDERATION
STAUFF LLC
Office 205, Building 7
Scharikopodschipnikovskaya 11
Moscow, 115088
Tel.: +7 495 987 36 29
       +7 495 223 89 61
Fax: +7 495 679 90 48
sales@stauff.ru

UNITED KINGDOM
STAUFF UK
500, Carlisle Street East
Off Downgate Drive
Sheffield, S4 8BS
Tel.: +44 114 251 85 18
Fax: +44 114 251 85 19
sales@stauff.co.uk

UNITED STATES
STAUFF Corporation
7 Wm. Demarest Place
Waldwick, 07463-1542
New Jersey
Tel.: +1 201 444 78 00
Fax: +1 201 444 78 52
sales@stauffusa.com

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Im Ehrenfeld 4	filtrationtechnology@stauff.com
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