



# Hydraulic Filters

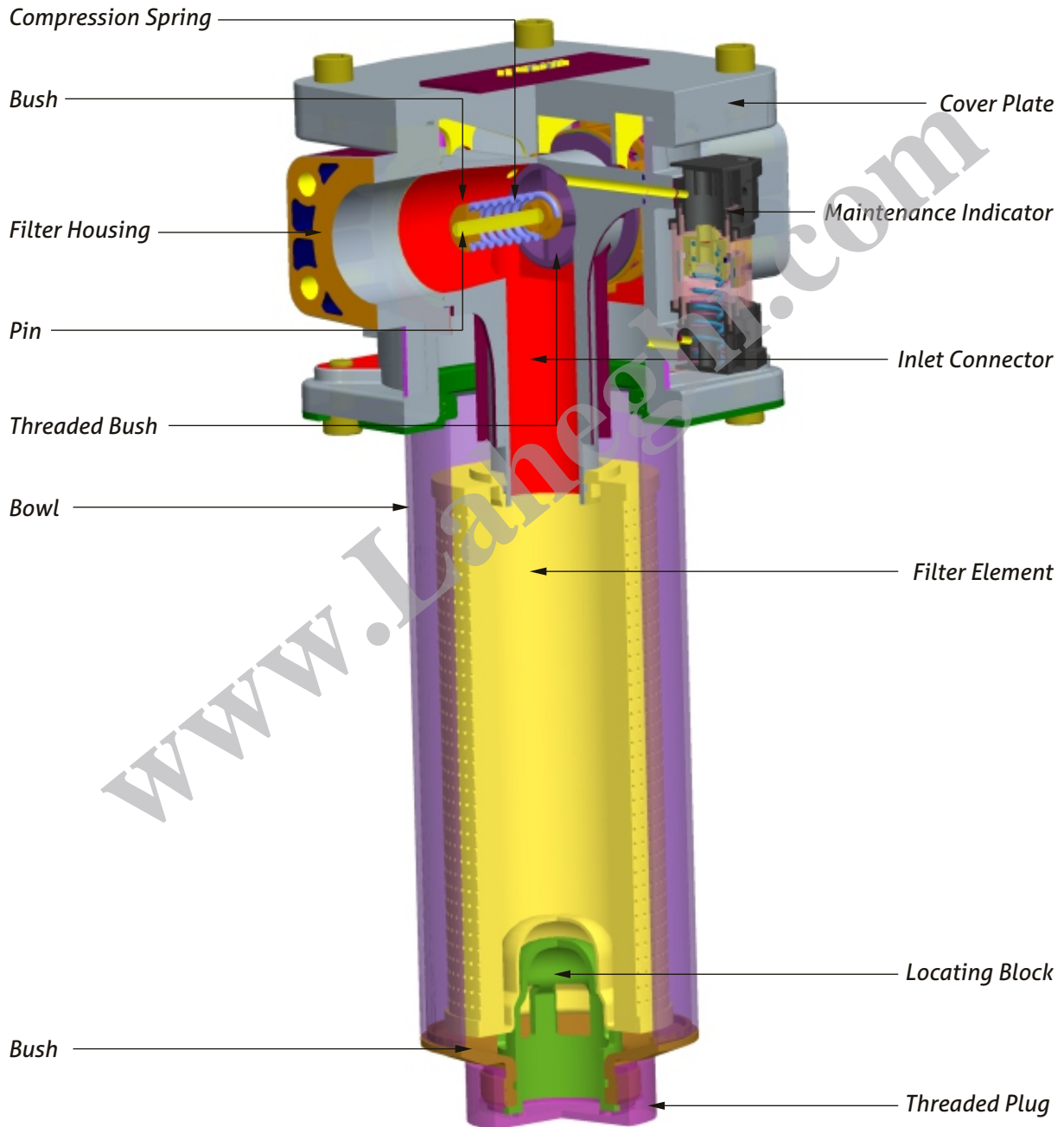
Size : 3/4" to 2½"



## FEATURES:

- High dirt holding capacity
- Lower pressure drop
- Water removal elements
- Several Mountings and porting options
- Indicator shows when no element installed
- Easy to service
- Head and cover plate made of aluminum
- Low installation cost.
- Easy replacement of cartridge
- Visual and Digital clogging indicator

# Construction Details Inline Filter





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## Introducing

### Low Pressure Return Line Filters :

Specifications				
Port Size	3/4"	1¼" & 1"	2" & 1½"	2½"
Flow Rating	48 GPM (180 LPM)	UP TO 70 GPM (264.9 LPM)	150 GPM (568 LPM)	300GPM (1363 LPM)
Max .Operating Pressure	145 PSI (10 bar)	145 PSI (10 bar)	200 PSI (13.8 bar)	145 PSI (10 bar)
Temp. Range	-20°F to 250° F (-29°C to 121°C)	-20°F to 250° F (-29°C to 121°C)	-20°F to 250° F (-29°C to 121°C)	-20°F to 250° F (-29°C to 121°C)
Bypass Setting :	14.5 psi (1bar)	40 psi (2.8 bar)	2, 3, 15, 25, 35 psid 0.1, 0.2, 1, 1.7, 2.4 bar	25 psid (1.7 bar)
Head	Aluminum	Aluminum	Aluminum	Aluminum
Cover Plate	Aluminum	Aluminum	Aluminum	Aluminum
Element Collapse Rating	150 PSID (10 bar)	150 PSID (10 bar)	50 PSID (3.4 bar)	50 PSID (3.4 bar)

### Features :

- High dirt holding capacity
- Low pressure drop
- Water removal elements
- Several mounting and porting options
- Indicator shows when no element installed
- Easy to service
- Head and Cover plate made of aluminum
- Low installation cost.
- Easy replacement of cartridge (Element)
- Visual clogging indicator



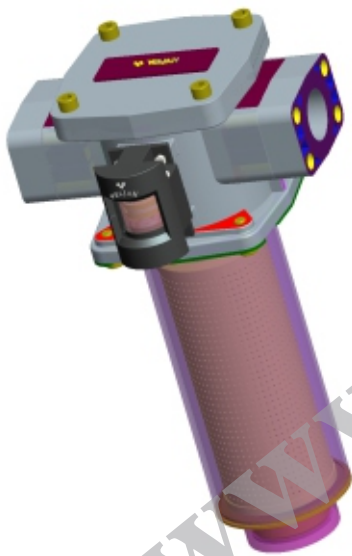
## Mountings / Porting Configuration :

Inline Mounting Filter

Tank Mounted Return Line Filters

Tank Mounted Suction Line Filters

## Mountings /porting Schemes :



Inline Filter



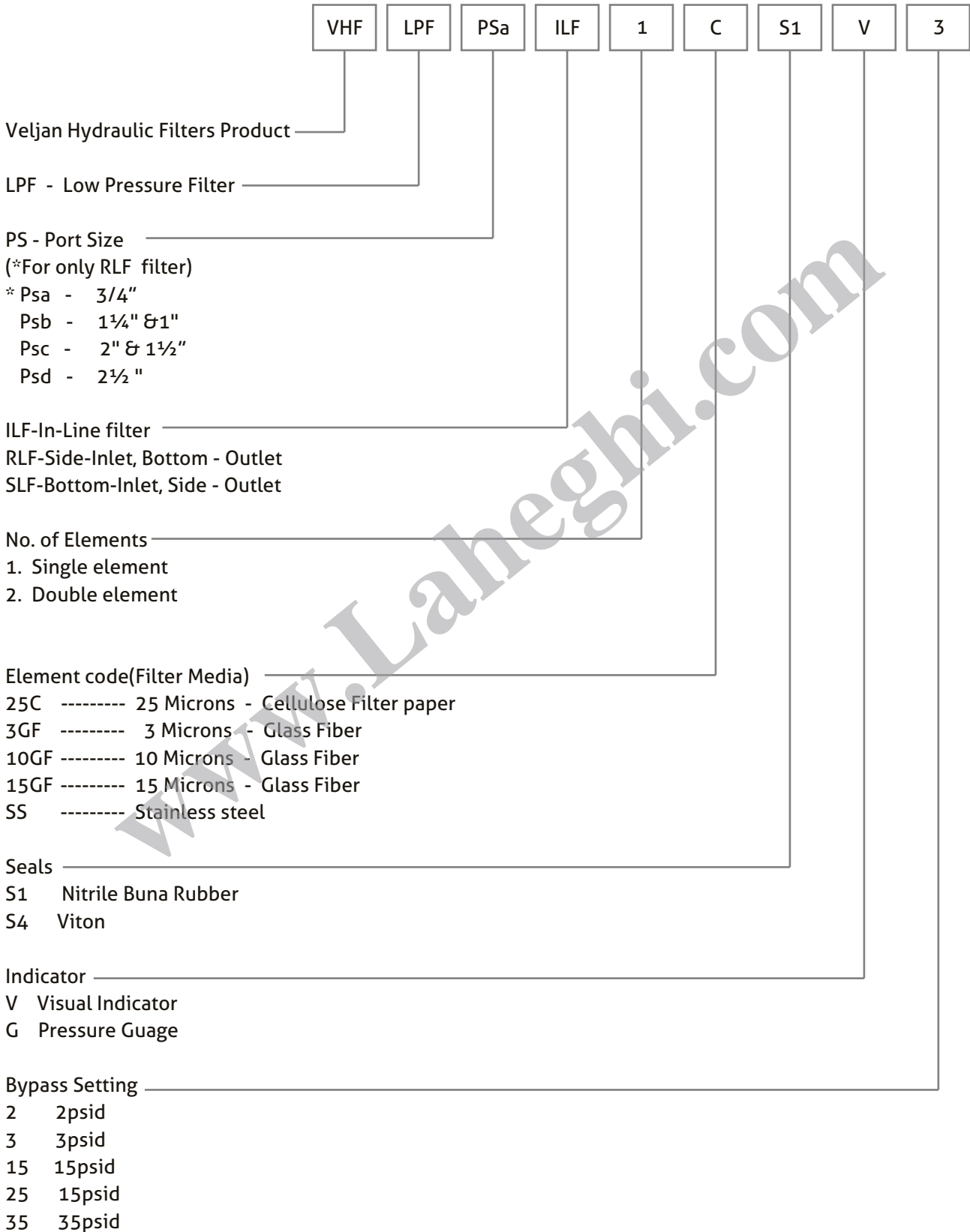
Return Line Filter



Suction Line Filter



## Ordering Code



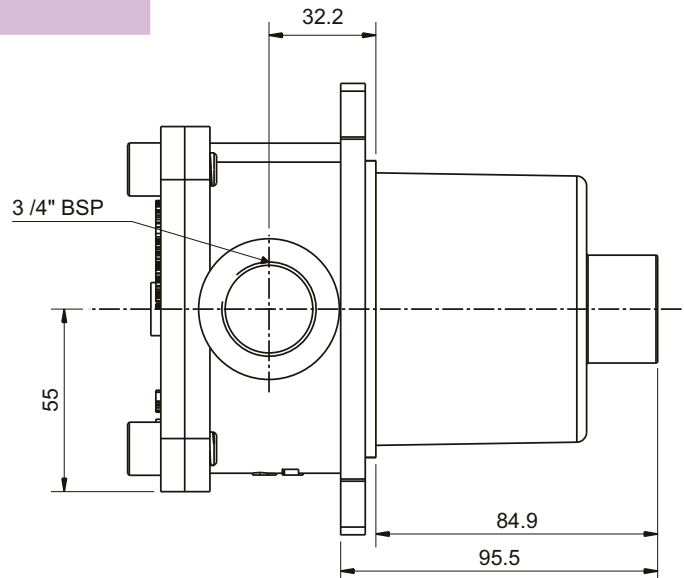
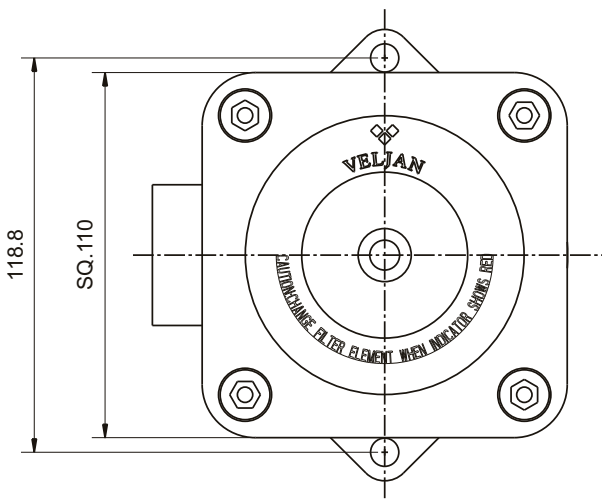


## 3/4" Return Line Filter



### Specifications :

Port size	3/4" BSP/ NPTF
Flow Rating	180 LPM (47.55 GPM)
Max .Operating Pressure	145 Psi (10 bar)
Temp. Range	-20°F to 250° F (-29°C to 121°C)
Bypass Setting :	14.5psi (1bar)
Head	Aluminum
Cover Plate	Aluminum





## 1" & 1¼" Return Line Filter



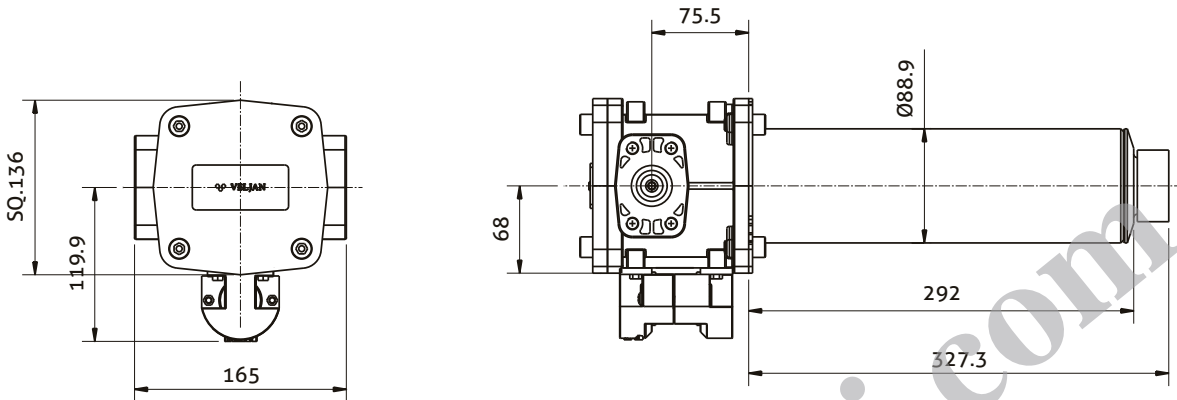
Specifications :	
Port size	1" & 1¼"
Flow Rating	UP TO 70 gpm
Max .Operating Pressure	145 Psi (10 bar)
Temp. Range	-20°F to 250°F (-29°C to 121°C)
Bypass Setting : Cracking	2,3,15,25,35psi (0.1,0.2,1,1.7,2.4 bar)
Head	Aluminum
Cover Plate	Aluminum
Element Collapse Rating	150 psid (10 bar)



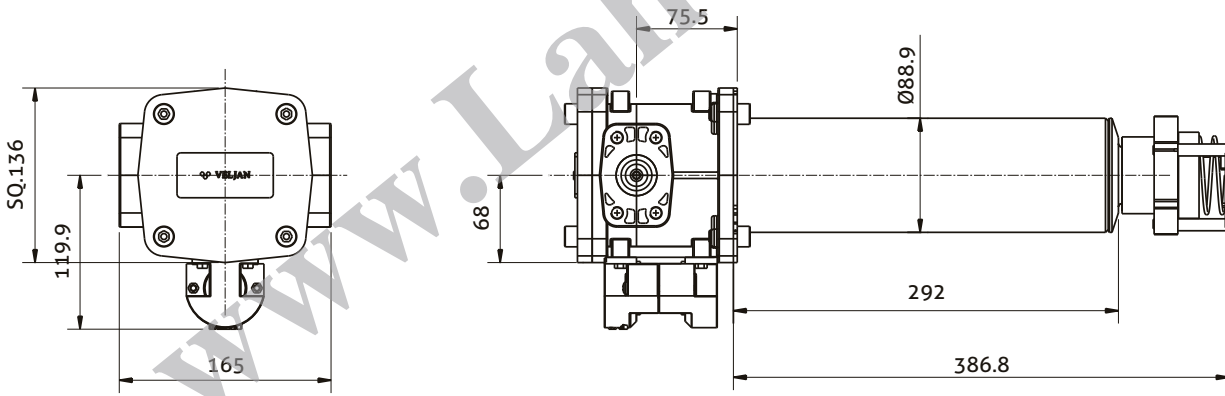


## 1" & 1 1/4" Return Line Filter

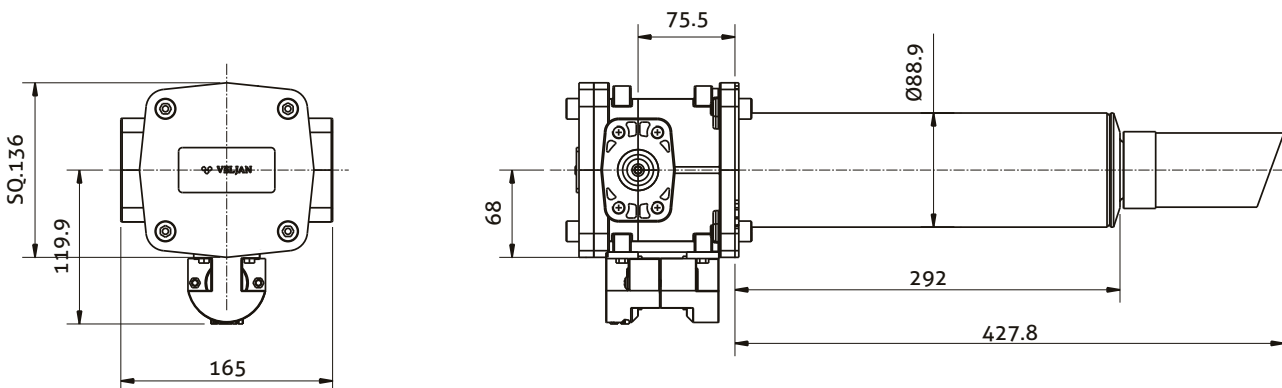
### Inline Filter - 1 1/4" :



### Return line Filter - 1 1/4" :



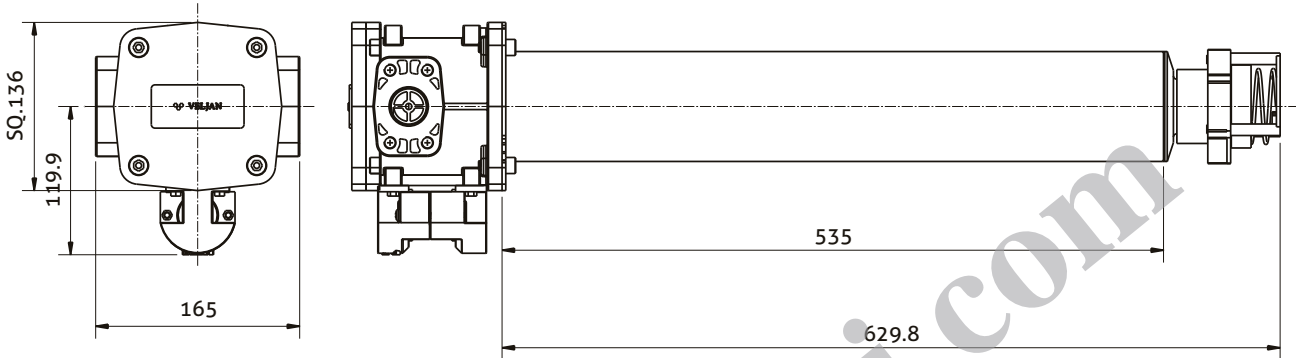
### Suction line Filter - 1 1/4" :





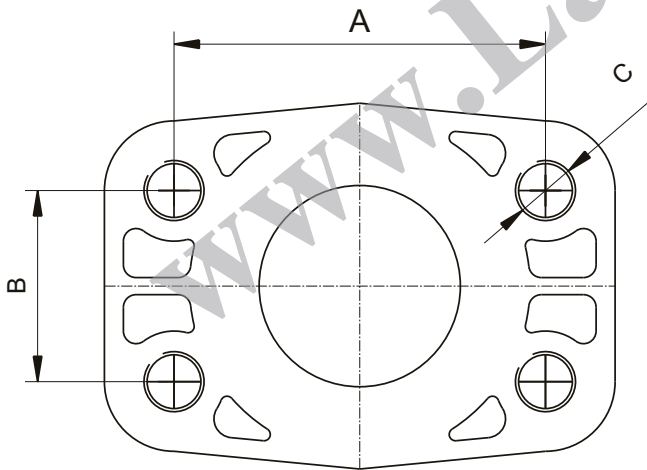
## 1" & 1 1/4" Return Line Filter

### Return Filter With Double Element - 1 1/4" :

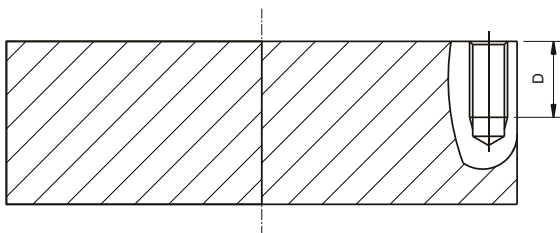


Note- Element length is common for Inline Line and Suction Line Filter

### Port Details - 1 1/4" :

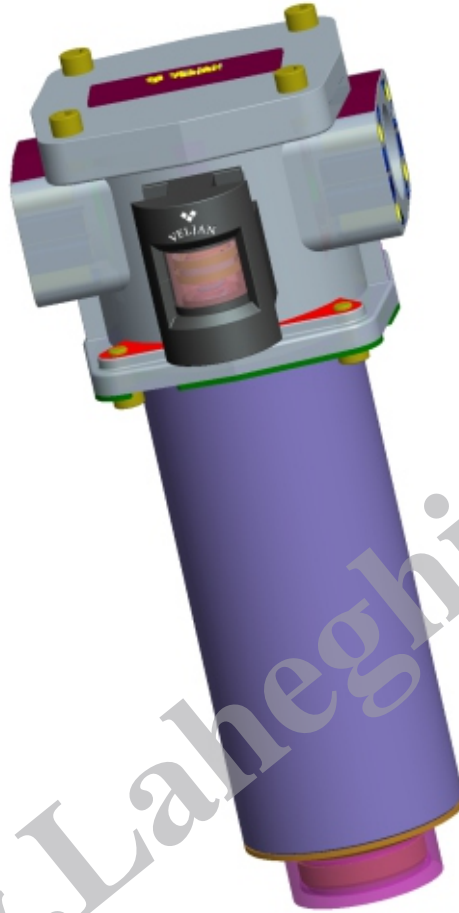


SAE flange size in.	A		B		Thread (C)		D mm
	mm	in.	mm	in.	UNC	Metric	
1 1/4"	58.7	2.31	30.2	1.18	7/16"-14	M10	20





## 1½ " & 2" Return Line Filter

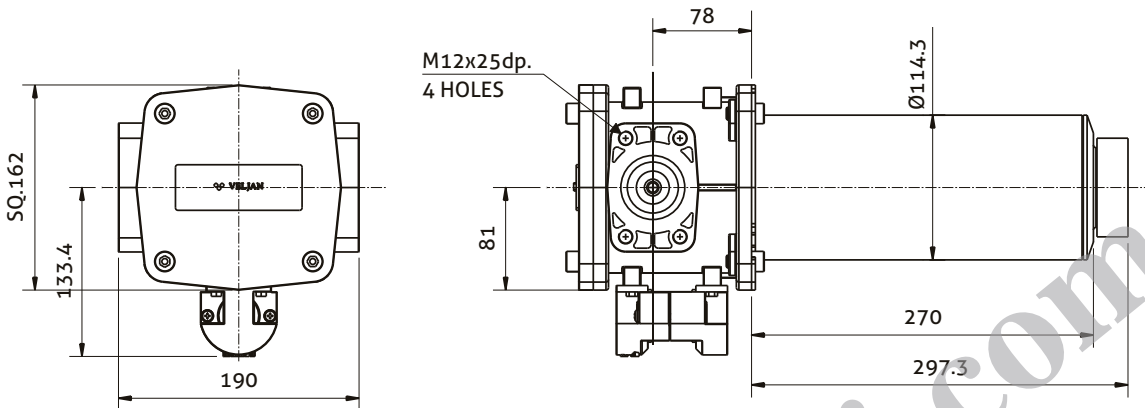


Specifications :	
Port size	1½" & 2"
Flow Rating	568 LPM (150 GPM)
Max .Operating Pressure	200 psi (13.8 bar)
Temp. Range	-20°F to 250°F (-29°C to 121°C)
Bypass Setting :	2, 3, 15, 25, 35 psid (0.1,0.2,1,1.7,2.4 bar)
Head	Aluminum
Cover Plate	Aluminum
Element Burst Rating	50 psid (3.4 bar)

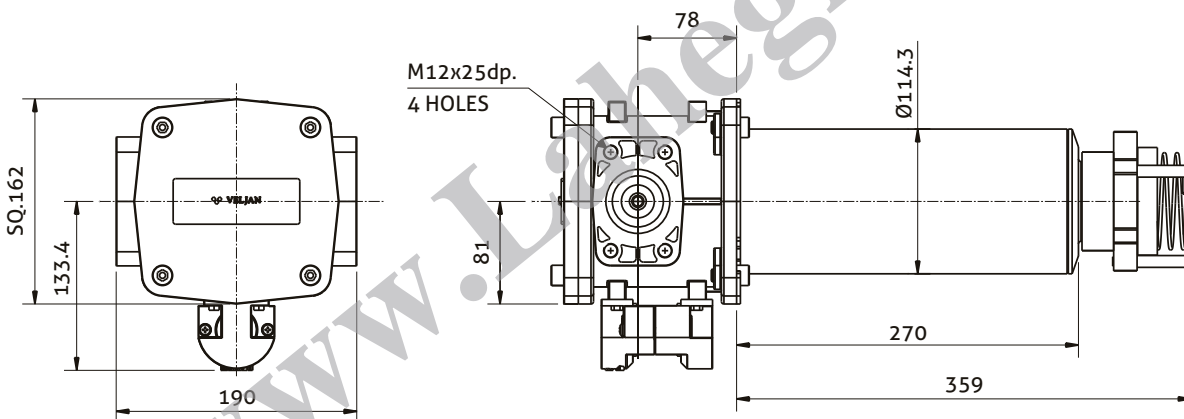


## 1½" & 2" Return Line Filter

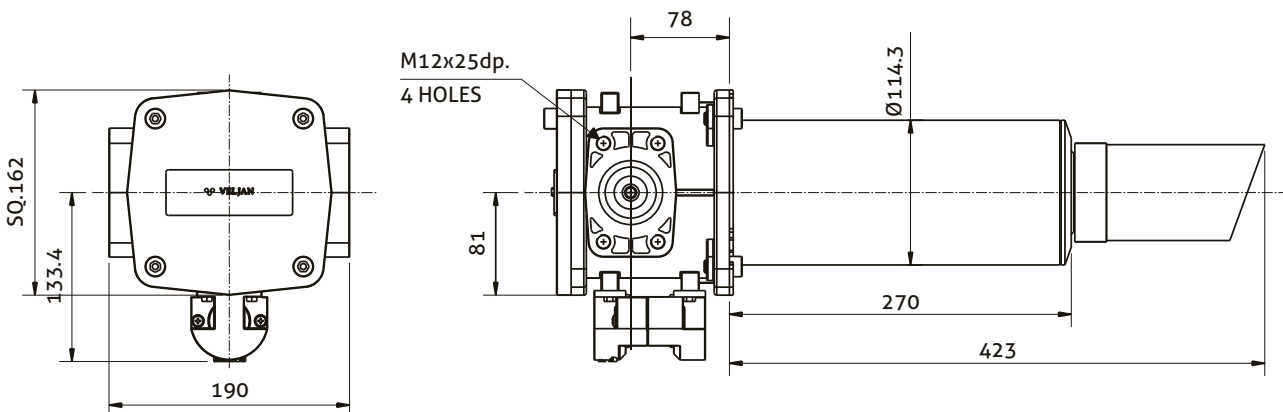
### Inline Filter with Single Element- 2":



### Return Line Filter With Single Element -2" :



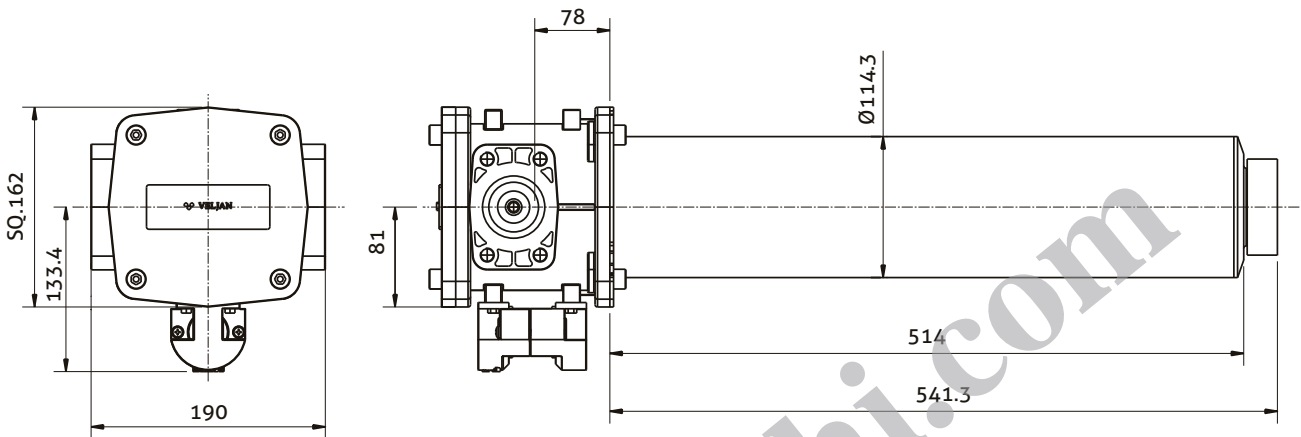
### Suction line filter With Single Element - 2" :





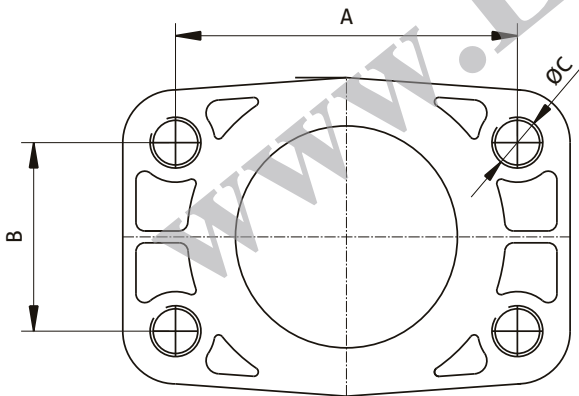
## 1½ " & 2" Return Line Filter

### Inline Filter With Double Element - 2" :

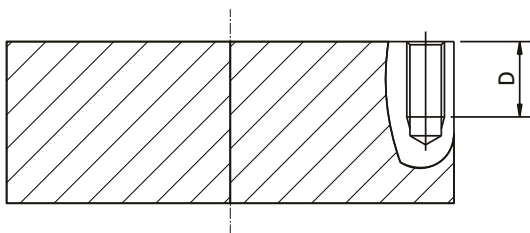


Note - Element length is common for Return Line and Suction Line Filter

### Port Details - 2":

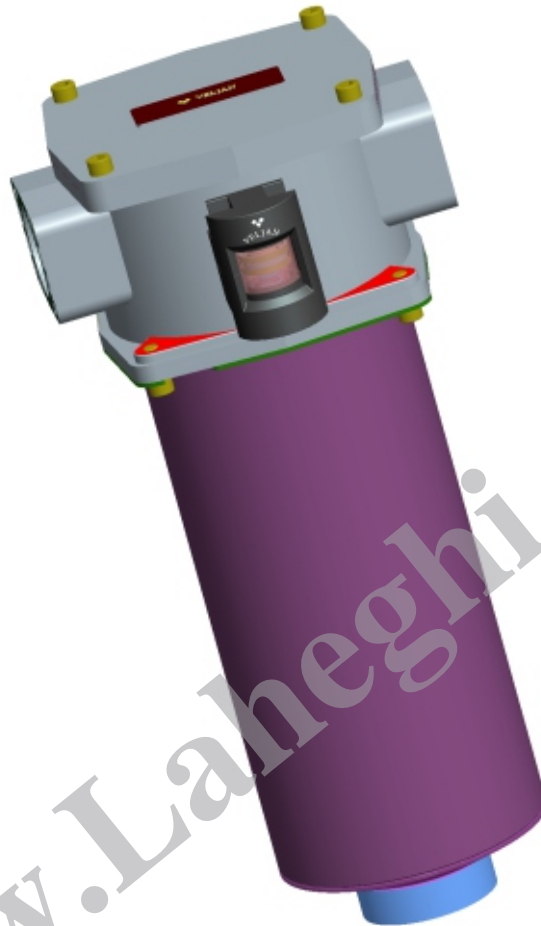


SAE flange size in.	A		B		Thread (C)		D mm
	mm	in.	mm	in.	UNC	Metric	
2"	77.8	3.06	42.9	1.69	1/2"-13	M12	25





## 2½ " Return Line Filter

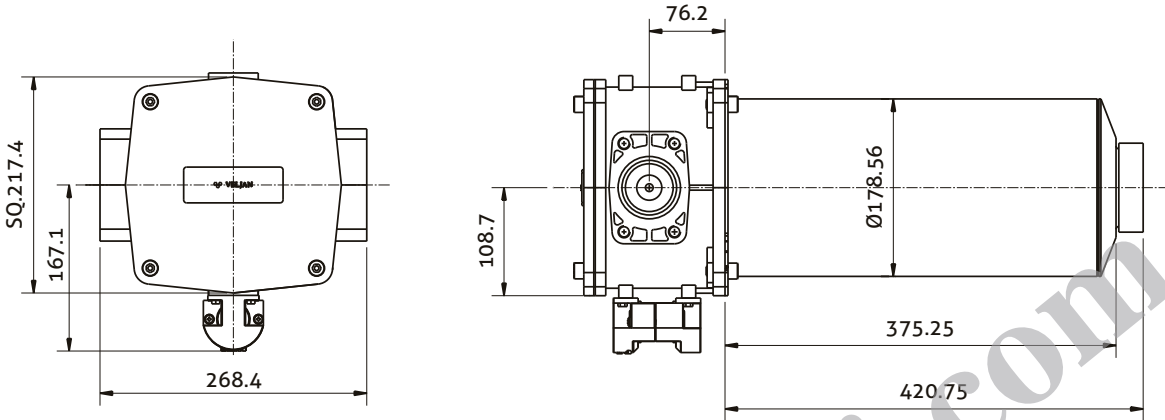


Specifications :	
Port size	2½"
Flow Rating	300gpm (1136 lpm)
Max .Operating Pressure	145 psi (10 bar)
Temp. Range	-29°C to 121°C (-20°F to 250° F)
Bypass Setting :	25 psid
Head	Aluminum
Cover Plate	Aluminum
Element Collapse Rating	50 psid (3.5 bar) minimum

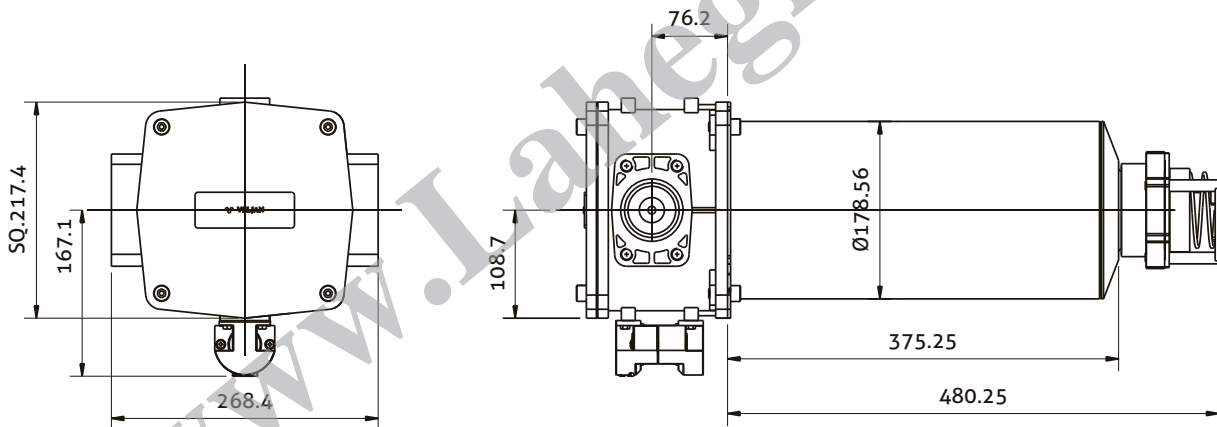


## 2½ " Return Line Filter

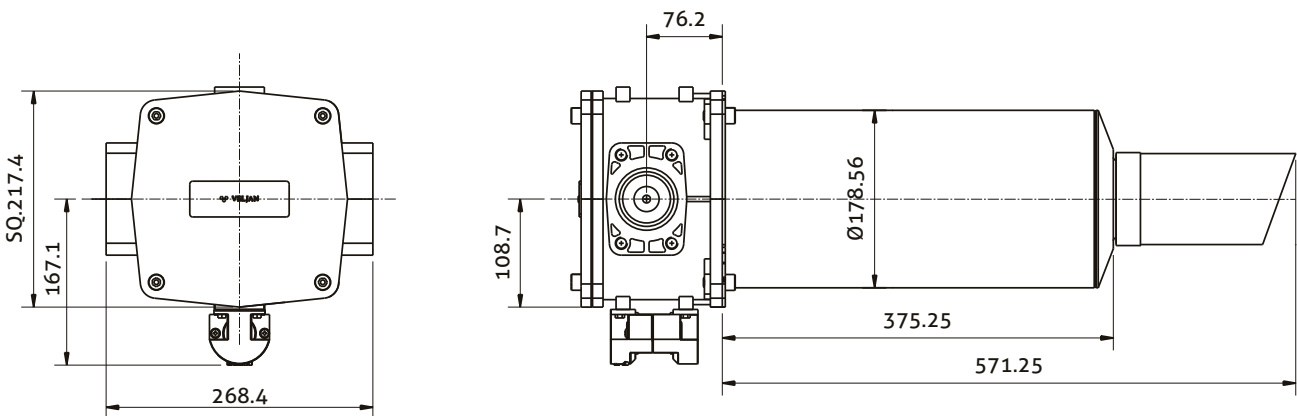
### Inline Filter with Single Element- 2½" :



### Return Line Filter With Single Element - 2½" :



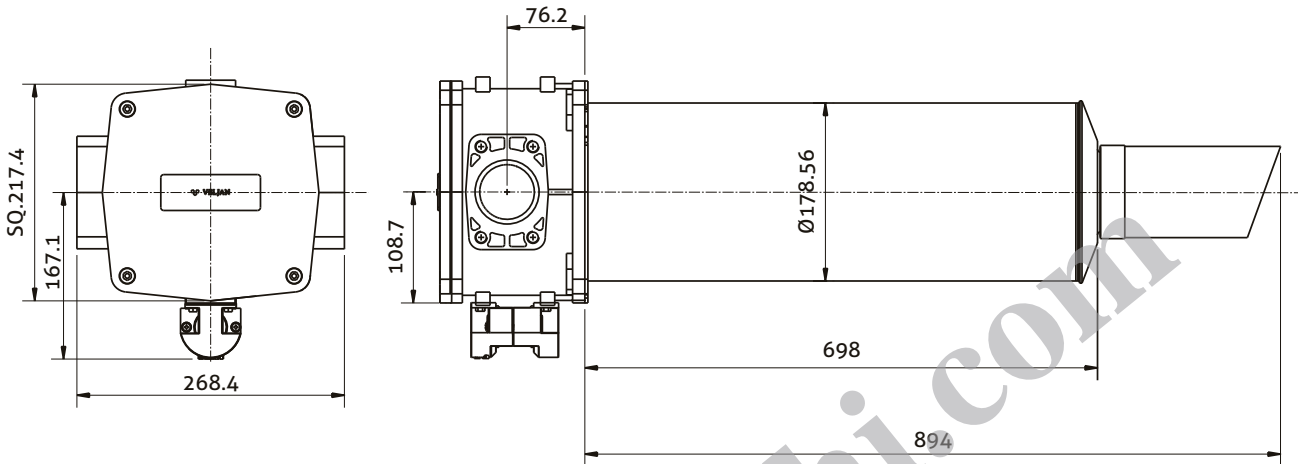
### Suction line filter With Single Element - 2½" :



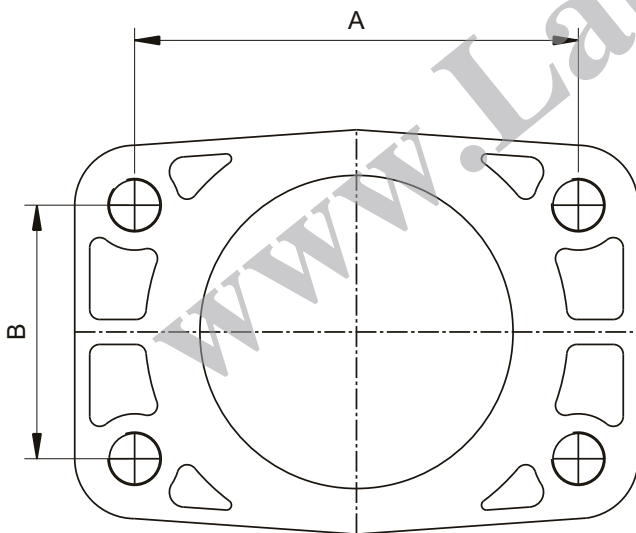


## 2½ " Return Line Filter

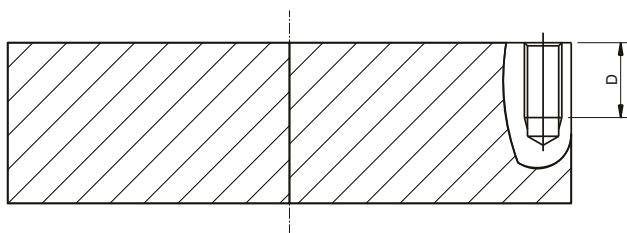
Suction line Filter with Double Element- 2½" :



Port Details -2" :-



SAE flange size in.	A		B		Thread (C)		D mm
	mm	in.	mm	in.	UNC	Metric	
2 1/2"	88.90	3.50	50.80	2.00	1/2"-13	M12	25







### Filtration :

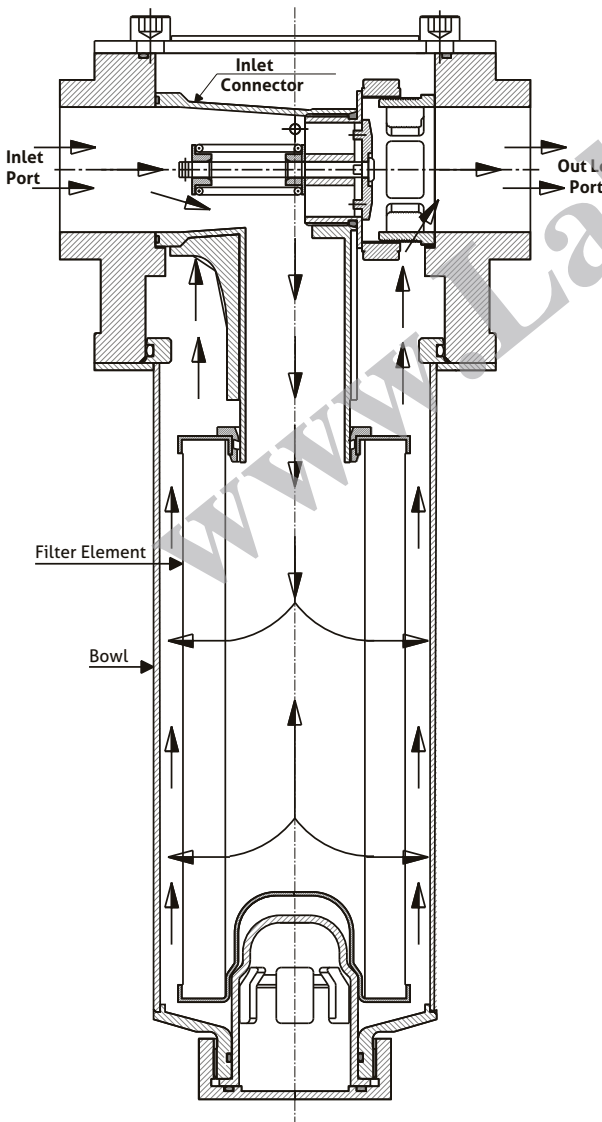
The Process by which the solid particles are separated from a fluid by passing through permeable material that will not allow the solid particles to pass through.

### Inline Filter Function :

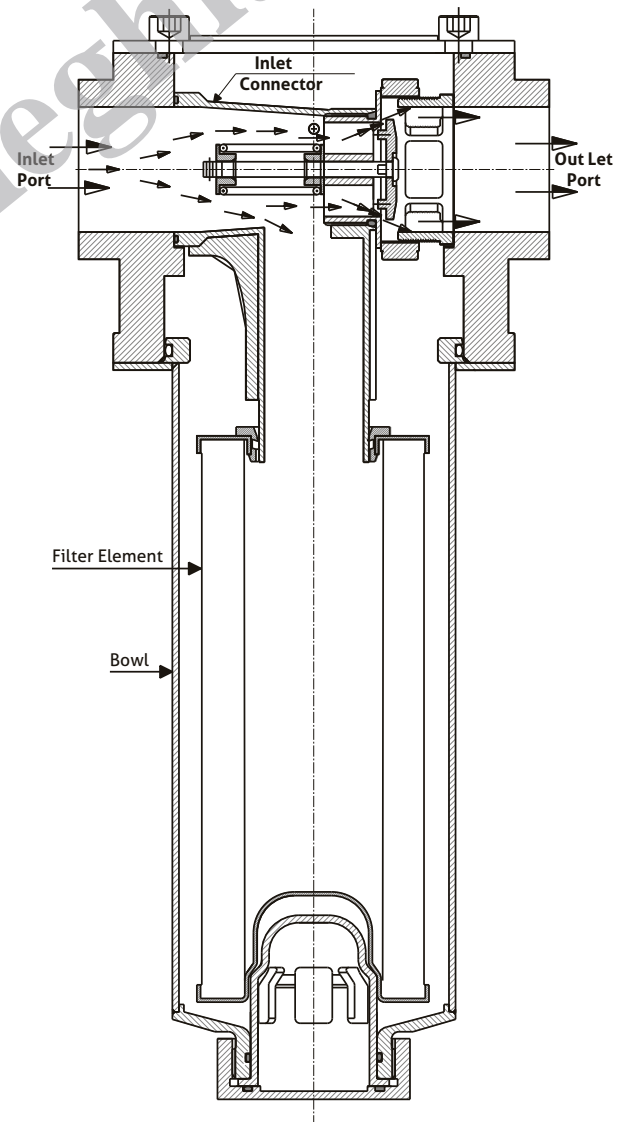
The contaminated oil enters the filter element through the inlet port and the inlet connector in the head. After the oil is filtered it is collected in the bowl and is delivered (flows) through the outlet port.

However when the filter element gets clogged the filter element fail to filter oil anymore. This raises the pressure inside the inlet connector once this pressure exceeds the set value. The oil pressure pushes bypass valve seat and the spring gets compressed gradually to open the bypass valve and allowing the oil to flow directly into the out let port and so on.

When Normal Filtration is in process the bypass is closed



When Filter reaches the bypass setting, the bypass is in open condition



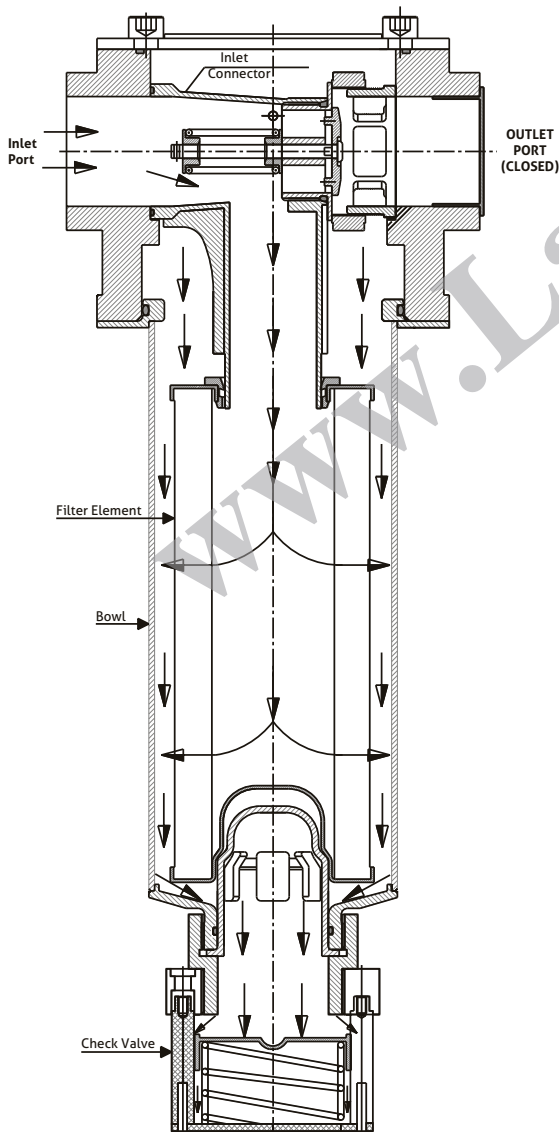


## Returnline Filter Function :

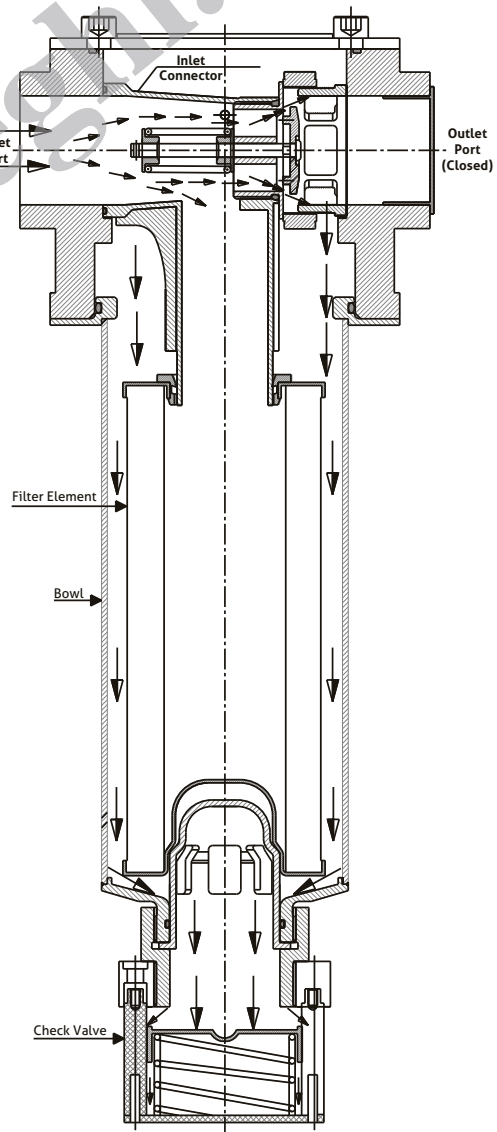
The Contaminated oil enters the filter element through the inlet port and the inlet connector in the head. After the oil is filtered it is collected in the bowl and is delivered (flows) into the tank through the check valve while the oil pressure pushes the spring in the spring retainer to get compressed to open the check valve into the tank.

However when the filter element gets clogged the filter element fail to filter oil anymore. This raises the pressure inside the inlet connector and once this pressure exceeds the set valve the bypass valve gets opened allowing the oil to flow directly into the bowl and so on.

**When Normal Filtration is in process  
the bypass is closed**



**When Filter reaches the bypass setting,  
the bypass is in open condition**

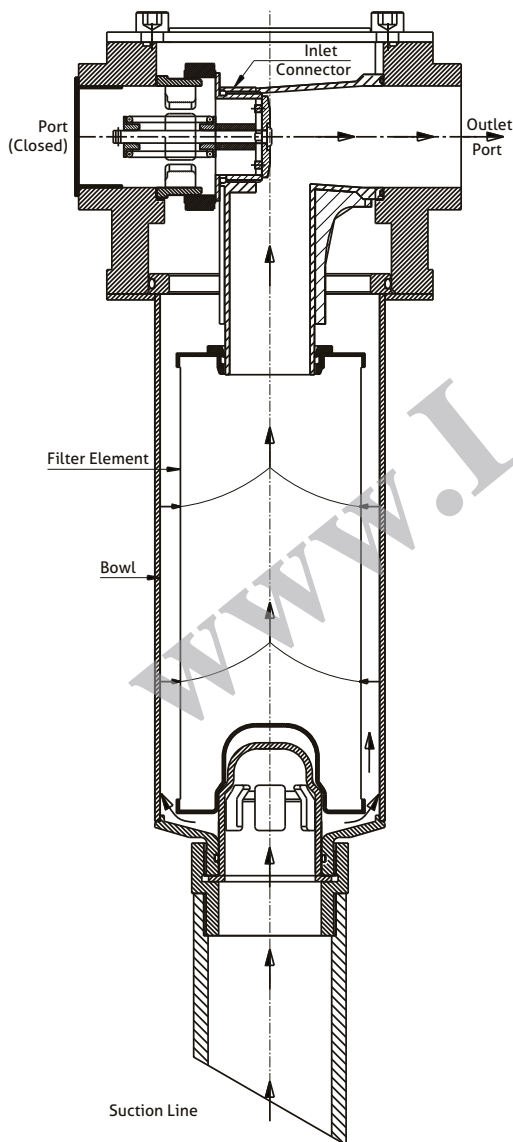




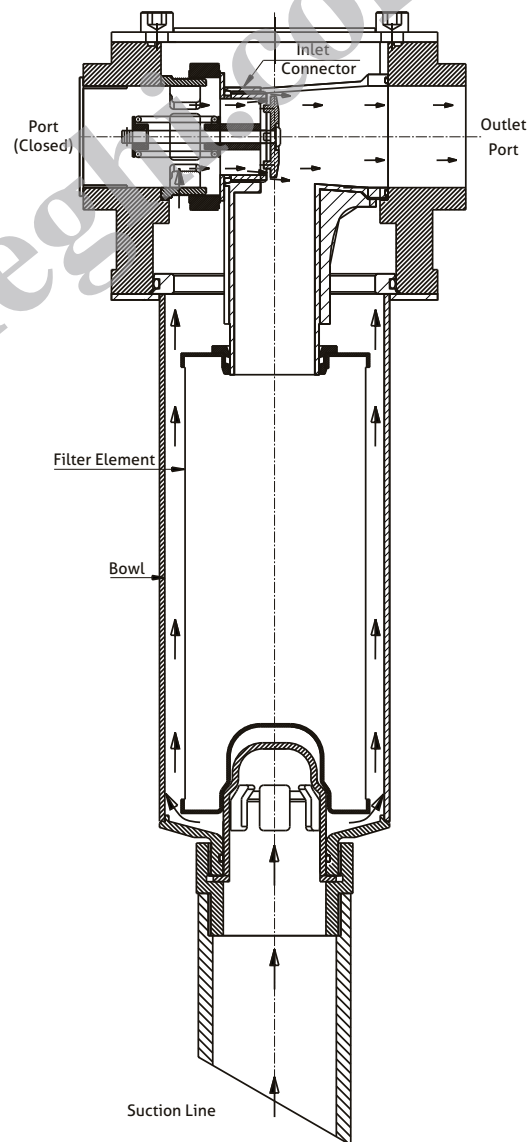
## Suction Filter Function :

The contaminated oil enters into the filter element through the suction line into bowl and the cleaned oil flows through the inlet connector to the out let port. However when the filter element gets clogged the element fails to filter oil anymore this raises the difference in Vacuum pressure at the pump inlet. Thus, when the oil pressure inside the bowl exceeds the set value, the oil pressure pushes the bypass valve seat and the spring gets compressed gradually to open the bypass valve and allowing the oil to flow directly into the outlet port and so on.

**When Normal Filtration is in process the bypass is closed**







**When Filter reaches the bypass setting, the bypass is in open condition**





## Clogging Gauge Function :

veljan clogging gauge informs the viewer instantly, clearly and at all times the condition of the filter element.

Colour	Indication
	Filter Empty - No Filter element
	All Clean - Filter element is clear
	Change - Element is getting contaminated
	Bypass - Stop and replace element immediately as bypass may open at any time letting down dirty oil.

A built in warning system, to visually pin point, the impending danger of clogging of element, the clogging indicating gauge is built into the filter head to minimize this danger.

## Clogging Indicator Function:

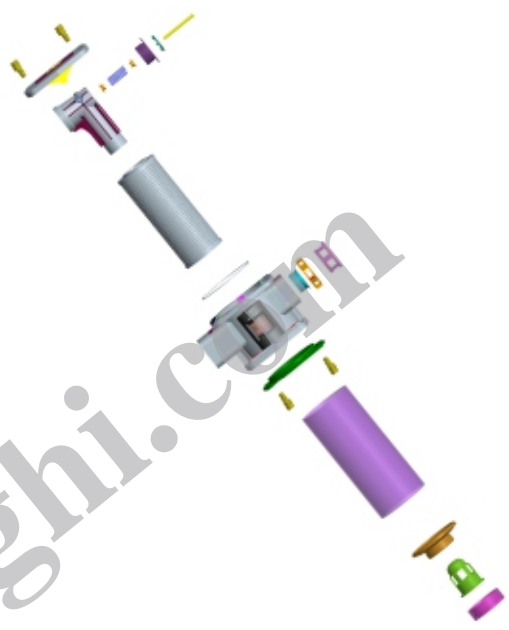
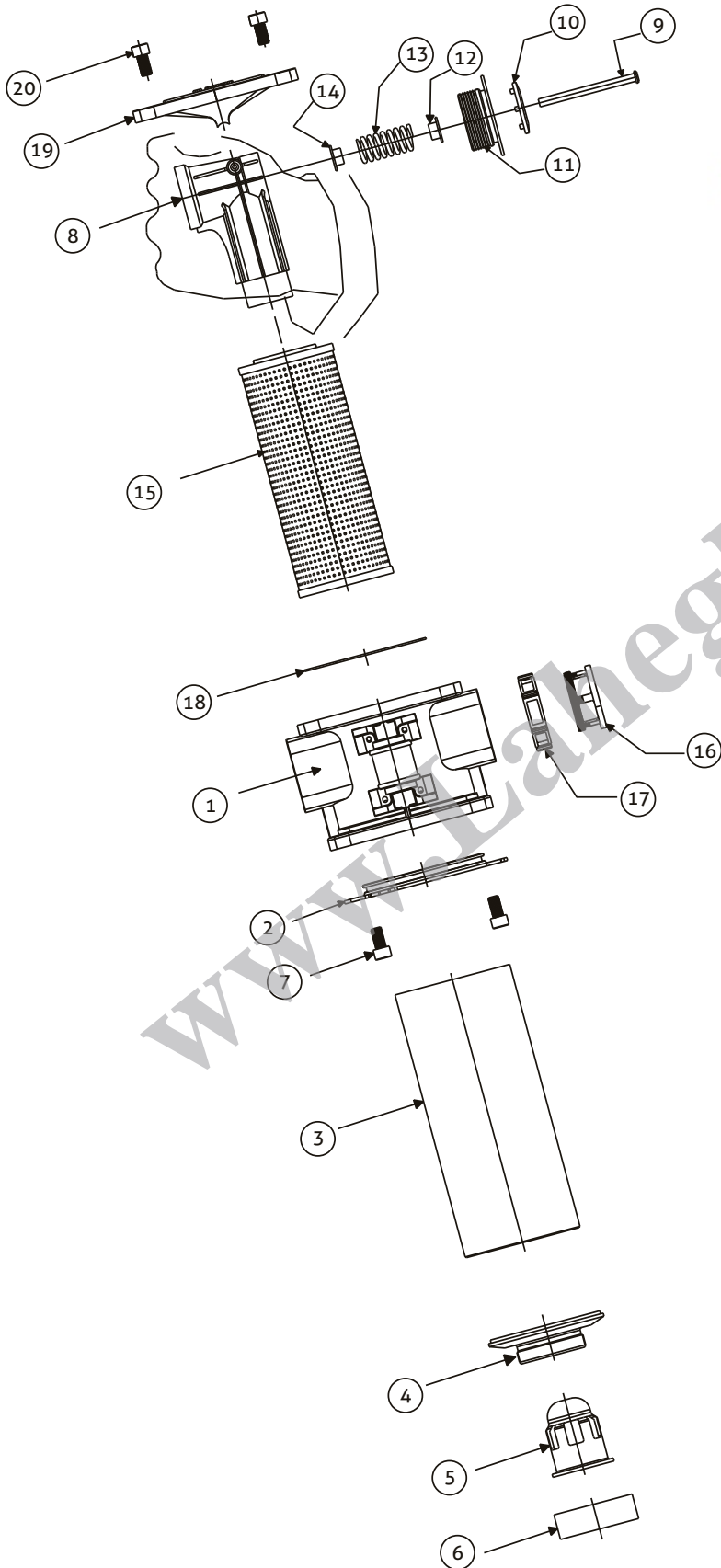
When the new element is installed in the filter the difference between inflow pressure and outflow pressure of the filter will be nominal, then normal filtration is in process but once the filter gets clogged the filter element gradually loses its filtration capacity that which rises the pressure inside the inlet connector. The difference between the inflow pressure and outlet flow pressure of the filter gradually increases then, indicator trigger its position and the oil from the inlet flow of the indicator pushes the piston along with the magnetic cover towards downward i.e it displaces on to the bypass position in the visual indicator.

Through the function of clogging indicator one can understand the status of the filter element so that it gives advance information of replacing the filter element.





# VHF Veljan Hydraulic Filters



Item	Part Description	Qty
01	Head	01
02	Bowl Flange	01
03	Bowl	01
04	Bush	01
05	Locating BLock	01
06	Threaded Plug	01
07	Hex.Soc.Hd.Cap Screw	04
08	Inlet Connector	01
09	Pin	01
10	Bypass valve seat	01
11	Threaded Bush	01
12	Bush	01
13	Compression Spring	01
14	Bush	01
15	Filter Element	01
16	Supporting Screw	01
17	Supporting Nut	01
18	Oring	01
19	Cover Plate	01
20	Hex.Soc.Hd.cap Screw	04



## Design

Filter head with inlet & outlet Ports and the Inlet - connector which holds the element in the bowl and the bypass valve is positively closed when normal filtration is in progress, or is positively open when the filter has reached its bypass setting. The poppet - type bypass valve acts quickly when the bypass setting is reached. A unique knife - edge face on the poppet practically eliminates hydrostatic friction, sticking, and hysteresis when the bypass actuates.

## Filter Elements:

The filter element is developed to allow the filter to operate at top design effectiveness. The pleats being deeper and are in number, they give the element more surface area for the filter housing size than other filter element of the same size.

More surface area indicates more dirt -holding capacity, and less need for service and frequent element replacement. As the replacement element is the heart of the filter. Veljan offers these elements in three types of media viz., Glass Fiber, Cellulose and stainless steels mesh.

### Glass Fiber:

Multi - layered glass fiber elements are used in aerospace technology to produce high efficiency silt-control filtration. To produce high filtration efficiency, multilayered glass fiber elements are produced in 3 and 10 micron rating and a beta efficiency of 75. The glass fiber elements are epoxy bonded and withstand a temperature range -15°C to 120°C

### Cellulose:

Resin - impregnated cellulose media has low cost and disposable convenience. Being a depth - type filter, it has high dirt - holding capacity for long life. Available in 3, 10 and 25 micron efficiency ratings. Cellulose elements are bonded with epoxy for excellent fluid compatibility

### Stainless Steel:

The four available mesh sizes 30, 60, 100 and 200. They are epoxy bonded and withstand a temperature of -15°C to 120°C



## Filter Selection Criteria :

- Filter size must be compatible with the circuit maximum flow
- Filtration capacity must be suitable for the circuit components.
- Uniform filtration despite reasonable temperature/ viscosity changes.
- Low pressure drop i.e differential pressure differential between inlet and outlet
- Design must promote easy servicing and installation
- Compatibility with the fluid.
- Filter element must sustain nominal pressures, over pressures or mechanical stress, they must also be long - lived and retain the particles blocked.

Environmental conditions are very important while selecting filter element as it plays an important role in fluid contamination. Protected places such as laboratories, industrial sites, lifts have fairly good conditions. whereas the maritime and mobile industries experience difficult conditions and foundries are subjected to very bad environmental conditions.

The quality of filter is strictly related to working hours. The solidity of the filter body and filter element depend on the working pressure and kind of the cycle

**Maximum tolerable contamination of oil hydraulic components (general data).  
Contamination classes under ISO 4406**

	$P_{max} = 70 \text{ bar}$	$P_{max} = 130 \text{ bar}$	$P_{max} = 200 \text{ bar}$
Gear pumps	20/18/15	19/17/15	-----
Vane pump - fixed displacement	20/18/15	19/17/14	18/16/13
Vane pump - variable displacement	18/16/14	17/15/13	-----
Piston pumps - fixed displacement	19/17/15	18/16/14	17/15/13
Piston pumps - variable displacement	18/16/14	17/15/13	16/14/12
Directional solenoid valves	-----	20/18/15	19/17/14
Pressure control valves	-----	19/17/14	19/17/14
Flow control valves	-----	19/17/14	19/17/14
Non - return valves	-----	20/18/15	20/18/15
Proportional directional solenoid valves	-----	17/15/12	15/13/11
Pressure Control Proportional valves	16/14/12	15/13/11	-----
Servo - valves	-----	16/14/11	15/13/10
Cartridge valves	-----	18/16/13	17/15/12
Hydraulic remote control valves	18/16/13	-----	-----
Cylinders	20/18/15	20/18/15	20/18/15
Vane motors	20/18/15	19/17/14	18/16/13
Axial piston motors	19/17/14	18/16/13	17/15/12
Radial piston motors	20/18/14	19/17/13	18/16/13
Orbital motors	21/19/17	20/18/15	19/17/14
Closed circuit (hydrostatic drive)	-----	17/15/13	16/14/12

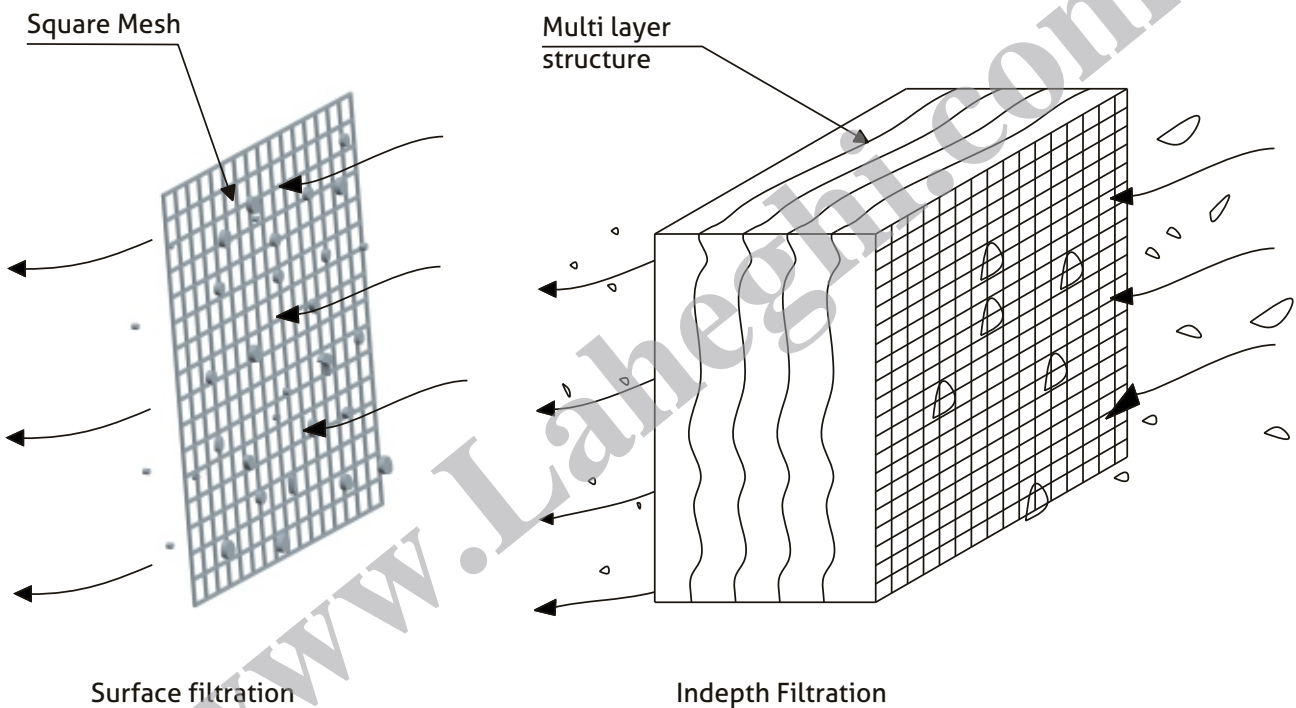




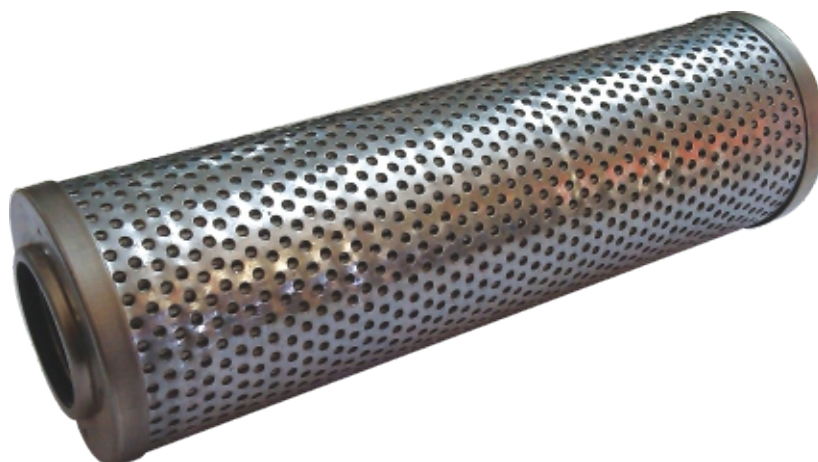
## Filter Element :

The retaining of particle can be performed through in-depth filtration or surface filtration. In surface filtration, impurities with large size than meshes pile up on the side, penetrated by the fluid, while in-depth filtration particles are blocked in the filter element. The surface filter elements are made of rolled metal square mesh ending with two shaped discs to perform filtrations up to  $25\mu\text{m}$

### Piling up of particles in filter elements



### Filter element

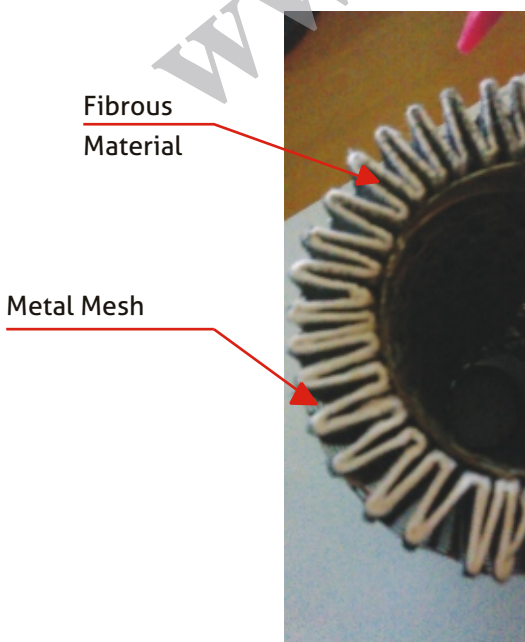
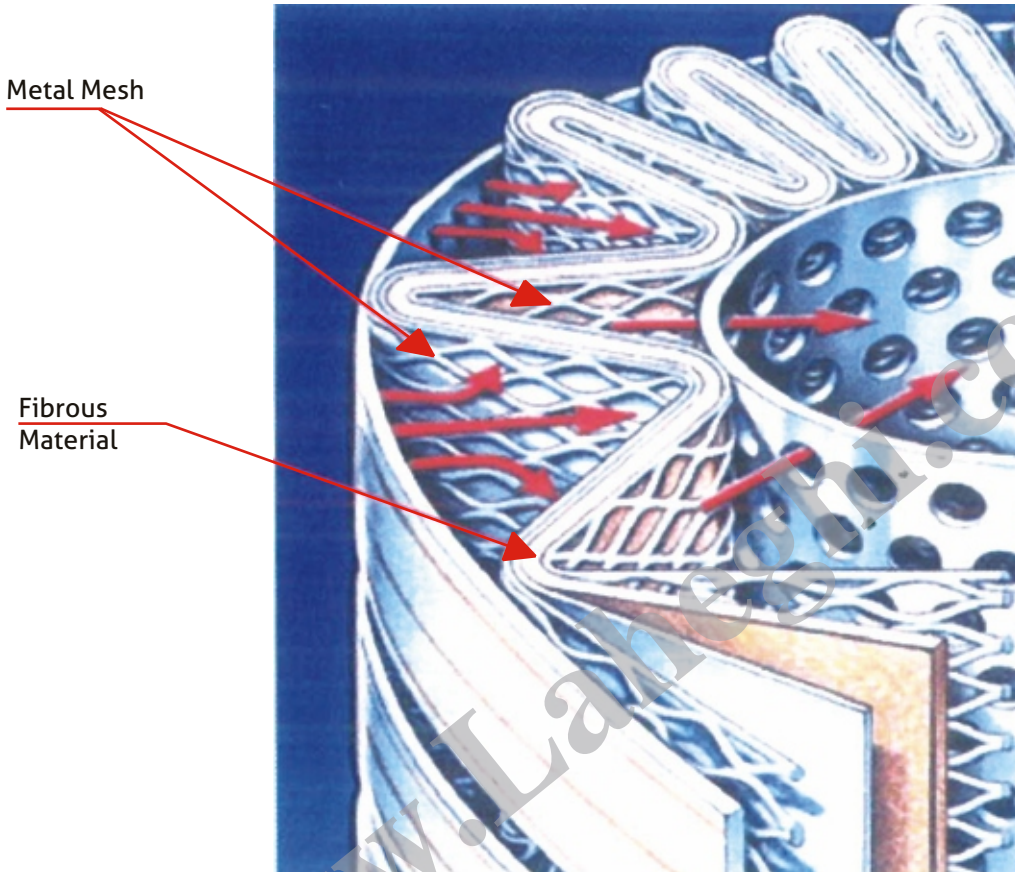






## Filter Media

Fibrous or surface filter elements cartridge for inlets or outlets are solidly arranged inside the bucket of the filter body.





## Filters used in the Hydraulic System :

- Suction line filter: A filter which is located between reservoir and pump
- Return line filter: A filter which is located on the return line, just before the line enters the reservoir

## Suction Filters :

These type of filters protect the pump from Coarse Fluid Contamination which cause sudden pump failure. Due to risk of cavitation of the pump, relatively coarse filter materials with a filtration rating of greater than 25µm are used. Therefore for this reason suction filters are not suitable for ensuring the component protection.

## Key Points :

- Pump must be protected against cavitation
- Risk of cavitation, particularly at low temperature.
- Fine filtration not possible

## Return line Filters :

Return line filter are located in the return line as an inline filter or as a tank-mounted filter *on* the tank or *in* the tank. This means that the operating fluid coming from the system flows back into the tank completely filtered. Therefore all contaminated particles are filtered from the fluid before reaching the tank. When selecting the correct filter size, and the maximum possible flow rate must be taken into account. To avoid possible foaming of the fluid in the tank, the fluid outlet from the filter is always below the fluid level in all operating conditions.

## Benefits :

- No System contamination reaches the tank
- All fluid flowing back to the tank.

## Key points :

- In case of high-value components a pressure filter must be used in addition
- In case of single filters, the system must be switched off to change the element.
- Large filters are required for high flow rates
- It is advisable to fit a bypass valve

## Advantage of Suction and Return line Filters :

According to filtration view, the pump intake is an ideal location for filtering media. The absence of both high fluid velocity, which disturbs trapped particles, and high pressure - drop across the element, which can cause migration of particles through the media, increase filter efficiency. These advantages are outweighed by the restriction the element creates in the intake line and the negative effect this has on the pump life.

The principal for locating filtering media in the return line is : If the reservoir and the fluid it contains starts out clean and all air entering the reservoir and returning fluid is adequately filtered, then fluid cleanliness will be maintained. The other advantage of the return line as the filter location with that sufficient pressure is available to force the fluid through fine media (typically 10 microns), but the pressure is not high enough to alter filter or housing design. This combined with relatively low flow velocity, means that a high degree of filtering efficiency can be achieved at an economical cost. For these reason return line filtration is a feature of most hydraulic systems. The main disadvantage of return line filtration is that, the back pressure created by the element can damage some components.



Almost all of our health problems are due to bad hygiene like wise most of the hydraulic problems are due to contamination of hydraulic fluid as such management of contamination occupies great important in hydraulic system maintenance and it is every bodies concern.

Hydraulic System

**Why is filtration necessary?**

- Impurities in the Hydraulic system affect the components of the hydraulic system and shorten their service life.
- Reduction in service life of the components occurs in two ways:
  - Wear and Tear
  - Breakdown of component

Filters are used to remove the smallest insoluble particles and keep the hydraulic system clean

CONTAMINATION  
MANAGEMENT

NO EXCEPTION  
THIS IS EVERY BODY'S CONCERN FOR EVERY MINUTE

Human Health





## Technical Data :

### Filter Efficiency Standards ISO Beta Ratio Information

1) BETA - Means counting particles less than 40 microns in size and using ISO fine test dust (ISO MTD) as test contaminate.

$$2) \text{ Ratio - Is : } \frac{\text{Particle Count * In Upstream Oil (One pass thru filter)}}{\text{Particle Count * In Downstream Oil (One pass thru filter)}}$$

\* The number of particles of a given size or greater per unit of volume

3) Examples:  $\frac{1000 \text{ particles } 10\mu \text{ or greater in upstream oil sample} = 2 \quad (\mu = \text{micron})}{500 \text{ particles } 10\mu \text{ or greater in downstream oil sample}}$

$$\frac{1000}{500} = 2 \text{ (filter removed 50\% of particles } 10\mu \text{ or greater in one pass)}$$

4) Terminology -  $B_{10} = 2$  (Beta ten ratio equals two)

5) Other ratio numbers and equivalent efficiency.

- Beta<sub>(x)</sub> = 1 represents 0.00% efficiency in one pass
- Beta<sub>(x)</sub> = 1.14 represents 12.28% efficiency in one pass
- Beta<sub>(x)</sub> = 1.5 represents 33.33% efficiency in one pass
- Beta<sub>(x)</sub> = 2 represents 50.00% efficiency in one pass - Nominal rating
- Beta<sub>(x)</sub> = 3 represents 66.67% efficiency in one pass
- Beta<sub>(x)</sub> = 4 represents 75.00% efficiency in one pass
- Beta<sub>(x)</sub> = 10 represents 90.00% efficiency in one pass
- Beta<sub>(x)</sub> = 16 represents 93.75% efficiency in one pass
- Beta<sub>(x)</sub> = 20 represents 95.00% efficiency in one pass
- Beta<sub>(x)</sub> = 50 represents 98.00% efficiency in one pass
- Beta<sub>(x)</sub> = 75 represents 98.67% efficiency in one pass - Absolute rating

Don't let beta ratings ratings mislead you

There is only one industry standard : ISO 16689

The ISO (International Standards Organisation) 16889 standard was developed to create a common testing format for filter manufacturers to rate filter media efficiencies. This standardization gives the end user the ability to reliably compare published filter rating between manufacturers. Part of that standard says the maximum reliable filtration ratio is Beta(X) = 75 (commonly know as the absolute rating). That's it. Anything above Beta(X) = 75 cannot be statistically verified. So, filters with rating higher Beta(X) = 75 indicates in terms of reliability and data consistency.

6) A "2 / 20 / 75 " rating for the filter media is the most common way of describing media on three particle sizes. A "2 / 20 / 75 " rating of 5 / 10 / 15 means 50% efficiency 5μ or greater,95% efficiency on 10μ or greater, and 98.67% efficiency on 15μ or greater particles in one pass.



### **Introduction :**

Contamination control in the hydraulic systems is very wide and complex matter. 70 TO 90% of the hydraulic systems failures are caused by contaminants in the fluid. Even when no immediate failures occurs high contamination levels can sharply decrease operating efficiency. The function of the fluid in the hydraulic system is transmitting forces and motion.

### **Contamination:**

Is defined as any foreign substance in the fluid system damages its performance.

### **Contamination Management :**

Optimization/Monitoring of cleanliness in material flows and the system assembly

### **Basic Contamination :**

The quantity of contamination present in subsequent to assembly

### **Ingress Contamination :**

Particulate contamination caused by ingress

### **Intial Damage:**

Damage to surfaces caused during function testing/commissioning/assembly of systems

### **Contamination Monitoring :**

Analysis of processes with regard to the ingress of dirt caused by them .

### **Fluid power system :**

Hydraulic systems, including automotive systems containing fluid fillings.

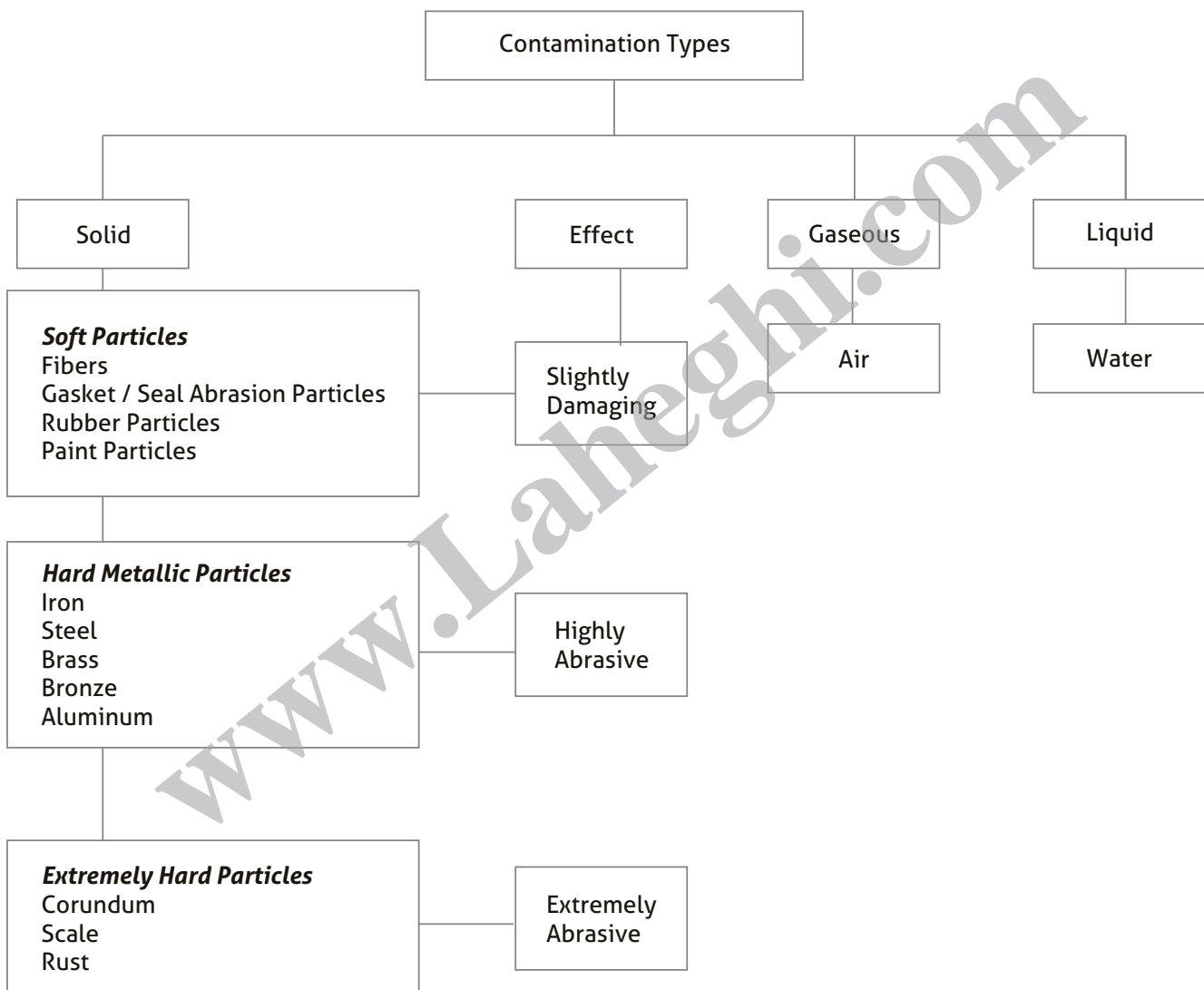
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**Online Measurement :** This is a process of measurement where in the sample to be analysed is directly fed to a measuring device from the hydraulic system .

**Offline Measurement:** In this process of measurement the test sample is collected from the hydraulic system and sent to a test laboratory, where it is measured and analyzed.

### Types of Contamination :



Contamination can exist in three states namely Gaseous, liquid and solid. Solid contamination (particulate). Particulate contamination enters the system in various shapes and sizes and is generally abrasive in nature and is recognized, as the main cause of mall functioning and premature failure and breakdowns of the hydraulic systems.

The Solid particles are subdivided into three groups : soft particles, hard and extremely hard. Extremely hard particles have to be removed as quickly as possible otherwise they can cause substantial damage in fluid power system.





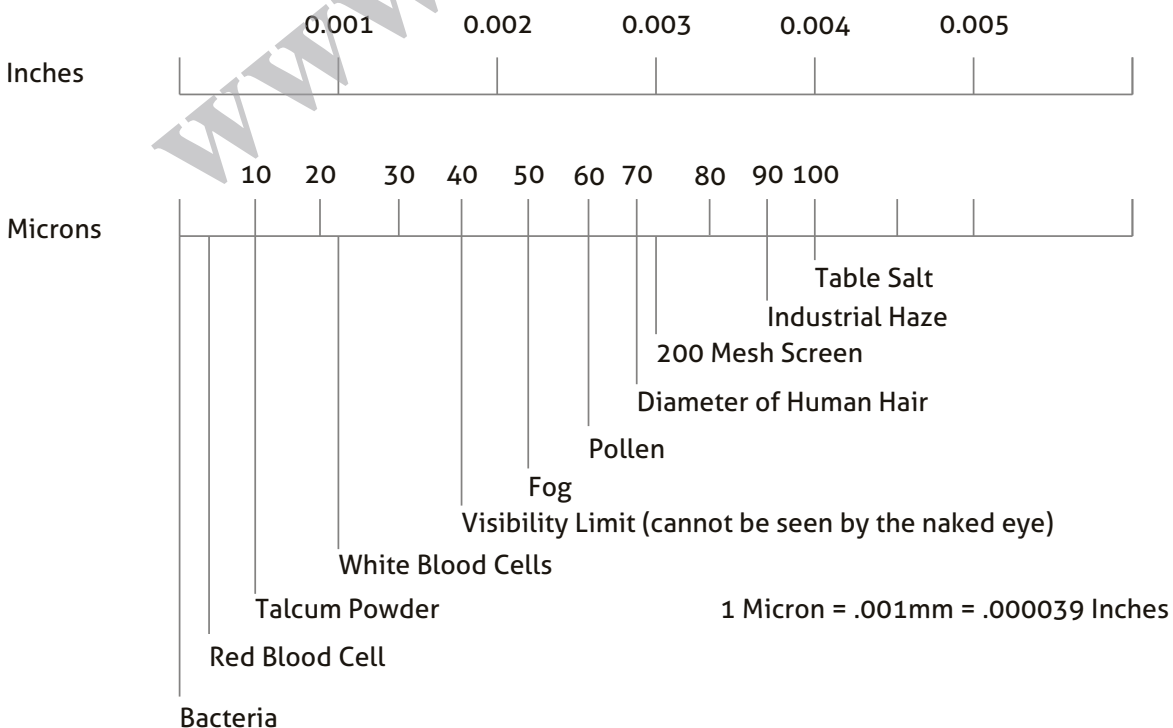
### Sizes of Solid Contaminants:

The size of solid particle contaminants is commonly measured in micrometers,  $\mu\text{m}$ , (usually referred to as microns,  $\mu$ ). A micron is a unit of length equal to one millionth of a meter or about .00004 inch. Particles that are less than  $40 \mu$  cannot be detected by the human eye.

### Sizes of Particles in Micro-meters:

- Grain of Table Salt 100
- Human Hair 70
- Lower Limit of Visibility 40
- White Blood Cells 25
- Red Blood Cells 8
- Average Bacteria 2
- 100 mesh screen = 149
- 325 mesh screen = 44
- 1 micro-meter = .000039 in or 39/1,000,000 of an inch

### Sizes of know Particles in Inches and Microns :





## Sources of contamination :

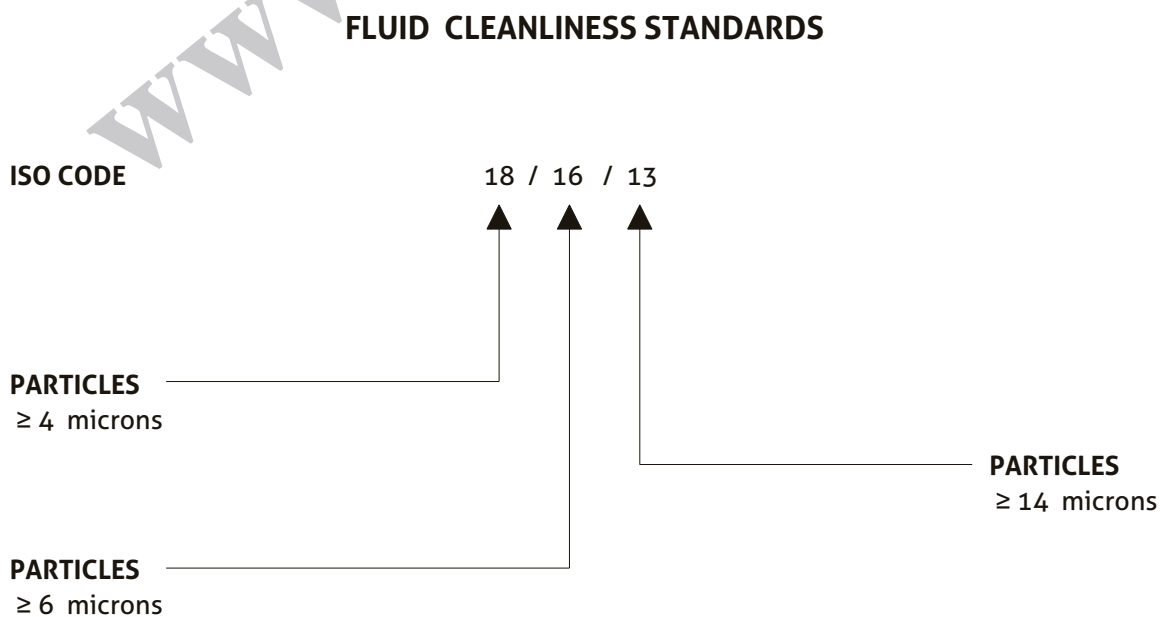
1. New Oil
2. From manufacturing and handling of components during shipping and fabrication
3. Ingressed contamination
4. Wearing of components

## New Oil :

Particles found in new fluids in the form of rust, dirt, sand, & water from either condensation or leakage into a container from sitting in the elements. New Oil gets contaminated even when it is stored properly, one can still find various particles.

As the New oil has a rating of approximately 33 micron or 17/16/14 on the ISO 4406 chart from a reputable supplier. And according to the hydraulic specialist study guide, suggests that new oil is in the range of 20/18/14. That means there are between 81 and 160 particles 14 microns in size per ml.

**conclusion :** Therefore the new hydraulic oil has to be *filtered* before entering in to the Hydraulic system.







## Classification Of Particulate Contamination in fluids :

Currently there are 4 procedures for classifying particulate contaminants in fluids : ISO 4405, ISO 4006:1999, NAS 1638, SAE as 4059.

Standard	ISO 4405	ISO 4406 : 1999	NAS 1638	SAE AS 4059
Application	Highly Contaminated media, e.g washing media, machining fluids.	Hydraulic Fluids lubrication oils	Hydraulic Fluids lubrication oils	Hydraulic Fluids lubrication oils
Parameters	(mg/litres of fluid)	Number of Particles > 4 $\mu\text{m}_{(C)}$ > 6 $\mu\text{m}_{(C)}$ > 14 $\mu\text{m}_{(C)}$	Number of Particles 5 - 15 $\mu\text{m}$ 5 - 25 $\mu\text{m}$ 25 - 50 $\mu\text{m}$ 50 - 100 $\mu\text{m}$ > 100 $\mu\text{m}$	Number of Particles > 4 $\mu\text{m}_{(C)}$ > 6 $\mu\text{m}_{(C)}$ > 14 $\mu\text{m}_{(C)}$ > 21 $\mu\text{m}_{(C)}$ > 38 $\mu\text{m}_{(C)}$ > 70 $\mu\text{m}_{(C)}$
Analysis Methods	In this lab method, 1 liter of the fluid undergoing analysis is filtered through a prepared membrane, which is then weighed	<p><b>1. Manual Evaluation :</b> The fluid undergoing analysis is filtered through a prepared membrane and the cleanliness class (contamination rating) estimated or counted by hand using a microscope.</p> <p><b>2. Automated particle counting :</b> The fluid undergoing analysis is conducted through a particle counter, which tallies the particle fractions.</p>		
Remarks	Very time - consuming method	<p><b>1. Manual Evaluation :</b> Very time - consuming, not very exact.</p> <p><b>2. Automated particle counting :</b> Result available almost immediately.</p>		



## SAE 4059 STANDARD:

The SAE cleanliness classes are based on particle size, number and distribution. The particle size determined depends on the measurement process and calibration; consequently the particle sizes are labeled with letters(A-F)

The SAE cleanliness classes can be represented as follows:

1. Absolute particle count larger than a defined

Example: **cleanliness class according to AS 4059:6**

The maximum permissible particle count in the individual size ranges is shown in the table in boldface.

Cleanliness class according to AS 4059:6

size B particles may not exceed the maximum number indicated for class 6.

6B=max.19,500particles of a size of 5µm or 6µm

2. Specifying a cleanliness class for each particle size

Example: **Cleanliness class according to AS 4059: 7B/6C/5D**

Size B (5µm or 6µm(c)): 38,900 particles /100ml

Size C (15µm or 14µm(c)): 3,460 particles /100ml

Size D (25µm or 21µm(c)): 306 particles /100ml

3. Specifying the highest cleanliness class measured

Example: **Cleanliness class according to AS 4059: 6 B-F**

The 6B-F specification requires a particle count in size ranges B-F. The respective particle concentration of cleanliness class 6 may not be exceeded in any of these ranges.

Maximum Particle Concentration * (particle /100ml)						
Size ISO 4402 Calibration or Visual Counting	>1µm	> 5µm	>15µm	>25µm	>50 µm	>100 µm
Size ISO 11171, Calibration or Electron Microscope**	>4 µm(c)	>6 µm(c)	>14 µm(c)	> 21µm(c)	> 38µm(c)	>70µm(c)
Size Coding	A	B	C	D	E	F
000	195	76	14	3	1	0
00	390	152	27	5	1	0
0	780	304	54	10	2	0
1	1,560	609	109	20	4	1
2	3,120	1,220	217	39	7	1
3	6,250	2,430	432	76	13	2
4	12,500	4,860	864	152	26	4
5	25,000	9,730	1,730	306	53	8
<b>6</b>	<b>50,000</b>	<b>19,500</b>	<b>3,460</b>	<b>612</b>	<b>106</b>	<b>16</b>
7	100,000	38,900	6,920	1,220	212	32
8	200,000	77,900	13,900	2,450	424	64
9	400,000	156,000	27,700	4,900	848	128
10	800,000	311,000	55,400	9,800	1,700	256
11	1,600,000	623,000	111,000	19,600	3,390	1,020
12	3,200,000	1,250,000	222,000	39,200	6,780	

Table shows the cleanliness classes in relation to the particle concentration determined.

\* particles sizes measured according to the longest dimension.

\*\* particle sizes determined according to the diameter of the projected area- equivalent circle.



## Procedure in Evaluating Fluid Samples

### According to ISO 4406:1999, NAS 1638 and SAE As 4059 :

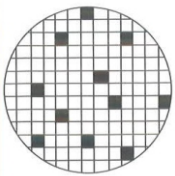
#### 1. Manual Procedure according to ISO 4407 (Hydraulic fluid power - Fluid contamination - Determination of particle contamination by the counting method using a microscope).

ISO 4407 contains a description of a microscopic counting method for membranes. 100 ml of the sample undergoing analysis is filtered through an analysis membrane featuring an average pore size of  $< 1 \mu\text{m}$  and square markings.

The standard also describes the cleaning procedure and maximum particle count of the negative control.

After the analysis membranes are dried, 10, 20 or 50 squares are counted depending on the size of the particles, followed by adding the values and extrapolating to the membrane diameter.

The manual count of the particles is done in the "old" levels of  $> 5 \mu\text{m}$  and  $> 15 \mu\text{m}$  since the longest dimension of a particle is counted in ISO 4407 yet the diameter of the area-equivalent circle is counted in the "new" ISO 4406:1999. As described above, the reference values obtained for this count correspond to the reference values of the "new" evaluation.



This counting method can only be used for very clean samples. Generally speaking, the cleanliness classes are estimated on the basis of reference photographs or the samples automatically counted.

#### 2. Automated particle counting :

Below follows a description of how common particle counters employing the light extinction principle function.

The figure below shows a simplified rendering of the measurement principle employed in the light extinction principle.

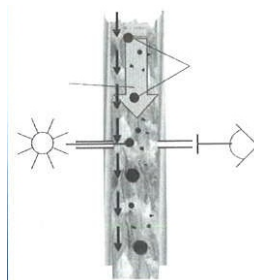
The light source transmits the light (monochromatic light for the most part) onto an optical sensor, which emits a specific electrical signal. A shadow is created on the photo diode if a particle (black) comes between the light source and the photodetector. This shadow causes the electric signal emitted by the sensor to change.

This change can be used to determine the size of the shadow cast by this particle and thus the particle size to be determined.

This procedure enables the cleanliness classes according to ISO 4406:1987, ISO 4406:1999, NAS 1638 and SAE AS 4059 to be accurately determined.

The "noise" involved in this measurement principle is extraneous liquids and gases which cause the light beam to be interrupted and thus be counted as particles.

The particle counter should be calibrated according to ISO 11943 (for ISO 4406:1999). E 7.604.1/05.09





## Allocation of Particle Counts to Cleanliness Classes :

No. of Particles/ml		Cleanliness Class
Over	Up to	
1,300,000	2,500,000	> 28
640,000	1,300,000	> 27
320,000	640,000	> 26
160,000	320,000	> 25
80,000	160,000	> 24
40,000	80,000	> 23
20,000	40,000	> 22
10,000	20,000	> 21
5,000	10,000	> 20
2,500	5,000	> 19
1,300	2,500	> 18
640	1,300	> 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

### We measure fluid contamination as described under:

Structure of ISO-Code: The number of dirt particles in a 1 ml of sample larger than these specified size: 4µm / 6µm / 14µm / 21µm

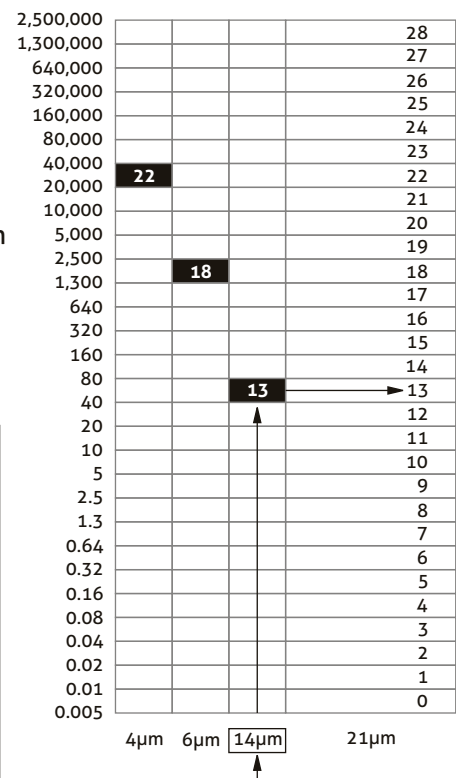
Example :

Large than 4µm = 22,340

Large than 6µm = 1,720

Large than 14µm = 42

ISO Code = 22 / 18 / 13 /





## Contamination Monitoring Of Hydraulic System Is As Important As Maintaining Hygiene For A Human Body

Contamination Control is important as



Hygiene for human body

Filtration = Contamination control

### Filtration is Necessary to :

- Reduce Wear and Failure of System Components
- Reduce Overall System Malfunction
- Control Particulate Contamination on a Continuous Basis

Contamination Control - Threats

- Bacteria and viruses
- Parasites, Allergens
- Rodents/Pests, Mold, toxins, Contaminants

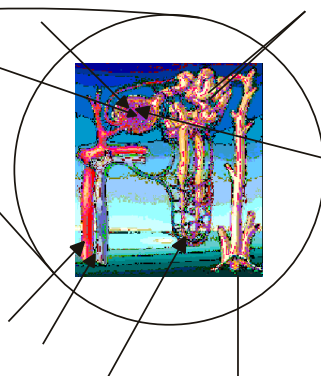
As the human Kidneys contain millions of *filters* called nephrons, which filter our entire body supply every 45 minutes. *Filtration* takes place because blood pressure forces water, salt, glucose, amino acids and urea into structures know as Bowman's capsules.

In the Same way the *Hydraulic Filter* also *filters* the Contaminated particles in microns from the oil and cleaned oil is delivered to the System.

Kidney



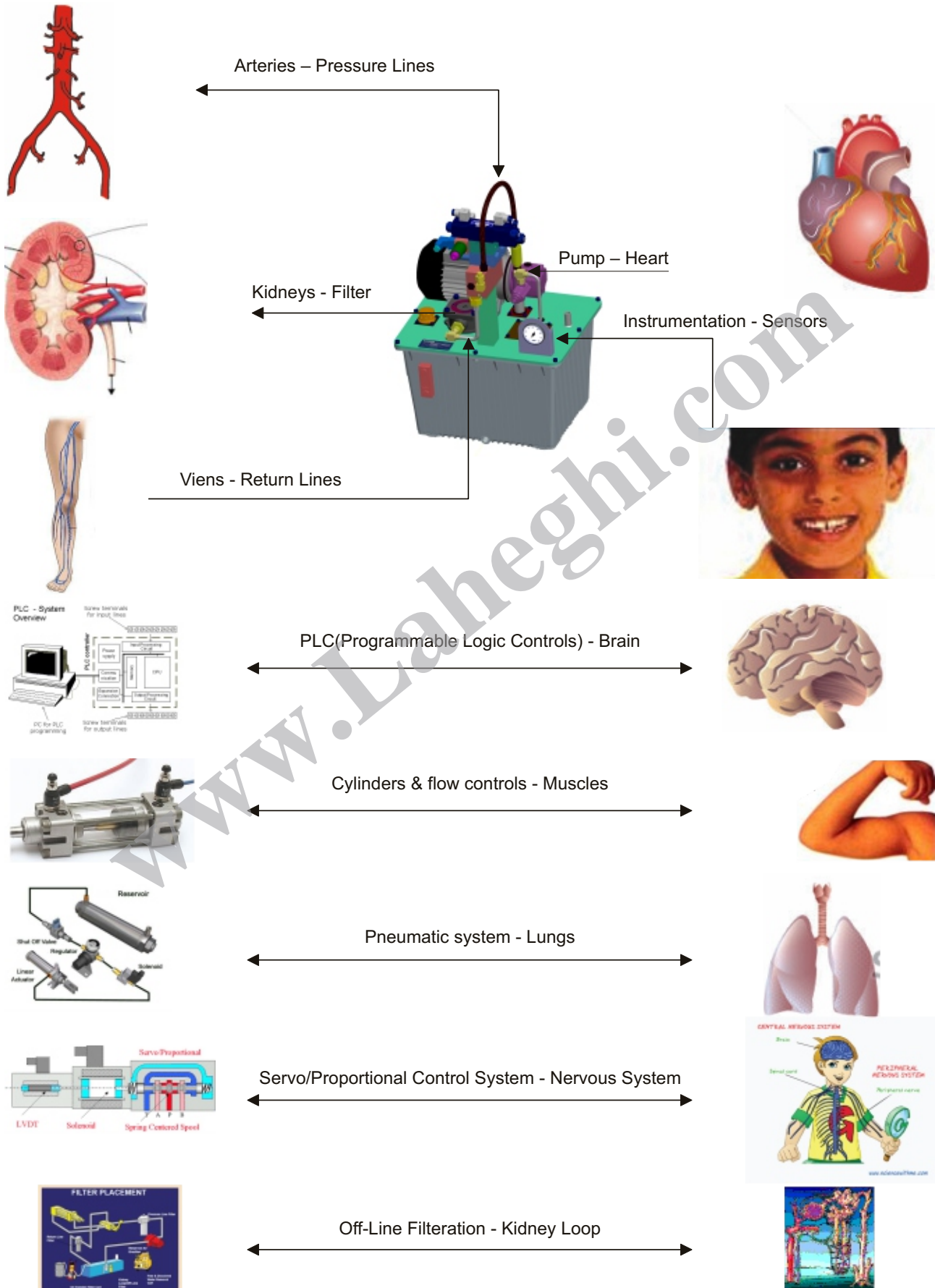
Nephron



Bowman's capsules



Hydraulic Filter



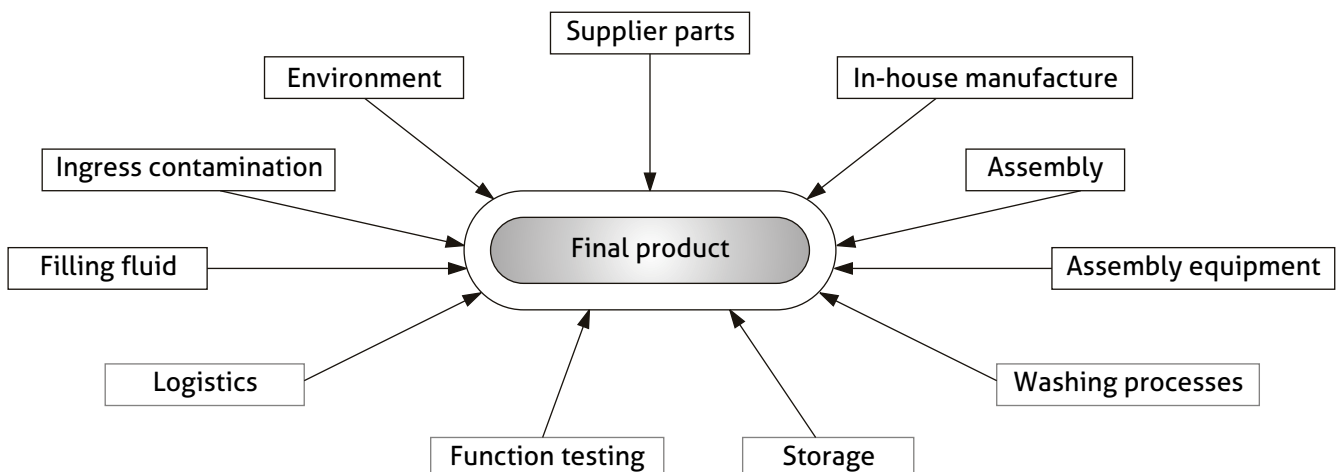


## 2. From manufacturing and handling of components during shipping and fabrication :

Manufacturing contamination come from :

- Components ports not plugged
- Components stored in bad environment
- Pumps/motors prefilled with dirty or unfiltered oil
- Use of floor dry or similar oil absorbents in shop areas
- Dirty hands, shop rags & lint used during assembly
- Dirty work benches
- Dirty oil in test bench use to performance check components
- Welding and fabrication contaminate
- Broken tools during manufacturing
- Fittings laying around and not cleaned
- Dirty hoses from assembly that were not cleaned and capped
- Assembly in a fabrication environment
- Dirty manufacturing procedures
- Dirty cutting fluid
- Improper flushing techniques
- Is a high enough velocity used to create flow turbulence when flushing parts?
- Dirty ports plugs
- Shop rags used to plug ports
- Not cleaning around ports before removing plugs for assembly
- Reservoirs not clean properly before assembly
- Filters on the shelf but not in sealed con

### Sources of Contamination in the Manufacturing of Hydraulic Systems:







## The Process That Causes For Fluid Contamination And System Damage :

### **Abrasion :**

Particles already found in the fluid penetrate the gap between two opposite mobile surfaces (opposite teeth of a gear pump or motor), thus abrading their surfaces. The ensuing particles are a source of contamination.

### **Erosion :**

Particles already found in the fluid are pushed against a solid part (metal) at a high speed, abrade its surface and produce more contaminants. As pressure rises, even the smallest particles foster the erosion process.

### **Adherence :**

The contact of two metal parts causes adherence because of molecular attraction ; for this reason some particles can stick together or to any surface.

### **Mechanical stress :**

Tearing can occur in highly stressed components; the ensuing particles contaminate the fluid.

### **Corrosion :**

Water and other chemical substances attack sensitive materials, Rust due to oxidation increases the number of abrasive particles.

### **Cavitation And Air Inclusion :**

The presence of gas can cause or promote cavitation phenomena

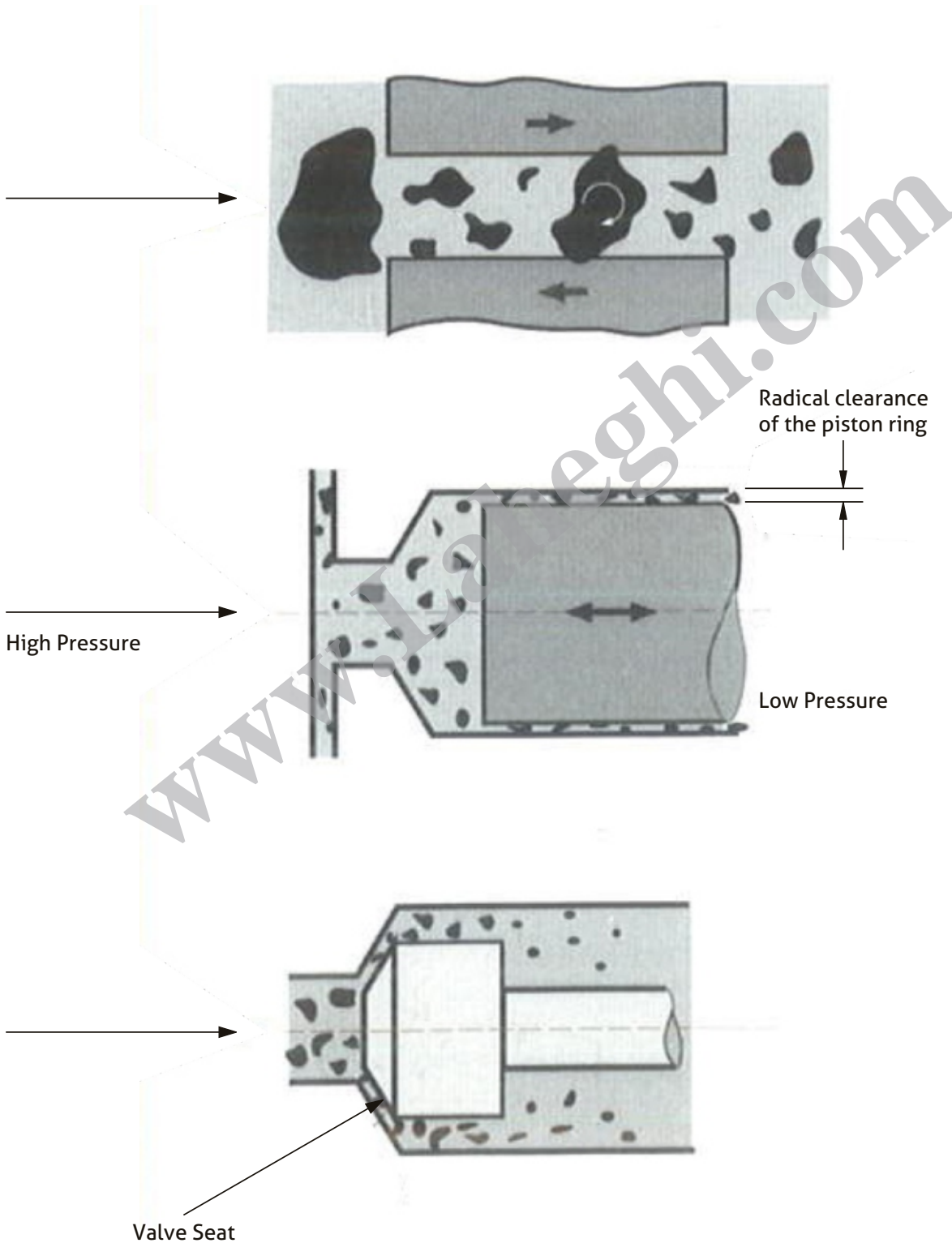
### **Microbial Reproduction :**

The presence of water promotes the large - scale reproduction of the few microorganisms found in the mineral fluid. Fluid properties are thus undermined and highly corrosive phenomena occur.





## Example of Wear to Movable Surfaces

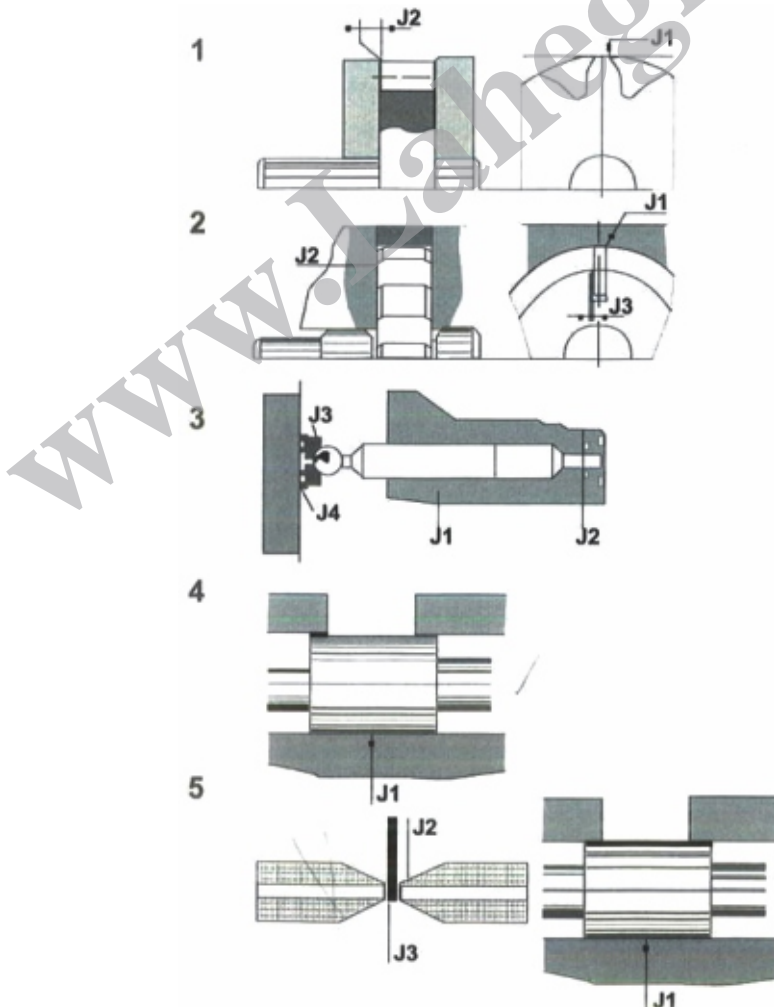




## Contamination Basics

The actual thickness of a lubricating film depends on fluid viscosity, applied load, and the relative speed of the two surfaces. In many components, mechanical loads are to such an extreme that they squeeze the lubricants into a very thin film, less than 1 micrometer thick. If the loads become high enough the film will be punctured by the surface roughness of the two moving parts. The results contributes to harmful friction.

Component	Typical Critical Clearance ( $\mu\text{m}$ )
1. Gear Pump (J1 J2)	0.5 - 5
2. Vane- Cell Pump (J1)	0.5 - 5
3. Piston Pump (J2)	0.5 - 1
4. Control Valve (J1)	5 - 25





## Ingressed Contamination

- Reservoir vent port
- Access covers not sealed
- Components ports left open
- Cylinder wiper seals damage by outside sources such as rust or nicks in rods
- Cavitation
- Wear of components cause by dirty oil or too low of viscosity of oil
- Wrong or poor additives
- Too course a filtration

## Wearing of Components :

Majority of the contaminates passing through the pump will also reach the motor where it will cause a similar performance degradation. If for example, due to wear, the volumetric efficiency of the pump falls to 85% of its original value and the volumetric efficiency of the motor falls to 90% of original, then the overall volumetric efficiency of the pump and motor will drop to  $0.85 \times 0.9 = 76.5\%$  of the original value.

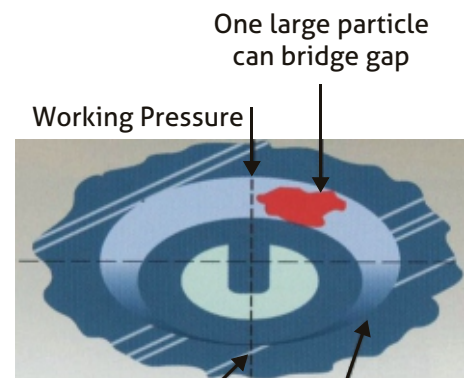
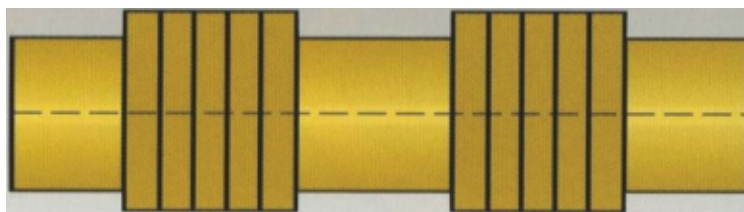
## Hydrostatic Transmission :

Hydrostatic transmissions most often consist of a servo controlled pump and a fixed volume motor. Wear to critical surface in any component will degrade the overall performance of the transmission. Failures of the component can spread debris throughout the system causing extensive and expensive secondary damage. High efficiency filtration is the key factor in achieving long, reliable service from a close loop hydrostatic transmission.

## Direction Control Valve :

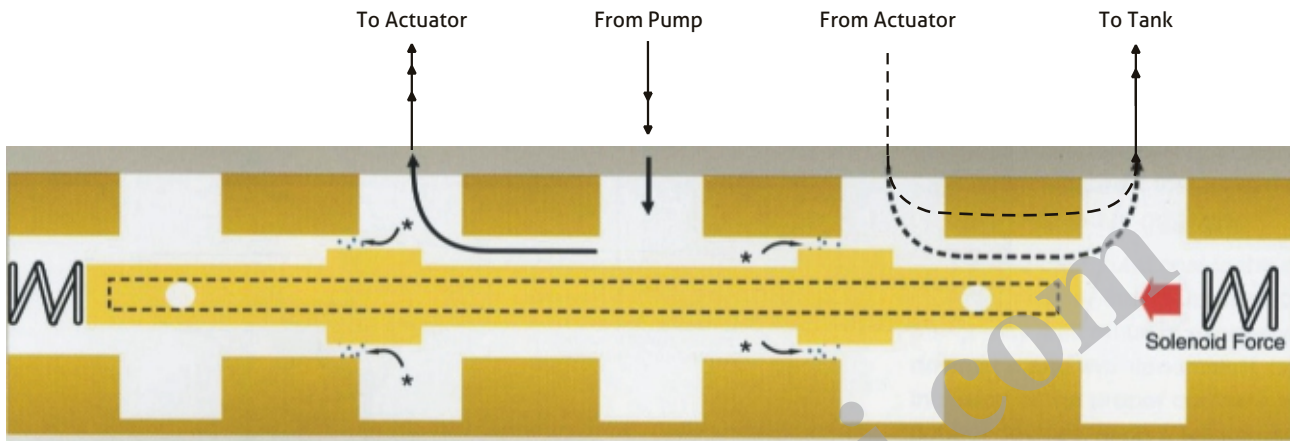
In an electrically operated valve, the forces acting on the solenoid are : flow forces, spring forces, friction forces and inertia forces. Flow, spring and inertia forces are inherent factors, but friction forces are to a great extent dependent on the cleanliness. If the system is heavily contaminated with particles similar in size to the radial and the diametrical clearances, higher forces will be needed to move the spool.

An even worse situation results from silting, where contaminant is forced into the clearances under pressures, eventually leading to breakdown of the oil film and spool binding.





## Valve spool clearances (with flows and forces) :



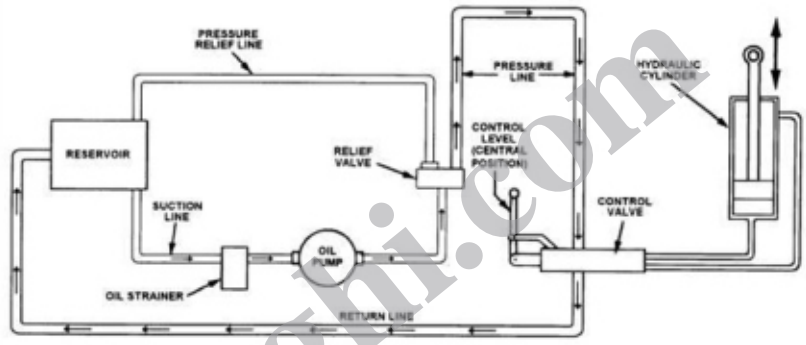
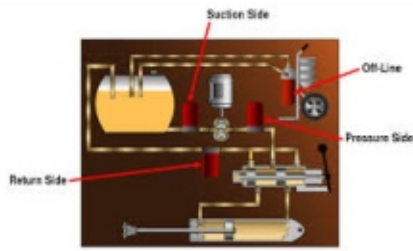
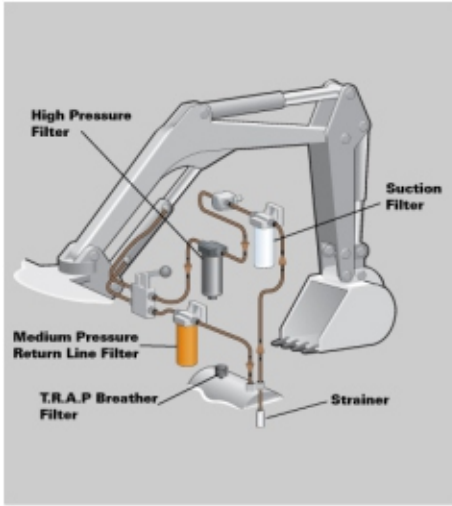
\* Silt Collects in tight clearance leak paths causing increased resistance to shifting.

This situation occurs when valves subjected to continuous pressure are operated infrequently. Such valves should preferably have local filtration of a high efficiency in the pressure line, but due account should be taken of possible pressure surges generated during component operation. The use of filter as the special protection for single units or groups of units can result in the need for large filter element of high capacity, if the general cleanliness level in the system is poor.

If the valve of this type remains in the spring offset or energized position for a lengthy period of time, silting takes place between spool and bore has been found through experiments to be approximately 30 pounds, but both spring and solenoid are designed to exert only 10 pounds. The effect of the excessive sitting can be total system failure.

The Above information is compiled from various standards, Text books, and presentation made by Companies in hydraulics and standards organisations like NFPA, DIN, ISO and SAE.





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**HYDRAULICS :**

**Pumps**

Vane : • Fixed Displacement (Single / Double / Triple & Drive Train) 6 to 540 cc / rev and up to 320 bar pressure

• Variable Displacement Vane (11 & 22 cc / rev)

Piston : • Variable Displacement Piston ( Swash plate design for Open loop) 9 to 140 cc/rev and up to 280 bar pressure

**Motors**

Vane : • 5 to 811 Nm Torque and Max. Pressure 4000 rpm

Roller Cam : • 71 to 3040 Nm Torque & 400 to 750 rpm

**Pressure Controls**

• Relief / Reducing / Unloader / Sequence Valves (up to 350 Bar pressure with threaded or flanged ports) 3/8" to 1 1/2"

**Check Valves**

• Direct and Pilot operated ( 3/8" to 2" )

**Throttle Valves**

• With & without free return flow check valve (3/8" to 1 1/2")

**Flow Control Valves**

• pressure and temperature compensated (3/8" to 3/4")

**Directional Control Valves**

• Manual / Pilot and Solenoid operated (1/4" to 3/4")

**Mobile Valves**

• 1 to 12 sections, 80 LPM flow and up to 350 bar pressure.

**Cartridge & Seat valves**

• Manifolds and Complete Power packs

**Cylinders**

• 40 to 1000 mm bore, up to 8500 mm stroke and 500 bar pressure Tie Rod, Mill Duty, Mobile Duty and Custom designs

**PNEUMATICS :**

**FRLs**

• 1/4" to 2"

**Cylinders**

• Compact, ISO, Heavy Duty Tie Rod and Custom designs (10 - 500 mm Bore) and up to 17 bar pressure

**Rotary actuators**

• 90° actuation

**2/3/4-way DC Valves**

• Spool (with & without seals), Poppet, Diaphragm & D-slide Designs. M5 and 1/8 to 1" size. Manual / Mechanical / Pilot & Solenoid Operators.

**Auxilliary Valves**

• Flow Control, Non-Return, Shuttle, Quick Exhaust Etc.

**Presses**

• C-frame and Column type

**SYSTEMS :**

• Ship Stabilizers & Steering Gear and complete Turnkey Hydraulic /Pneumatic / Hydro Mechanical systems

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