SEBU9208-00

CATERPILLAR®

# Operation and Maintenance Manual

## Caterpillar Filters Recommendations

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**Operation and Maintenance Manual**
**Caterpillar Filters Recommendations**
**Media Number -SEBU9208-00** **Publication Date -01/12/2013** **Date Updated -13/12/2013**

# Foreword

# Fluids/Filters Recommendation

### Literature Information

This manual should be stored in the literature holder or in the literature storage area on the machine. Immediately replace this manual if lost, damaged, or unreadable.

The information contained in this document is the most current information available for fluid maintenance and service products. Special maintenance and service products may be required for some machine compartments. Refer to the Operation and Maintenance Manual for your machine for the maintenance and service requirements. Read, study, and keep this manual with the product. This manual should be read carefully before using this product for the first time and before performing maintenance.

Whenever a question arises regarding your product, or this publication, consult your dealer for the latest available information.

### Safety

Refer to the Operation and Maintenance Manual for your machine for all safety information. Read and understand the basic safety precautions listed in the Safety Section. In addition to safety precautions, this section identifies the text and locations of warning signs used on the machine.

Read and understand the applicable precautions listed in the Maintenance and Operation Sections before operating or performing lubrication, maintenance, and repair on this machine.

### Maintenance

Refer to the Operation and Maintenance Manual for your machine to determine all maintenance requirements.

Proper maintenance and repair are essential to keep the equipment and systems operating correctly. As the owner, you are responsible for the performance of the required maintenance listed in the Owner Manual, Operation and Maintenance Manual, and Service Manual.

### Maintenance Interval Schedule

Use the Maintenance Interval Schedule in the Operation and Maintenance Manual for your machine to determine servicing intervals. Use the service hour meter to determine servicing intervals. Calendar intervals shown (daily, weekly, monthly, etc.) can be used instead of service hour meter intervals if calendar intervals provide more convenient servicing schedules and approximate the indicated service hour meter reading. Recommended service should always be performed at the interval that occurs first.

Under extremely severe, dusty, or wet operating conditions, more frequent lubrication and/or filter changes than is specified in the maintenance intervals chart might be necessary.

Following the recommended maintenance intervals reduces the risk of excessive wear and potential failures of components.

**Aftermarket Products and Warranty**

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**NOTICE**

**When auxiliary devices, accessories or consumables (filters, oil, additives, catalysts, fuel, etc.) made by other manufacturers are used on Cat products, the Caterpillar warranty is not affected simply because of such use. Failures that result from the installation or usage of other manufacturers auxiliary devices, accessories or consumables, however, are not Caterpillar factory defects and therefore are NOT covered by Caterpillar's warranty.**

**Caterpillar is not in a position to evaluate the many auxiliary devices, accessories or consumables promoted by other manufacturers and their effect on Cat products. Installation or use of such items is at the discretion of the customer who assumes ALL risks for the effects that result from this usage.**

**Furthermore, Caterpillar does not authorize the use of its trade name, trademark, or logo in a manner which implies our endorsement of these aftermarket products.**

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# General Filter Information

**SMCS -** 1054; 108K; 1261; 1263; 1308; 5068; 7342

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**NOTICE**

**Every attempt is made to provide accurate, up-to-date information. By the use of this document, you agree that Caterpillar Inc. is not responsible for errors or omissions.**

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The information that is provided is the latest recommendations for Cat machines and diesel engines. This information supersedes all previous published recommendations related to filters.

Specific filters, for example High Efficiency or Ultra High Efficiency, may be required for certain applications and use of these special products will be continue to be necessary. Refer to the applicable Operation and Maintenance Manual.

This publication is a supplement to the Operation and Maintenance Manual. This publication does not replace the engine-specific Operation and Maintenance Manual.

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**NOTICE**

**In order to avoid potential damage to your Cat machine and/or Cat engine, only purchase Cat filters and Cat fluids through your Cat dealer or Cat authorized outlets. For a list of authorized Cat parts outlets in your area, consult your Cat dealer.**

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**If you purchase what appear to be Cat filters and/or Cat fluids through other outlets or sources, you are at a very high risk of purchasing counterfeit products.**

Counterfeit or "look-alike" products may visually appear the same as the original Cat product, but the product performance and internal quality will typically be very low.

Counterfeit or "look-alike" products have a very high likelihood of causing and/or allowing engine and/or machine compartment damage.

Many of the guidelines, recommendations, and requirements that are provided in this Special Publication are interrelated. Before using the provided information, the user of this Special Publication is responsible for reading and understanding the information provided.

The user of this Special Publication is responsible for following all safety guidelines found in this Special Publication and in the engine and/or machine-specific Operation and Maintenance Manual when performing all recommended and/or required engine, engine systems, and/or machine maintenance.

For questions concerning the information presented in this Special Publication and/or in your product Operation and Maintenance Manual, and/or for additional guidelines and recommendations (including maintenance interval recommendations/requirements) consult your Cat dealer.

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**NOTICE**

**Commercial products that make generic claims of meeting "Cat" requirements without listing the specific Cat recommendations and requirements that are met may not provide acceptable performance. Commercial products may cause reduced engine and/or machine fluid compartment life. Refer to this Special Publication and refer to product specific Operation and Maintenance Manual for Cat filter recommendations and requirements.**

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**NOTICE**

**Heavy loads and cycles, working in dusty environment, filling machine compartments with contaminated fluids, and poor system cleanliness are some of the contributors to shorter filter life. Filter maintenance intervals may be shorter under these conditions.**

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Refer to the appropriate Operation and Maintenance Manual for guidance.

Early filter plugging or even filter collapse may occur when operating in dusty environment, operating in heavily contaminated environments, operating at heavy loads and cycles, using fluids that are not clean and/or poorly maintaining systems cleanliness. If the plugged filters are not changed, component or engine damage may occur. The plugged filters cause restriction of the fluid flow and shutdown in some cases. Plugged filters cannot protect the engine or machine compartment from contamination. This contamination can cause a number of issues including an increase in component wear and damage, filter collapse, short component life, component down time, increased cost, and other damage. If the filters are not changed at the first signs of bypass, or if the pressure indicator or other indicators are ignored, the potential for damage increases. Follow the filter service recommendations provided in this Special Publication and/or given in your engine Operation and Maintenance Manual.

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**NOTICE**

**Use of filters that do not meet at least the minimum performance recommendations and/or requirements may lead to lower component performance and/or component failure. Problems/failures that are caused by using improper filters or filters that do not meet the minimum recommended and/or required performance level for the**

**components are not warrantable by Caterpillar, and are the filter manufacturer and customer responsibility.**

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When filters made by other manufacturers are used on Cat products, the Caterpillar warranty is not affected simply because of such use. Failures that result from the installation or usage of other manufacturer filters, however, are not Caterpillar factory defects and therefore are NOT covered by the Caterpillar warranty. Caterpillar is not in a position to evaluate the many filters promoted by other manufacturers and the filter performance in Cat products. Installation or use of such items is at the discretion of the customer who assumes ALL risks for the effects that result from this usage.

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**NOTICE**

**Not following the recommendations found in this Special Publication can lead to reduced performance and compartment failure.**

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**NOTICE**

**When installing a new fluid filter, never add the used fluid into the new filter to help the engine or the machine compartment start. The dirty fluid is added at the clean side of the filter and will contaminate the engine or machine compartment with dirty fluid. Follow all the instructions for filter installation that are printed on the filter can or as described in your Operation and Maintenance Manual.**

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The overall performance of engine and machine compartments is dependent on the choice of lubricants and on maintenance and cleanliness practices such as choice of filtration products, contamination control, tank management, and general handling practices. Filtration products and lubricants that are produced by Caterpillar offer optimal performance and system protection.

This Special Publicationcovers the filtration products used on Cat products and offers general information on filtration products. This information is offered to assist customers in the selection and understanding of filtration products that are used on Cat machines and engines.

**Cat Fluid Filters**

- Engine oil filters
- Hydraulic oil filters
- Powertrain oil filters
- Fuel filters
- Fuel water separators
- Breathers

- Priming pumps
- Diesel exhaust fluid filters
- Off board filters
- Bulk fuel filters
- Coolant filters

**Cat Air Filters**

- Engine air filters
- Cab air filters

**Cat Natural Gas Engine Filters**

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# Cat Filters

**SMCS -** 1054; 108K; 1261; 1263; 1308; 5068; 7342

Cat filters are designed and built by Caterpillar to offer optimum performance in Cat equipment and engines. Cat filters are manufactured worldwide to the same precise Caterpillar specifications. As a result, Cat filters are of common quality and design and offer the same performance worldwide.

Cat filters are extensively tested and validated to ensure the optimal performance in Cat machines and engines. Cat filters are optimized for Cat equipment.

Caterpillar designs and builds filters to service all the filtration needs of Cat complete machine and engine product lines. Cat filters have been designed and constructed of high-quality materials in order to keep machine compartment and engines at the desired level of cleanliness. These filters allow the machine compartments and engines to function per the quality designed into these components. Cat filters are used as factory fit and for product service.

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i05539289

# General Information (Fluid Filters)

**SMCS -** 108K; 1261; 1263; 1308; 5068

Fluid filters, also called liquid filters, are responsible for continuously cleaning the fluids (also referred to as lubricants) in an engine or machine compartments by removing, or filtering out, particulate contamination from these fluids. When the recommended filters are used and the recommended maintenance intervals are followed, the particulate contamination in the fluid is reduced resulting in the following:

- Reduced component wear
- Protection of moving components and low interference with clearances
- Lower engine or machine downtime
- Enhanced performance
- Preservation of the reliability and life built into the engines or machine components

This section in this Special Publicationprovides a description of the construction and components of fluid filters and the measurement of the performance of filters.

Fluid filters available in the marketplace vary significantly in quality and performance. Knowing the quality of filters from visual observation is not possible. Cat filters are of high quality and hence offer improved value and protection for the machine. The initial cost of a high-quality filter is expected to be higher than a poor quality filter due to the amount of media, quality of media and overall construction of the filter. The overall value of the filter includes initial cost of the filter, value of equipment protection, reduction of downtime of equipment, and extension of equipment life. As a result, the lifecycle value of high-quality filters outweighs the initial difference in cost.

Cat offers two distinct types of fluid filters:

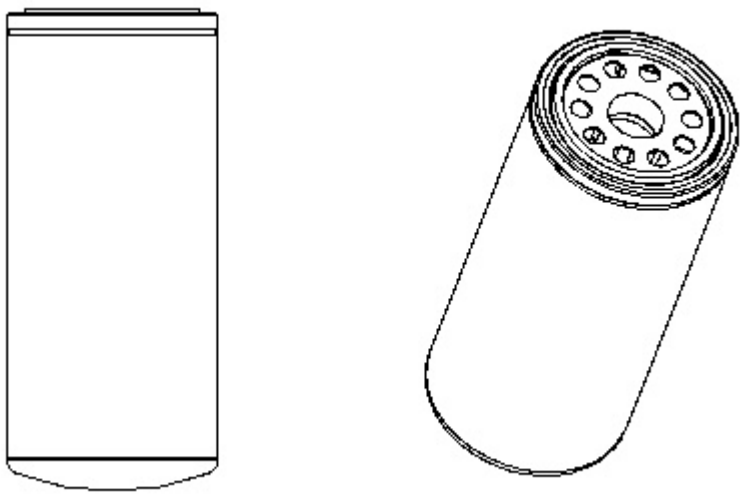

Illustration 1 g03525737

Spin-on Filter

**Spin-on Filters** - A single filter part that is used once by spinning onto the filter base. The entire filter is disposed of at the end of the filter life. Spin-on filters are common and simple to maintain. In general, small Cat engines use spin-on fuel and lube filters. Some new small engines have moved to cartridge filter designs.

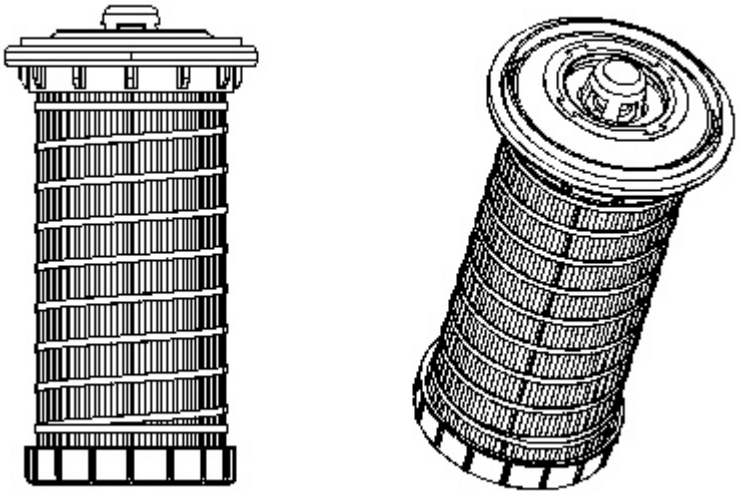

Illustration 2 g03525763

Cartridge Filter

**Cartridge Filters** - Cartridge filters are composed of separate filter elements and housing unit. The housing is retained and used for the life of the vehicle and the filter element cartridge is changed at the end of each filter service life. Cartridge filters eliminate waste since only the filter element is disposed of and the metallic housing is retained and reused during filter maintenance. In general, large Cat engines use cartridge filters for fuel and lube applications.

Details are provided in this Special Publication, "Fluid Filters Components".

Caterpillar offers a variety of fluid filters for applications in all Cat machines and engines. This Special Publication provides guidelines for using the filters. This Special Publication also details the design and quality built into the various Cat filters.

Cat fluid filters are designed with optimized capacity and rating for Cat equipment. Cat offers fluids filters of three efficiency levels:

1. Standard Efficiency
2. Advanced High Efficiency
3. Ultra High Efficiency

Detailed information on the capacity and rating of the various fluid filters offered by Cat is given in this Special Publication, "Filter Capacity".

**Note:** Substituting a higher-efficiency filter than recommended is typically safe. Substituting a lower efficiency filter than recommended is not acceptable.

Caterpillar has introduced a "Plus" (+) designation for some filters. The "Plus" designation indicates an improved performance characteristic. Any of the three efficiency filter levels can also be designated as "Plus" if the filter has an improved characteristic. For example, a "Plus" Advanced Efficiency filter may have an improved characteristic such as better capacity or better flow restriction.

In order to choose the appropriate filter size, efficiency and capacity, refer to your machine or engine Operation and Maintenance Manual and consult your local Cat dealer.

Consult your Cat dealer for availability of Cat filters.

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# Fluid Filter Components

**SMCS -** 1261; 1308; 5068

Fluid filters are constructed of many components. The quality of each component is important to the overall quality of the finished filter.

The main components of fluid filters are:

# Filter Housing

Fluid filter housings, also called cans, are typically of metallic construction. Cat filter housings are high quality metallic one piece design. The filter housings are of optimal material thickness in order to withstand the pressure of fluid flow. Cat filter housings provide structural strength and anti rupture protection. Cat filter housings are constructed with precision threading to prevent leaks and to prevent unthreading due to vehicle vibrations and operation. The housings precisely fit onto the filter base to prevent leaks and ingress of contamination. Instructions on the assembly of the filter are printed on the filter housing. The housing may or may not be reused depending on the filter design

- The housing of a spin-on type filter contains the filter element as an integral part. This unit of housing and element are changed at every maintenance interval. Spin-on filter housings may display the filter part number and identification as well as critical assembly information in order to ensure proper maintenance practices.
- The housing of a cartridge type filter is separate from the filter element. At maintenance intervals, only the filter element is changed and the housing is reassembled on the machine with the new filter element.

Details of these two types of filters are discussed later in this Special Publication.

# Filter Media

The media is responsible for capturing contaminants in the fluid. Filter media can be made of natural material such as cellulose, synthetic material such as glass fibers, or of a combination of natural and synthetic material. Media material can also be filled or impregnated with custom materials such as glass or resins to enhance strength and durability. Cat filter media is high-quality media and can be multiple layers with varying efficiencies for each layer, or one layer that is thick for increased depth filtration.

Cat filter media is of high quality. The media of Cat filters is of optimized thickness and area to withstand the fluid pressures and flows designed into Cat engines and compartments. The media material quality and construction allows the filter to resist flow spikes, cold start pressures, and extreme temperatures of the fluid. Cat filter media does not shed materials that add undesirable contamination into the fluid. The total area of the filter media is designed to capture the appropriate level of contamination for the designed

life of the filter with specified system cleanliness. A note of importance is that the pores in the filter media are not uniform in size or in shape. As a result filters can be designed so that particles of various shapes and sizes can be captured or allowed to pass through the filter if desired.

Filter media is typically pleated to add surface area for effective filtration and service life. Pleating quality and density of the filter media is essential to the durability, structural integrity, and ability to remove contamination. The pleats should be equally spaced and densely constructed. The pleats in Cat filters are stabilized to eliminate bunching, to preserve the pleats spacing and to hold contaminants even under engine or machine vibrations.

In many Cat filters the media is stabilized with spiral roving that is wrapped and secured to the media with non-shedding long lasting adhesive. Acrylic beads are also applied to the media of many Cat filters. Roving and acrylic beads maintain pleat stability and spacing to eliminate bunching, prevent potential tearing of the media, and to hold contaminants even under engine or vehicle vibrations.

Quality media and roving allow for optimal filter efficiency and capacity, longer filter life, and better protection of engine or machine compartments.

## Filter Inner Support

The construction of the filter inner support, also called a center tube, including thickness and strength, is essential to the stability of the filter media and the overall quality of the filter. Center tubes can be metallic or non-metallic. Most Cat filters use a non-metallic inner support that provides strength without contributing contamination such as metallic burrs or corrosion products typically associated with metal center tubes. The strength of Cat center tubes prevent collapsing during pressure spikes and cold oil starts.

## End Caps

End caps are the enclosures that connect the media and center tubes and eliminate the gaps. Cat end caps are high quality and are typically one piece that is constructed of metallic, non-metallic or a combination material. Tight bonding of the end caps with the media keeps out contamination, eliminates leak paths, and contributes to the overall quality of the filter. The end caps used in Cat filters are precisely designed to fit the filter bases used on Cat engines and machines.

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# Particle Removal in Fluid Filters

**SMCS -** 1261; 1308; 5068

Fluid filter media can be of multiple layers of microscopic fibers. The media has to be continuous in order to prevent particles and contaminants from passing through. At the same time, the media has "holes" that allow the fluid to pass through. The size and shape of the holes in the media vary significantly. Additionally, the flow rate of the fluids passing through the filter media vary significantly depending on the loads and speeds of the machine or engine, and on the temperature at the start of the machine and engine. As the flow rate through the media changes, the holes in the media change shape, and the path through the media changes and may be compressed to become shorter.

Media quality, thickness, and fluid flow rate determine the size and number of particles trapped in the filter and number of particles that may be released into the fluid. The ratio of number of particles captured in the filter media to number of particles that pass through the media determines the efficiency of the filter.

Table 1

$$\text{Filter Efficiency \%} = \frac{\text{Number of Particles Captured}}{\text{Number of Particles Entering}} \times 100$$

**Note:** Early plugging of a filter does not indicate a "bad quality" filter. Early plugging can indicate higher than usual debris in the fluid. Early plugging indicates that the filter is performing as designed and capturing contaminants. Early plugging may occur in early hours of operation. If early plugging occurs inspect the system for potential causes.

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**NOTICE**

**When installing a new fluid filter, never add the used fluid into the new filter to help the engine or the machine compartment start. The dirty fluid is added at the clean side of the filter and will contaminate the engine or machine compartment with dirty fluid. Follow all the instructions for filter installation that are printed on the filter can or as described in your Operation and Maintenance Manual.**

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# Filter Performance

**SMCS** - 1261; 1308; 5068

Filter performance is indicated by the filter rating and the filter capacity. Cat high-quality filters are designed with the capacity and ratings that are suitable for the engine or compartment designs.

# Filter Rating

Filter rating is a measure of filter efficiency of removing and retaining particles of a certain size. Two factors must be specified when describing filter rating:

**Particle Size** - Particle size is measured in microns (µm). This measurement is also called micron rating.

**Efficiency** - Efficiency is the number of particles of specific size or larger (also called rated size) that are captured in the filter, versus the number of the rated particles that passed through the filter. This measurement is also expressed as beta ratio.

Filters must be identified by the micron rating and the beta ratio. For example, if a filter is rated at 5 microns, the number of particles that can be trapped by the filter is not indicated. When a filter is rated at 5 microns and a beta of 200, this rating implies that of 200 particles entering the filter only one particle of 5 microns or larger size passes through.

**Note:** Designating filters by micron rating only without designating the beta ratio is not acceptable. The combination of micron and beta ratio provide a better description of the filter performance.

Table 1

| **Example of Filter Beta Ratio** | | | | | |
|---|---|---|---|---|---|
| **Filter Rating** | **Particle Size** | **Particles Entering Filter** | **Particles Passing Through Filter** | **Beta Ratio** | **Representation** |
| 5 µm | ≥ 5 µm | 200 | 1 | 200/1 = 200 | $B_5 = 200$ |
| 5 µm | ≥ 5 µm | 200 | 4 | 200/4 = 50 | $B_5 = 50$ |
| 10 µm | ≥ 10 µm | 200 | 1 | 200/1 = 200 | $B_{10} = 200$ |
| 10 µm | ≥ 10µm | 200 | 4 | 200/4 = 50 | $B_{10} = 50$ |

# Absolute Rating

In addition to micron rating and beta ratio, Caterpillar rates filters with an "absolute" efficiency rating. The term absolute signifies a beta ratio of 75.

**Note:** All Cat fluid filters are rated at "absolute" (Beta 75) or higher efficiency. This rating implies that out of 75 particles in the fluid, the filter stops 74 particles of the specified size or larger.

The actual efficiency of a filter to trap particles is dependent on the particles passing through the filter. Efficiency of a Beta 75 filter is only slightly lower than the efficiency of a Beta 200 filter as demonstrated in Table 2 below.

Table 2

| Beta Ratio | Particles Entering Filter | Particles Passing Through Filter | Filter Efficiency |
|---|---|---|---|
| Beta 75 | 75 | 1 | 98.67% |
| Beta 200 | 200 | 1 | 99.5% |

The equation to convert the Beta ratio of a filter to efficiency number is:

% Efficiency = 1 - (1 / beta ratio)

# Filter Capacity

Filter capacity is a measure of the mass of contaminants that can be trapped by the filter media. Filter capacity is dependent on the media type and the amount of the media. Cat filters are high-quality filters and hence offer an optimized filter media area to trap contaminants expected to be generated in a specific compartment. Filter capacity is expressed in a plot of "Delta Pressure" across the filter versus the mass of contaminants in the fluid.

When filters reach capacity, the filters start to plug. Some filtration systems are designed with a warning signal to indicate to the operator that the filter is plugged. The warning signal operates by measuring the pressure difference across the filter. If the designated pressure is exceeded, the signal is triggered. Filtration systems that are not equipped with a warning signal are designed to be changed at specific service intervals. Refer to this Special Publication, "Filter Bypass". Refer to the Operation and Maintenance Manual of your machine or engine for the filter service interval.

Cat fluid filters are designed with optimized capacity and rating for Cat equipment. Cat offers fluids filters of three efficiency levels:

1. Standard Efficiency
2. Advanced High Efficiency
3. Ultra High Efficiency

Table 3 provides the typical micron rating categories for fluid filters offered by Caterpillar.

Table 3

| Cat Fluid Filter Options | | | |
|---|---|---|---|
| **Filtration Type** | **Standard Efficiency** | **Advanced Efficiency** | **Ultra High Efficiency** |
| Engine Oil Filters | 27 - 40 µm (absolute) | 10 - 27 µm (absolute) | 6 - 12 µm (absolute) |
| Hydraulic Filters | 27 - 40 µm (absolute) | 10 - 27 µm (absolute) | 5 - 10 µm (absolute) |
| Powertrain Filters | 27 - 40 µm (absolute) | 10 - 27 µm (absolute) | 5 - 10 µm (absolute) |
| Fuel Filters | > 10 µm (absolute) | 5 - 10 µm (absolute) | < 4 µm |
| Fuel/Water Separators | > 20 µm (absolute) | 10 - 20 µm (absolute) | 5 - 10 µm (absolute) |

**Note:** Substituting a higher-efficiency filter than recommended is typically safe. Substituting a lower efficiency filter than recommended is not acceptable.

In order to choose the appropriate filter size, efficiency and capacity, refer to your machine or engine Operation and Maintenance Manual and consult your local Cat dealer.

## Filter Bypass

When a fluid filter is full of contaminants to the designed capacity, the filter is called plugged and dirty lubricant will bypass the filter. The dirty lubricant will flow through the system without cleaning, if the system is equipped with a bypass valve. If equipped, an alarm is triggered when the filter plugs. Bypass is designed into filter bases so that engines and machine compartments are not starved of lubricants. Lubricant starvation can cause catastrophic failures of engines or machine components. The damage done by limited flow of dirty fluids can outweigh the catastrophic failure of lubricant starvation.

Fuel filters are not designed with bypass capability due to the detrimental impact of dirty fuel and due to the low tolerance for contamination in fuel systems.

## Filter Testing and Validation

The quality built into Cat filters is tested using standard industry tests and additional tests devised by Caterpillar.

The following are tests conducted by Caterpillar to validate Cat filters:

- Filter efficiency and capacity are validated by a multipass test per "ISO 16889" standard. In this test a specific amount of standard-size dirt is passed through filters at specific a flow rate. Particle counters are used to measure particles into and out of the filter to determine the filter efficiency and the amount of debris the filter is subjected to before reaching pressure limits determines the capacity of the filter.
- The filter flow capability and resistance to pressure pulses is determined by the Flow Fatigue test.

This test determines the maximum flow that a filter can support by exposing the filter to fluid flow pressures that surpass those pressures expected in the actual application. Passing the flow fatigue test ensures media integrity and resistance to pressure flow, pressure spikes, cold temperature fluids, and cold starts.

- Vibration resistance is tested using specially designed vibration test to simulate the worst conditions the filters can be exposed to during operation. This test ensures that the filters withstand the vibration expected on engines and machines. The knowledge Caterpillar has of the vibrations expected on machines allows the design of robust filters that can surpass the expected vibrations.
- Filter burst pressures are determined by the Burst Test. This test ensures that the filter can withstand pressures the filter will see in application and not rupture or leak fluid.
- The ability of the filter to withstand pressure delta across the media is determined by the Collapse Test. This test ensures that the filter will not rupture internally and allow debris that has been caught to pass through the filter due to a tear in media or inner tube collapse.

In order to choose the appropriate filter size, efficiency and capacity, refer to your machine or engine Operation and Maintenance Manual and consult your local Cat dealer.

Features of most of the Cat fluid filters include:

Table 4

| **Technology Features** | **Benefits** | **Results** |
|---|---|---|
| One-piece aluminum base plate | Added reinforcing to prevent ruptures due to cold starts | Protects against leaks and the introduction of contaminants for longer component life |
| One-piece urethane end caps | Tighter bond with filter media | Eliminates gaps, keeping contaminants out of components for added protection, eliminates leak paths |
| Spiral roving and acrylic beads | Maintains pleat stability and spacing to eliminate bunching and holds dirt under vibration conditions | Maximum efficiency and capacity, better protection, and longer component life |
| Non-metallic center tube to prevent collapsing during pressure spikes and cold oil start-ups | Stronger and cleaner than metal designs | Eliminates scored bearings and damage to other critical components |
| Resin-impregnated filter media | Custom blended media | Maximizes performance and life |
| One-piece, heavy gauge canister | Provides structural strength and anti-rupture protection | Durability and structural integrity |
| Full range of media options | Engineered to meet specific operating conditions, equipment requirements, and economical | Filtration matched system and performance needs |

| | | |
|---|---|---|
| | considerations | |

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# Engine Oil Filters

**SMCS -** 1308

Engine oils acquire a significant amount of wear metals from moving parts of the engine and soot from the combustion process. Most Cat engine oil filters are designed of robust construction, high-quality filter media, roving to ensure filter media stability, and capacity that allows the filter to operate for the designed service life. Refer to your Operation and Maintenance Manual for the service life of the engine oil filter.

Cat engine oil filters are available in Standard, Advanced, and Ultra High efficiency filtration. In order to choose the appropriate filter for your machine, refer to your Operation and Maintenance Manual and consult your Cat dealer for the availability of filters.

Particle count of engine oils to determine cleanliness is not recommended. Additives in engine oils and soot (after use) interfere with particle counting. Filtering of the oil is recommended that is filled into the engine through Advanced or Ultra High Efficiency filter to ensure cleanliness of the oil.

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# Hydraulic Oil Filters

**SMCS** - 5068

Hydraulic oils acquire wear metals and contaminants from hydraulic cylinders, motor seals, and hydraulic hoses. Dirt can also enter the hydraulic system through vent filters in vented systems and through seals of the hydraulic cylinders. Cleanliness of hydraulic oils is critical for the operation of hydraulic system, in particular the operation of hydraulic valves that are typically of very tight tolerances. Cleanliness of the hydraulic oils is especially important to modern hydraulic systems. These systems are built with close tolerances and precise designs that require low level of contamination and appropriate filter performance. Follow the recommendations in the Operation and Maintenance Manual of your machine.

Cat hydraulic filters are available in Standard, Advanced, and Ultra High efficiency. Fire resistant hydraulic filters of Ultra High Efficiency are also available.

Particle count of hydraulic oils to determine cleanliness is recommended. Filtering of the oil that is filled into the hydraulic system is recommended to achieve a cleanliness level of the oil of "ISO 16/13". Refer to this Special Publication, "Contamination Control" for details on the contamination requirements and ISO code information.

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# Powertrain Oil Filters

**SMCS** - 5068

Powertrain oils acquire wear metals and contaminants from friction materials, loaded gears and bearings, and passage around oil seals. Some dirt and moisture can also enter from the atmosphere through breathers if equipped.

Transmission filters are available in Standard, Advanced, and Ultra High Efficiency. Many lower powertrains, such as final drives, differentials and axles may not use filtration. Some do have filtration.

Off Board filtration is recommended for large systems. Refer to this Special Publication, "Oil Filtration Carts".

Particle count of powertrain oils to determine cleanliness is recommended. Filtering of the oil that is filled into the powertrain compartments is recommended to achieve a cleanliness level of the oil of "ISO 16/13". Refer to this Special Publication, "Contamination Control" for details on the contamination requirements and ISO code information.

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**Media Number -SEBU9208-00** **Publication Date -01/12/2013** **Date Updated -13/12/2013**

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# Fuel Filters

**SMCS -** 1261

Contaminants in the fuel, such as dirt and water, cause most of the fuel system issues. Fuel contamination decreases the life of injectors, causes increased parts replacement, increases machine or engine down time and lowers productivity. Contamination is acquired in the fuel during transport and storage and due to poor management of fuel during receipt and during all the stages until filling into the machine. The machine must be filled with clean fuel. Cat recommends an "ISO 18/16/13" with water content of 0.05% or less when fuel is filled into the machine.

Tolerances of fuel injectors are very tight to allow the precise injection of fuel and accurate injection timing. Dirt in the fuel causes wear and scoring of fuel injectors and hence leads to poor performance and shortened life. Common rail injection systems, used in some modern Cat engines, are more sensitive to contamination than other injection systems. Clean fuel and proper filtration aboard the engine are especially important for common rail injection systems.

Fuel filters on the engine are designed to be the final cleaning step for moderately clean supply fuel of "ISO 18/16/13" or cleaner, with water content of 0.05% or less. Bulk filtration of fuel storage tanks is recommended to ensure clean fuel supply into the engine. Refer to this Special Publication, "Bulk Filtration" for information. Refer to this Special Publication, "Contamination Control" for details on the contamination requirements and ISO code information. Additionally, information detailing contamination control measures for fuels and for fluids in general are provided in multiple Cat publications. Refer to this Special Publication, "Reference Information" for information.

Engines typically use two fuel filters, a primary and a secondary. In some machines multiple secondary filters are installed in series to ensure clean fuel. Primary filters can be Standard or Advanced Efficiency. Secondary filters are required to be Advanced High Efficiency with Ultra High Efficiency required in special or very harsh applications. Refer to your Operation and Maintenance Manual for information.

Secondary filters are typically 4 micron absolute. These filters remove more than 98% of all particles that are 4 microns or larger until the filter restriction becomes excessive. Typically, a secondary fuel filter is restricted when the filter reaches 10 psi delta pressure. Replacing the filter immediately is critical when a plugged filter warning light is activated in the operator compartment. Failure to replace a plugged fuel filter can cause serious fuel injector damage.

Refer to this Special Publication, "Contamination Control" for detailed recommendations.

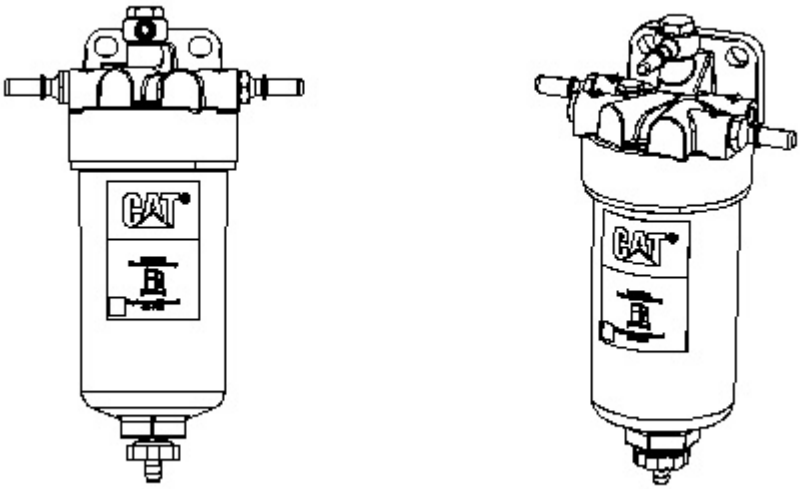

Illustration 1 g03525941

Example of a fuel filter assembly

**NOTICE**

**When the secondary fuel is restricted due to the buildup of contaminants, a plugged filter warning light, if equipped, is activated in the operator compartment. Replace the filter immediately in order to avoid fuel system contamination. If the filter is not changed upon the indication of excessive restriction, the pressure across the filter continues to rise and pushes contaminants that were trapped in the filter media through the filter and into the clean fuel. Contaminated fuel can cause serious fuel injector wear and damage.**

**Note:** Electric Priming pumps are recommended to pre-fill the secondary fuel filter with clean fuel when a filter is changed to help start the engine. Refer to this Special Publication, "Priming Pumps".

## Priming Pumps

In order to help prevent hard starting after the installation of new fuel filters, purging air from the fuel system is necessary prior to engine startup. Priming pumps remove this air from the system by pumping fuel through the fuel system. Priming pumps are typically installed on or near the fuel water separator, although in some cases priming pumps are remotely mounted.

Caterpillar offers two kinds of priming systems:

**Electric Priming Pumps** - Electric priming pumps work by either pushing a switch, or automatically run when the system is cycled on. These pumps take 2 to 6 minutes to prime the fuel system.

**Hand Priming Pumps** - Hand priming pumps are manually operated to prime the fuel system.

Caterpillar recommends against the practice of pre-filling fuel filters prior to filter installation. Doing so

can introduce debris into the fuel system which can cause harm to fuel injectors and result in downtime and increased maintenance costs. Using a priming pump avoids the introduction of this debris by ensuring the fuel has been properly filtered before the fuel reaches critical components of the fuel system.

**Note:** Electric Priming pumps are recommended to pre-fill the secondary fuel filter with clean fuel when a filter is changed to help start the engine. An electric priming pump contains another filter so that all the fuel supplied to the system has been pre-filtered. This type of pump reduces the time and effort needed to fill a new fuel filter compared with the manual priming pumps.

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# Fuel Filter (Water Separators)

**SMCS -** 1261; 1263

On many machines or engines, the primary fuel filter may be a combination primary filter and water separator. A water separator cleans the fuel of excess water. Water causes corrosion of fuel system surfaces and can damage fuel pumps. For injector components that are of tight clearances, water does not offer the lubricity and hence causes wear of the surfaces. The effective removal of water is critical to the performance of fuel system components.

Caterpillar offers effective barrier type fuel water separators that are recommended for use on any engine or machine. This barrier type filter removes large water droplets from the fuel. The water droplets fall to the bottom of the filter where the droplets are collected in a void or bowl. Water must be drained from the filter before the water reaches the filter media. Check the water level in the fuel water separator daily and by draining the water separator as necessary.

Cat fuel water separators are available in various capacities. Refer to your Operation and Maintenance Manual, and consult your local Cat dealer for more information.

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# Coolant Filters

**SMCS -** 1352-FI

Coolant pelleted filters have been historically used on some Cat machines or engines. The main function of these pelleted filters was to allow dosing of the supplemental coolant additives into the cooling systems that used DEAC coolants. Starting in 2013, Caterpillar pelleted coolant filters will be discontinued and will be replaced with a non-pelleted filter and direct dosing with supplemental coolant additive (SCA).

**Note:** The coolant pelleted filters are discontinued during 2013. The non-pelleted filter replacements require that the cooling system using Cat DEAC should be dosed directly with the supplemental coolant additive. For the recommended dosing volumes and dosing intervals follow the instructions provided in Special Publication, SEBU6250, "Caterpillar Machine Fluids Recommendations" or Special Publication, SEBU6251, "Cat Commercial Diesel Engine Fluids Recommendations".

The coolant filters that replaced the pelleted filters are a spin-on filter design. Servicing of these filters is recommended as follows:

- Replace the filter when you change the coolant fluid.
- If signs of corrosion appear on the filter, specifically at the top of the filter where the filter is assembled into the system. Inspect the filter for corrosion every time you dose the system with coolant additives.

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# Breathers

**SMCS -** 1054

Breathers are used on machine fluid tanks and on bulk fluid storage tanks. Breathers are designed and sized to equalize the pressure differentials between the inside of the tank and the outside atmosphere. The yield strength of the fluid tanks is also one of the design criteria for breathers.

At high temperatures, fluids may expand and create pressure inside tanks. Breathers allow the excess gas to flow from the tank to the outside, which relieves pressure buildup. Similarly, at low temperatures, pressure inside tanks may decrease and create a vacuum in the tank. Breathers in this case allow the ingression of external air to prevent tank collapse and at the same time filter the incoming air to keep the fluid clean. Breathers are also used to compensate for volume changes in the tank. For example, in hydraulic systems, when significant change of the length of hydraulic cylinders occurs quickly the change causes a sudden surge of oil flow into the hydraulic tank. This sudden flow of oil pressurizes the air in the tank. Breathers allow the pressurized air to escape from the tank, equalize the pressure, and avoid damage of the tank. Breathers are designed based on the tank size to allow the appropriate volume of gas flow in order to protect tanks. Breather design is also based on the rate of flow and the tank yield strength.

Most breathers may have an integral filter element or a separate serviceable filter element. Filter elements in breathers prevent the ingression of dirt as the air moves into the tank. Filter elements also prevent the movement of fluids such as fuels or oils from the tanks and into the atmosphere, which reduces contamination.

In general, breathers with filter elements are recommended for all fluid tanks. Breathers with filter elements are specifically recommended for use on fuel tanks, whether bulk or machine tanks. A four micron filter rating is recommended for these breathers to keep the fuels clean.

Some breather designs require the servicing of the filter element only, while other designs require the servicing of the entire breather. Follow the instructions given in your Operation and Maintenance Manual for breather service life recommendations. Consult your Cat dealer for availability of breathers for your applications.

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# Diesel Exhaust Fluid Filters

**SMCS** - 108K-FI

Diesel Exhaust Fluid (DEF), also generically referred to as urea, is a liquid that is injected into the exhaust system of engines equipped with Selective Catalytic Reduction (SCR) systems. SCR reduces emissions of nitrogen oxides (NOx) in diesel engine exhaust.

In engines equipped with an SCR emissions reduction system, DEF is injected in controlled amounts into the engine exhaust stream. DEF is then transformed chemically into ammonia. The ammonia, in the presence of SCR catalyst, converts NOx into harmless nitrogen (N2) and water (H2O). Refer to Special Publication, SEBU6250, "Caterpillar Machine Fluids Recommendations" or Special Publication, SEBU6251, "Cat Commercial Diesel Engine Fluids Recommendations" for details and requirements of DEF.

The cleanliness of DEF is critical to the performance and operation of the SCR aftertreatment system. Contaminants interfere with the controlled injection of DEF and with the SCR system pump performance. Contaminants are introduced into the system mainly during filling of DEF into the engine or machine tank. Dirt at the filling opening (neck) and surrounding area can be introduced into the tank if contamination control precautions are not taken. The surfaces surrounding filler cap should be thoroughly cleaned before opening. The opening of the dispensing container should also be thoroughly cleaned before filling the DEF. These steps help avoid the introduction of contaminants into the system and allow the system to perform as designed.

Another source of contamination is dirty DEF. DEF should be clean as the DEF is dispensed into the engine or machine tank. The dispensing container filling neck should be clean and should not introduce contaminants into the DEF engine or machine tank. Caterpillar recommended DEF fill fluid cleanliness is "ISO 18/16/13" as dispensed into the engine or machine tank. Refer to this Special Publication, "Contamination Control"for details.

Contamination of DEF can result in poor performance of the SCR system, down time, and increased cost. In order to avoid contamination related issues and downtime, follow all the contamination control guidelines detailed in this Special Publication, "Contamination Control".

**Note:** The cleanliness of the DEF is as important as the cleanliness of the fuel. Caterpillar recommends "ISO 18/16/13" cleanliness level for DEF fluid as dispensed into the engine or machine tank. Refer to this Special Publication, "Contamination Control"for details and guidelines.

Multiple filtration steps are designed into the SCR system:

**Inlet Filtration Screen** - There is a filtration screen at the inlet filling opening of the DEF tank. This screen reduces the contamination introduced during filling of DEF engine or machine tank. The screen is a serviceable part and should be changed if the filling time is slowed due to the dirt accumulation or at the published service intervals. Refer to your Operation and Maintenance Manual for information.

**Header Screen** - There is a DEF header screen located in the DEF tank. This screen helps reduce the contamination transported into the system from the tank. For questions about the tank screen, consult your Cat dealer.

**DEF Filter** - The DEF filter is 4 microns absolute efficiency. The DEF is circulated through the pump and then passes through the filter to protect the dosing injector from debris. This filter is serviceable and should be changed at the service hours published in the Operation and Maintenance Manual of the engine or machine. When the contamination level is high, the DEF filter may plug early. In this case, the filter should be changed as soon the first signs of plugging or increase of pressure are noticed. This change would avoid further damage and wear of the DEF system surfaces.

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# Oil Filtration Carts

**SMCS -** 1308; 5068

The oil filter carts are independent filtration carts used to perform kidney loop filtration, also called off board filtration. These carts are powered by air or electric pumps. The oil filter cart draws oil from a component on the machine, passes the oil through a large high efficiency filter on the cart, and returns the oil to the machine. Oil continues to circulate until the oil reaches the target cleanliness for the machine component. This kidney loop (or off board) filtration process is typically performed while other maintenance processes are conducted on the machine.

Filtration using the oil filter carts can clean the oil to very high levels of cleanliness. As the machine operates, debris is generated and on-board filtration may not be capable of maintaining the very high level of cleanliness needed for optimal operation and life of a machine component. When kidney loop filtration is repeated during the next maintenance process, the net effect is that the average cleanliness over time is significantly better and the component life is improved.

Kidney loop filtration is recommended to clean hydraulic systems or powertrain systems as a regular course of action or after the system has been open to replace a major component such as a pump or cylinder.

Cat offers several oil filter cart models that are designed to clean the oil in the final drives, axles, transmissions, hydraulic systems, or other systems. These carts offer high filter capacity at various flow rates that allow efficient off board filtration. Cat offered Oil Filter Carts can also be used to clean oil storage tanks to provide pre-filtration of bulk oils.

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# Bulk Filtration

**SMCS -** 108K; 1261; 1308; 5068

Bulk filtration is a large filtration unit that is used with external fuel storage tanks such as those used to fuel work sites. Bulk filtration is designed to remove contamination and water from large volumes of fuel in one pass. Bulk filter units are placed in the fuel supply line between fuel storage tank and fueling station. Proper storage tank settling and draining practices remove portions of dirt and water in the fuel. Bulk filtration removes the rest of the dirt and water and ensures that the fuel reaches the fueling station at the proper cleanliness level.

Bulk filtration units are typically made of two units. The units are connected with proper shutoff valves and pressure gauges that allow proper maintenance and ensure that the fuel is passing through free of water. The two units are:

**Particulate Filter** - A large capacity Ultra High Efficiency filter unit that removes dirt from the fuel.

**Coalescer Unit** - A Coalescer unit that removes water from the clean fuel. Typically the coalescer unit is made of multiple coalescing filter elements that can remove the water efficiently and quickly from the clean fuel. The separated water can be drained as needed.

Bulk filter units can be custom engineered to meet the needs of the customer fueling site.

Caterpillar offers specially designed bulk filtration units in four different capacities:

- 50 Gallons per Minute
- 100 Gallons per Minute
- 200 Gallons per Minute
- 300 Gallons per Minute

Each Cat bulk filtration unit is mounted on a skid, self contained, requires no electric power, and has the following features:

- 4 micron absolute particular filter
- 150 psi maximum pressure capability
- Filter delta pressure indicator
- Water coalescer with the capability to remove 3% continuous water in fuel. The fuel passing through the coalescer contains less than 100 ppm water by volume.
- Automatic slug control valve to shut off supply if large quantities of water in the fuel exceed the

automatic drain capacity, or if the particulate filters start to plug. This valve ensures that debris and water are not allowed to pass into the machine.

**Note:** The cost of bulk filter units is significant up front, but bulk units are more economical, less labor intensive and more reliable than installing and maintaining additional filtration units on each machine in a fleet. The filter coalescer unit ensures that only clean fuel enters the fuel tank of the machine or engine. If bulk filtration is used, the standard filtration on the machine is adequate to provide fuel filtration.

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# Handling and Storage

**SMCS -** 108K; 1261; 1308; 5068

Fluid filters are carefully designed for the optimal fluid flow and cleanliness of the engine or machine compartment. Proper storage and handling of fluid filters protects and ensures optimal performance and protects engines or machine compartments from contamination, increases filter life, improves efficiency, and reduces cost of servicing and downtime.

The following are the recommendations for appropriate storage and handling of filters:

- Store filters in the original packages, indoors and do not expose the filters to extreme temperatures. These storage conditions preserve the filter cleanliness and maintain the integrity of various filter components including non-metal components such as seals. This storage ensures that the filters will perform as designed and offer optimal protection of the components. Furthermore, when following these recommendations, the life of the filters on the shelf can be up to 5 years. The shelf life can be increased if all of the above conditions are met and the storage facility has a consistent climate controlled environment, which includes a steady temperature (no large fluctuations in temperature) and low/controlled humidity. If the climate control requirements are met, the shelf life can be extended up to 8 years.

- Minimize handling of the packaged filters during servicing. Keep the filter clean and in the appropriate packaging until ready to install the filter. Keep the filter exposure to open air to a minimum to limit introduction of dirt or element damage. Use care when handling a new filter element during servicing.

- Spin on filters are protected by the outer metal canister. Following the recommendations given above ensures that the filters are free from damage and dirt.

- Cartridge filters are not protected by a canister and hence must be handled with care to ensure that the media is not damaged or contaminated. Hold the cartridge unit from the end caps when removing from the packaging and quickly drop the cartridge in the canister to avoid contamination or damage. Ensure that the filter element is well seated and sealed against the housing.

# Filter Disposal

Fluid filters are full of dirty fluids when replaced. Most fluids are considered hazardous. Used filters should be disposed of according to local regulations. Filter disposal varies per state and per local municipalities. Refer to the regulations in your area in order to dispose of the filter appropriately per local regulations.

Consult with your Cat dealer for availability of filter collection or take-back programs. If these programs are available, the programs may include the separation of spin-on filters into steel components, which are recycled, and into the fluid-contaminated components that can be incinerated or disposed of according to

local regulations. Cartridge filters have one disposable component, which is the cartridge. The oil-filled cartridge can be disposed of according to local regulations or can be collected by the dealer for incineration or proper disposal.

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# General Information (Air Filters)

**SMCS** - 1054; 7342

Air filters, also called air cleaners, are responsible for continuously cleaning the air incoming into the engine or into the machine cab. Air filters are designed to effectively remove contaminants such as dust, dirt, soot, and other air-born particulates. When the recommended filters are used and the recommended maintenance intervals are followed, the particulate contamination in the incoming air is reduced resulting in the following:

- Reduced engine components wear and protection of moving components in the engine
- Lower engine or machine downtime
- Enhanced performance of the engine and reduced oil and fuel consumption
- Preservation of the reliability and life built into the engines or machine components
- Clean air in the cabin and operator comfort

Air system requirements may vary per application. Engines used in various applications such as marine, locomotive, mining, construction, on-highway, or off-highway applications have unique environments. In general, heavy-duty applications experience high dust in the work environments and high machine or engine vibrations.

Cat air filter designs are optimized to offer high performance, reliability, and cost value for all the applications of Cat engines and machines. These enhanced designs involve but are not limited to the following:

- Latest technologies of filter media
- Application-specific precleaner solutions
- Optimized filter design for the application
- Optimized filter efficiency and life for the application
- Appropriate filter restriction
- Precise fit into the engine
- Best cost value
- Consistent quality worldwide

Cat air filters are factory assembled into all Cat engines and machines. These filters are available for

aftermarket use through Cat dealers. The air filters available in the marketplace vary significantly in quality and performance. Knowing the quality of filters from visual observation of the filters is not possible. Cat filters are of high quality and hence offer improved value and protection for the machine. The expectation with a high-quality filter is the initial cost can be higher than poor quality filter due to the amount of the media, quality of media and overall construction of the filter. The overall value of the filter includes initial cost of the filter, value of equipment protection, reduction of downtime of equipment and extension of equipment life. As a result, the lifecycle value of high-quality filters outweighs the initial difference in cost.

This chapter provides details of the designs and efficiencies of Cat Engine Air Filters and Cat Cabin Air Filters. Refer to your machine or engine Operation and Maintenance Manual for the air filter requirements and service intervals. Cat air filters are available through Cat dealers.

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**NOTICE**

**Do not substitute any other air filter. Air filters that are not designed for the engine air flow and application can damage the engine and cause poor performance.**

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# Engine Air Filters

**SMCS** - 1054

The purpose of an engine air filter, which will be referred to as an air filter in this section, is to clean the air incoming into the engine, typically called intake air. In the engine, intake air mixes with fuel that is injected into the combustion chamber at precise ratios. This highly designed combustion process ensures that the engine operates as intended and per design.

The cleanliness of the intake air is critical to the performance of the engine. Dirty and contaminated intake air causes a lower quality combustion process, which results in a rough running engine and lower power. Also, dirty intake air introduces abrasive dirt into engine components that are moving at high speed such as pistons, rings, and bearings. The abrasive dirt scratches the surfaces of moving components and causes gouging and roughness. The rough and scratched surfaces lead to lower performance, higher oil consumption, reduced life of the engine, down time, along with other negative effects and higher maintenance cost.

Air filters are designed specifically for the machine or engine application in order to supply the proper air flow for the combustion process. Large engines may require multiple air filters to supply the needed volume of clean air. Refer to your machine Operation and Maintenance Manual for the specific air filter that is designed for your machine.

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**NOTICE**

**Do not substitute any other air filter. Air filters that are not designed for the engine air flow and application can damage the engine and cause poor performance.**

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Off-road and mining heavy-duty equipment and machines typically work in dusty and dirty environments. The air filter elements used in these applications have to offer strength and high dirt holding capacity in order to protect the engine for the designed service life of the filter.

Cat air filters are designed for optimal fit and performance into all applications of Cat machines and engines. These filters are developed using high-quality materials, precise designs, and dimensions. The filters offer the best capacity, level of filtration, and service life needed for all Cat engine models and machines for all conditions of operation.

High-quality air filter systems have the following characteristics:

- Allow the appropriate volume of clean intake air to the engine
- Designed with the capacity for the intended life and maintenance intervals

- Withstand the vibrations expected in the machine and application
- Effectively clean the intake air to protect the engine components
- Allow for ease of serviceability
- Precisely fit into the machine or engine design

**Note:** Air filters for off-road machines have to be robust and offer strength, desired life, and performance under demanding conditions. Off-road machines typically experience high vibration, high impacts, and dusty environments. Use of inferior quality filters or use of filters other than those filters recommended for your machine may cause poor engine performance and engine damage.

## Air Filter Selection Criteria

Air filters are selected based on the air flow requirements of the engine. The following are the main components for designing an air filter for the application.

**Rated Engine Air Flow** - Air flow needed for appropriate engine power and operation. Air flow is typically expressed in cubic feet per minute (cfm), cubic meters per minute ($m^3$/min), or kilograms per hour (kg/hr).

**Initial and Final Restriction** - Air restriction limit needed to ensure continuous flow of appropriate volume throughout the service life of the filter. Initial restriction is measured with a clean filter element. Final restriction is measured with a fully loaded dirty filter element. Restriction is typically expressed in inches of water (inH2O), or kilopascals (kPa).

**Dust Concentration** - Amount of dirt, dust, and contamination expected in the application environment. Dust concentration is typically expressed in grams per meter cubed (g/m3).

**Mounting** - Mounting is the available space to locate the air filter properly, while considering the vibrations expected during operation of the engine or the machine.

**Service Interval** - Expected frequency of dirty filter element replacement. The service interval is typically expressed in hours (hrs). A service interval based on the filter restriction is preferred. Refer to this Special Publication, "Servicing Engine Air Filters" for details.

## Air Filter Components

The designs of air filters may vary significantly among different air filter models. Some air filter designs are complicated and made of multiple components while others are simple and made of few components. Table 1 lists the components that can be included in air filters. These components may not be included in all air filter designs. Use only the recommended air filter for your machine.

**Note:** Air filters are also called air cleaners. Filter element refers to the disposable media.

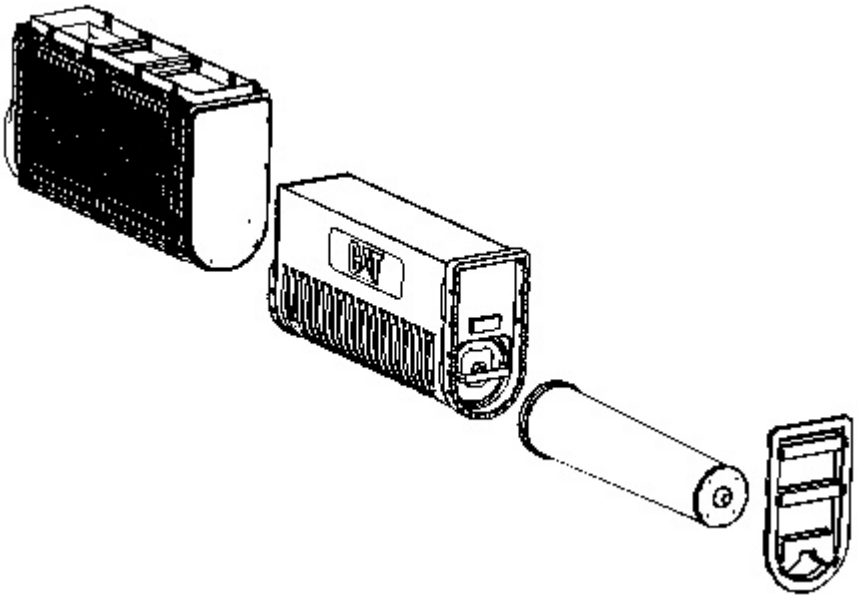

Illustration 1 g03525984

Example of air filter components

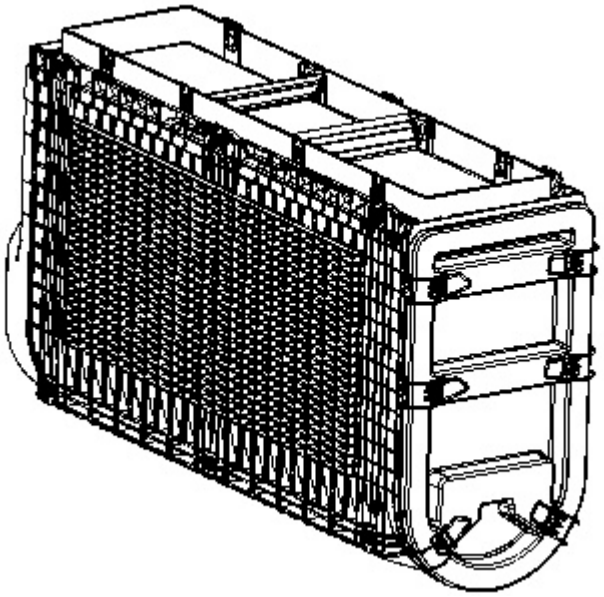

Illustration 2 g03525986

Assembled air filter

Table 1

| **Component** (1) | **Function** |
|---|---|
| Single stage air cleaner | No precleaning feature |
| Two stage air cleaner | Contains precleaning feature |
| Precleaner | Removes dirt prior to primary filter |
| Housing | Protects filter element |

| | |
|---|---|
| Primary filter element | Removes the majority of dust and dirt from intake air |
| Secondary filter element (Safety filter element) | Protects engine during service or failure of primary filter |
| Dust discharge / Scavenge port | Dirt discharge outlet for two stage air cleaners and precleaners |
| Dust discharge valve | Available on two-stage air cleaners and precleaners to discharge dirt |
| Filter service indicator / sensor | Indicates filter restriction and true filter service life |
| Rain cap | Protects air intake from rain and various forms of debris |
| Ejector check valve | Prevents exhaust backflow and protects air filter |

(1) These components may not be included in every filter design.

## Single Stage Air Cleaner (Air Filter)

A single stage air cleaner does not have a precleaning feature designed into the housing. This air cleaner typically has a primary and a secondary elements. Single stage air cleaners are commonly used for low dust applications.

## Two Stage Air Cleaner (Air Filter)

A two stage air cleaner contains a precleaning feature. The precleaning feature is typically designed into the housing. This design allows the incoming air to spin in the housing, which causes the separation of the large particles before the air enters the filter element. The large particles are then discharged from the housing through a built in discharge port. Typically, the two stage air cleaner has primary and secondary air filter elements. Two stage air cleaners are commonly used for high dust applications.

## Precleaner

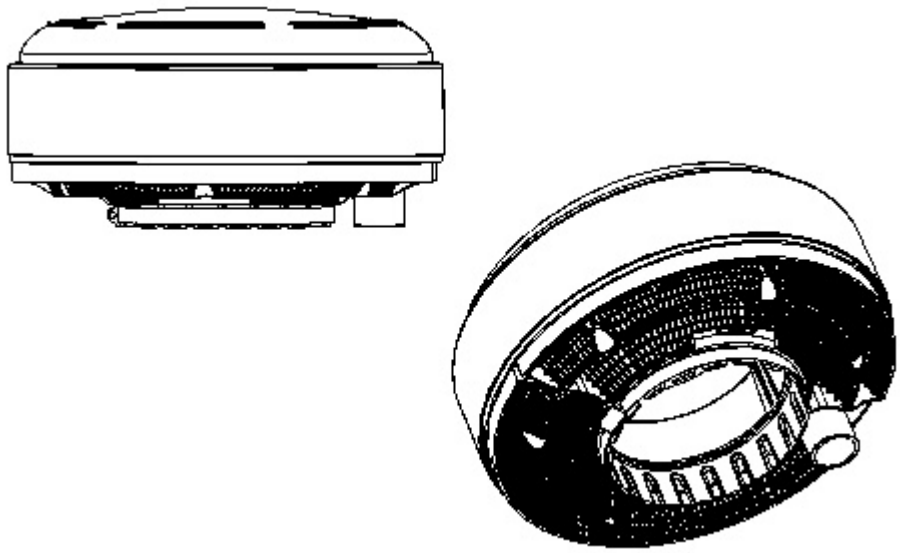

Illustration 3 g03526036

Example of a precleaner

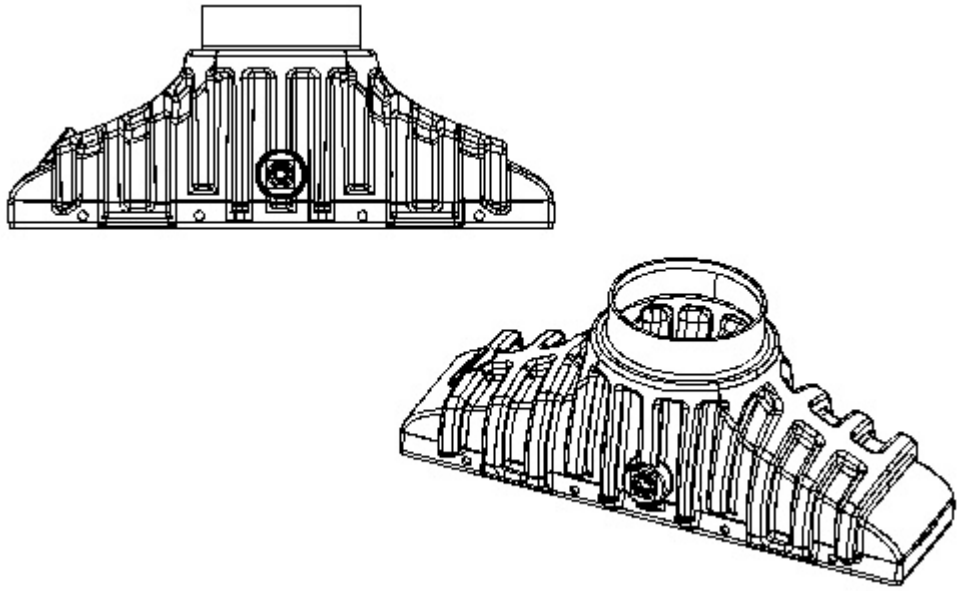

Illustration 4 g03526038

Example of a plenum that connects the precleaner to the filter

A precleaner can be separate or integrated into the air cleaner. The precleaner is designed to clean the intake air before the air flows through the primary filter element. Precleaners extend the life of primary filter elements by removing large particles of dust and dirt before the particle reach the primary filter element. There are two main types of precleaners, turbine and separator tube. Use of a built-in dust discharge port in the precleaner housing is recommended in order to limit dirt accumulation and maintenance.

Turbine precleaners use a rotating impeller to separate primarily large particles from the airstream. The rotating impeller forces most of the larger particles towards the outer edge of a single inlet airstream. The particles are then discharged through a diverter feature built into the edge of the housing. Turbine

precleaners do not typically require scavenge, although the turbine performance can be enhanced if scavenge can be used.

Separator tube precleaners use specially designed tubes to separate large and small particles from the airstream. Separator tube precleaners use several smaller fixed vane cyclonic tubes to force the dirt particles out of the divided airstreams by centrifugal motion. The dirt particles are then discharged through gravity fed or vacuum driven scavenge port.

Precleaners can be used with single or with two-stage air cleaners. However, the use of precleaners with two stage air cleaners is not generally recommended.

## Housing

Air filter housings can be metallic, non-metallic, or a combination. Housings can have various shapes and sizes. Air filter housings are designed to be vibration, corrosion, chemical, and impact resistant. Filter housings should be designed to fit the machine or engine application. The filter element is designed to fit precisely into the housing to ensure a good seal so that only clean air enters the engine.

## Primary Filter Element

The primary filter element is designed to remove the dirt from the airstream before entering the engine. The primary filter element media may be synthetic, cellulose, or a combination. Filter media may also contain resins and binders. The media could be of various designs including but not limited to pleated and fluted. A high-quality filter media allows high separation efficiency and extended service life. The filter element may be designed to offer a large surface area for additional dirt holding capacity. Refer to the Operation and Maintenance Manual for the recommended maintenance intervals.

Cat primary air filter elements are offered in standard and ultra high efficiency media.

- Cat standard efficiency filters are available for all Cat equipment models. Standard efficiency air filters are recommended for normal duty filtration. Standard efficiency media is designed to prevent dirt, soot, sand, and other contaminates from entering the engine under normal operating conditions.
- Cat ultra high efficiency (UHE) filters are available for some Cat equipment models. UHE air filters are recommended when extreme fine dust or soot make up a high percentage of the contaminants in the atmosphere. UHE elements have a higher initial and overall efficiency for improved engine performance. UHE elements have improved dirt holding capacity, which extends filter element service life, depending on the operating conditions.

## Secondary Filter Element

The secondary filter element is designed to prevent dirt from entering the engine during primary filter element service or as a backup if the primary element fails. For this reason the secondary filter element may also be called a safety filter. These filter elements are not used in every design but are highly recommended. Refer to the Operation and Maintenance Manual for the recommended maintenance intervals.

## Sealing of Media and Housing

Filter elements should have appropriate sealing between the media and the housing. The filter element is designed to fit precisely into the housing to ensure a good seal so that only clean air enters the engine. Sealing can be radial or axial.

- Radial sealed elements are designed to seal on the inside and/or outside diameter of the filter element as the element contacts the housing. This type of seal allows for more flexibility during the installation process, while still providing a robust seal. Most current air cleaner designs use radial sealing technology.

- Axial sealed elements are designed to seal only on the end of the filter element as the filter contacts the housing. This type of seal has less flexibility during the installation process, since the seal requires a near perfect position in the housing to provide an adequate seal. For this reason, radial sealing is preferred.

## Dust Discharge / Scavenge Port

The dust discharge port is used to provide an outlet for the dirt removed by the precleaner or two stage air cleaner. Dust discharge can be assisted by a discharge valve or by the use of a scavenge system. Without this port, the dirt may build up in the cleaner and clogging may occur.

## Dust Discharge Valve

The dust discharge valve uses gravity and pressure to help eliminate the dirt from the cleaner. Typically, this valve stays closed until the engine is turned off or pulsations trigger the valve to open. The valve can be attached directly to the dust discharge port or to an extension tube. The latter allows gravity to assist the discharge of dirt.

## Filter Service Indicator / Sensor

Filter service indicators allow the determination of the pressure drop across the filter. As dust and dirt buildup on the filter element, the pressure across the element increases. Indicators can be electronic or mechanical and may use remotely mounted displays for operator convenience. Filter elements must be serviced when the elements reach a pre-designed pressure drop. Indicators allow the determination of the pressure drop and hence allow for servicing at the right interval. Indicators help prevent over servicing and higher cost. The indicator also help prevent under servicing, loss of performance and potential engine damage. Refer to the Operation and Maintenance Manual for the indicator recommended reading or resetting if needed.

## Rain Cap

A rain cap protects the air intake from rain and various forms of debris. If needed, the rain cap may be integrated into the precleaner or can be a separate component.

## Ejector Check Valve

An ejector check valve prevents exhaust backflow and protects the air filter by only allowing air to flow in one direction.

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i05540289

# Servicing Engine Air Filters

**SMCS** - 1054

The capacity and restriction of air cleaners are carefully designed for the optimal intake air volume and cleanliness of the engine. Proper service and management of the air filter protects the engine from dirt and dust, reduces engine downtime, increases filter life, improves efficiency, and reduces cost of servicing.

- Use care when handling a new filter element during servicing. Keep the filter element clean and in the filters appropriate packaging until ready to install into the housing. Keep the filter element exposure to open air to a minimum to limit introduction of dirt or element damage.
- Inspect the new filter element prior to installation into the housing to ensure that the element is free from any damage. Ensure that the filter element is well seated and sealed against the housing.
- Do not remove the filter element from the housing in order to visually inspect the element prior to the service interval. Visual inspection of the filter element to determine the filters service life is not useful and is not recommended. Removing the filter element from the housing before the recommended and designed service interval can introduce dirt to the clean side of the filter element. This dirt can then be ingested into the engine causing damage and decreasing the performance.
- A filter element would appear dirty during visual observation, but the filter may still have significant service life. Filter elements develop a "dirt cake" or a dirt layer during normal operation. The dirt layer increases the filter element efficiency. The efficiency of the filter element is lowest when the filter is new and the dirt layer has not formed yet.
- Do not "tap" a filter element, such as on a hard surface, to remove the dust. Hitting the filter element on a surface to remove the dust can damage the filter element. Deeply embedded dirt cannot be removed by tapping the filter element. This process will also remove the dirt layer that increases the filter element efficiency.
- Frequent opening of the housing for visual inspection, may lead to engine damage by potentially exposing the clean side of the filter to dust and dirt.
- Always change air filter elements based on the air filter service indicator, not the appearance of the filter. Change the primary filter element when the restriction is at the level indicated in the Operation and Maintenance Manual.
- Changing the air filter element based on a restriction indicator allows for optimal service life and efficiency of the air cleaner. Changing the air filter element prior to the designed life increases service time and cost unnecessarily. Changing an air filter element late may damage the engine due to potential failure of the filter element.
- Air filter service indicator may need to be reset after new filter element is installed. Refer to the Operation and Maintenance Manual for instructions.

- Typically secondary elements do not need to be serviced at every primary filter element service interval. Refer to the Operation and Maintenance Manual for the recommended maintenance intervals.
- Use of filter covers and rain caps is preferred to protect the filter from water and large debris.
- Inspect the dust discharge valve periodically to remove accumulated dust from the precleaner or two stage air cleaner.
- For precleaner servicing (if needed) refer to the Operation and Maintenance Manual.
- When servicing the air filter, inspect the connections, clamps, and mounting components for apparent damage. Also inspect the filter element service cover seal (if included) and latches for apparent damage. Replace as needed.
- Never attempt to replace an air filter element while the engine is running.

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i05540308

# Management and Cleaning of Engine Air Filters

**SMCS** - 1054

Appropriate storage, handling, and use of air filter elements extend the life and allow for optimal engine performance and lower cost due to appropriate service intervals.

- Always store the filter elements sealed and in a box. Do not allow a filter element to be exposed to dirt, water, or other contaminants during storage.
- Store filters in the original packages, indoors and do not expose the filters to extreme temperatures. These storage conditions preserve the filter cleanliness and maintain the integrity of various filter components including non-metal components such as seals. This storage ensures that the filters will perform as designed and offer optimal protection of the components. Furthermore, when following these recommendations, the life of the filters on the shelf can be up to 5 years. The shelf life can be increased if all of the above conditions are met and the storage facility has a consistent climate controlled environment, which includes a steady temperature (no large fluctuations in temperature) and low/controlled humidity. If the climate control requirements are met, the shelf life can be extended up to 8 years.
- Exercise care when removing the filter element from the box and from the bag so that the element is not exposed to any contamination.

# Cleaning Primary Air Filter Elements

Caterpillar does not recommend the cleaning of air filter elements since there is not a relatively feasible and reliable method of inspecting air filter elements for damage. A damaged air filter element can allow dirt to pass through, which results in reduced efficiency.

Cleaning the air filter element will result in a progressive reduction from the original filter capacity each time the filter is cleaned. However, if the owner insists on cleaning primary air filter elements to extend filter life, the following instructions may help to minimize the risks.

Do not clean the air filter elements by bumping or tapping as these actions can cause damage. Do not use air filter elements with damaged pleats, gaskets, or seals. Discard damaged air filter elements.

Do not use solvents or water to wash the air filter element.

When attempting to clean the primary air filter element, use a maximum gauged air pressure of 207 kPa (30 psi) at a minimum distance of 75 mm (3 inch) for at least 3 minutes. Do not aim the high-pressure air stream directly at the filter media, but rather so the air flows along the length of the filter media surface. Take extreme care during this procedure to help prevent damage to the filter element and to prevent forcing dirt further into the pleats. This procedure may be used for a maximum of three cleanings before filter element replacement.

The engine air filter secondary (safety) element should never be cleaned and should be replaced every third primary air filter element change, or as required.

Never attempt to replace a filter element while the engine is running.

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**NOTICE**

**Due to the lack of a feasible and reliable filter element inspection procedure, the customer is encouraged to closely monitor the engine S·O·S (scheduled oil sampling) as the best means to detect dust ingestion into the engine. Refer to the Operation and Maintenance Manual for more details.**

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**Note:** Caterpillar is not responsible for damage to the air filter elements and/or contingent damage to Caterpillar equipment due to unauthorized air filter cleaning. Any cleaning of air filter elements voids the Caterpillar Parts Warranty associated with the parts.

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# Cab Air Filters

**SMCS** - 7342

The purpose of a cabin air filter is to clean the air coming into the cab. There are typically two cabin air filters, a fresh air filter and a recirculation filter. The fresh air filter cleans the outside air prior to entering the cab. The recirculation filter cleans the air that is inside the cab. Cabin air filters help to protect the cab heating and cooling system from dirt and debris. Cabin air filters also help with operator well-being by providing clean air within the cab. The cabin air filters help to create a comfortable working environment for the operator.

**Note:** Cabin air filters are not for use in filtering hazardous materials.

Cabin air filters are designed specifically for the application in order to supply the proper air flow to the cab. Consult your Cat dealer for the specific cabin air filter that is designed for your machine. Do not substitute any other cabin air filter.

**Note:** Cabin air filters that are not designed for the air flow and application can damage the cab heating and cooling system causing poor performance. Consult your Cat dealer for the specific cabin air filter that is designed for your machine and do not substitute any other cabin air filter.

High-quality cabin air filter systems have the following characteristics:

- Allow the appropriate volume of clean air to the cab
- Designed with the capacity for the intended life and maintenance intervals
- Withstand the vibrations expected in the machine and application
- Effectively clean the air to protect the cab heating and cooling components
- Create a cleaner and more comfortable working environment for the operator
- Allow for ease of serviceability
- Precisely fit into the machine design

**Note:** Cabin air filters for off-road machines have to be robust and offer desired life and performance under demanding conditions. Off-road machines typically experience high vibration, high impacts, and dusty environments. The cabin air filter elements used in off-road applications have to offer high dirt holding capacity in order to protect the cab heating and cooling system for the designed service life of the filter. Use of inferior quality filters or use of filters other than the filters recommended for your machine may cause poor performance and damage to the cab heating and cooling system.

Cat cabin air filters are designed for optimal fit and performance into all Cat machines. These filters are developed using high-quality materials, along with precise designs and dimensions. These filters offer the

best capacity, level of filtration, and service life needed for all Cat machines and for all conditions of operation.

Cabin air filters are selected based on the air flow requirements of the cab. The following are the main components for designing a cabin air filter for the application.

**Cab Air Flow** - Air flow needed for appropriate cab pressurization, as well as heating and cooling. Cab air flow is typically expressed in cubic feet per minute (cfm), cubic meters per minute (m3/min), or kilograms per hour (kg/hr).

**Initial and Final Restriction** - Air restriction limit needed to ensure continuous flow of appropriate volume throughout the service life of the filter. Initial restriction is measured with a clean filter. Final restriction is measured with a fully loaded dirty filter. Restriction is typically expressed in inches of water (inH2O) or kilopascals (kPa).

**Dust Concentration** - Amount of dirt, dust, and contamination expected in the application environment. Dust concentration is typically expressed in grams per meter cubed (g/m3).

**Mounting** - Available space to locate the cabin air filter properly, while considering the vibrations expected during operation of the machine.

**Service Interval** - Expected frequency of dirty filter replacement. The service interval is typically expressed in hours (hrs).

# Cabin Air Filter Options

## Standard

Standard efficiency cabin air filters are available for all Cat equipment models. Standard efficiency cabin air filters are recommended for normal duty filtration. Standard efficiency media is designed to prevent dirt, soot, sand, and other contaminates from entering the cab under normal operating conditions.

## High Efficiency

High efficiency cabin air filters are available for some Cat equipment models. High efficiency cabin air filters are recommended for extremely dusty environments. High efficiency cabin air filters have a higher initial and overall efficiency for improved performance. High efficiency cabin air filters have improved dirt holding capacity, which extends filter service life, depending on the operating conditions.

## Activated Carbon

Activated carbon cabin air filters are available for some Cat equipment models. These cabin air filters are recommended in situations where odor is a problem. Activated carbon cabin air filters absorb odors as well as capturing dust. Activated carbon cabin air filters must be replaced regularly for maximum odor reduction.

## Lower Restriction

Lower restriction cabin air filters are available for some Cat equipment models. Lower restriction cabin air filters are typically recommended in situations where there is poor cab air flow. Lower restriction cabin air filters allow for more air flow into the cab, but typically have a lower efficiency.

# Cabin Air Filter Servicing

The capacity and restriction of cabin air filters are carefully designed for the optimal cab air flow and cleanliness. Proper service and management of the cabin air filters protects the heating and cooling system from dirt and dust, increases filter life, improves efficiency, and reduces cost of servicing. Proper service and management of the cabin air filters also creates a cleaner and more comfortable working environment for the operator.

- Use care when handling a new filter element during servicing. Keep the filter element clean and in the appropriate packaging until ready to install the filter into the housing. Keep the filter element exposure to open air to a minimum to limit introduction of dirt or element damage.
- Inspect the new filter element prior to installation into the housing to ensure that the element is free from any damage. Ensure that the filter element is well seated and sealed against the housing.
- Do not "tap" a filter element, such as on a hard surface, to remove the dust. Hitting the filter element on a surface to remove the dust can damage the filter element. Deeply embedded dirt cannot be removed by tapping the filter element. This process will also remove the dirt layer that increases the filter element efficiency.
- Always change air filter elements based on the recommended service interval, not the appearance of the filter. Refer to the Operation and Maintenance Manual for the recommended maintenance intervals.
- Changing the air filter element based on the recommended service intervals allows for optimal service life and efficiency. Changing the air filter element prior to the designed life increases service time and cost unnecessarily. Changing an air filter element late may cause damage to the cab heating and cooling system due to potential failure of the filter element.
- When servicing the air filter, inspect the housing and mating components for apparent damage. Replace as needed.

# Cabin Air Precleaners

The purpose of the cabin air precleaner is to clean the air before the air reaches the fresh air filter. This precleaning is accomplished by using a motor and fan to spin the incoming air at very high speed inside the precleaner. The heavy particles ride on the outside of the precleaner body and are ejected back to the outside before ever reaching the filter.

Cabin air precleaners extend the life of the fresh air filters. Customers have demonstrated a typical increase in filter life of 5 to 10 times compared to systems without the precleaner. As a result, the use of cabin air precleaner reduces the cost associated with frequent air cleaner changes and reduces the maintenance time for filter replacement.

Additionally, cabin air precleaners result in positive (higher) and more consistent cabin air pressure. This positive cabin air pressure keeps the clean air inside the cab while keeping the dirty air outside. Without positive cabin air pressure, dirty outside air can enter the cab through any small openings including broken door seals, window cracks, skip welds, and cab penetrations (harnesses, hydraulic lines, hoses). Without a precleaner, the cab pressure is higher at the fastest fan speed setting and lower at the lowest fan speed setting. With a precleaner installed, the cab pressure remains high no matter what fan speed is selected.

# Cab Pressure Monitor

Cab pressure is very important to maintaining a clean, healthy working environment inside the cab. Due to this importance, measuring cabin air in real time and to monitoring cabin air is useful. This monitoring allows the operator to receive feedback if a door or window is left open or if a filter has become plugged with dirt. Caterpillar has released a cabin pressure monitor for dealer installation with a digital readout, programmable pressure set point, and audible alarm. Consult your Cat dealer for more information and refer to your Operation and Maintenance Manual for more information.

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i05540408

# General Information (Gas Engine Filters)

**SMCS** - 1054; 1261; 1308

Natural gas engines require fuel that is clean, dry and at the acceptable pressure for engine operation. Filters for natural gas engines are critical to supply the engine with the clean and dry fuel and are appropriately sized for the gas pressure required for engine operation.

Gas fuel filters are no less important than air filters in diesel engines to protect gas engines from dirt and debris. A proper gas fuel filter removes impurities that can damage internal components of the engine.

For many gas engines, fuel filters are a provision of the design for the application. These devices are included in the normal maintenance of the plant. Hence, Cat does not include a standard gas fuel filter as a part of each gas engine. However, gas fuel filters are available from your Cat dealer.

Cat natural gas filters have the following characteristics:

- Specially treated borosilicate glass microfibers that actively repel oil and water
- A positive o-ring seal to prevent entry of debris and particulate matter especially in high soot operating conditions that tend to plug normal filters
- Chemical resistant end caps built to withstand challenging operating environments

**Note:** Use a gas fuel filter that is designed to capture a minimum of 99 percent of the particles that are 1 micron in diameter.

Consult your Cat dealer for Cat natural gas fuel filters and about the requirements for filtering your fuel.

For information on the engine oil filters for gas engines, refer to this Special Publication, "Fluid Filters and Engine Oil Filters".

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i05540437

# Guidance for Use of Cat Filters on Other OEM Engines

**SMCS -** 1054; 108K; 1261; 1263; 1308; 5068; 7342

Cat filters are not designed to be used on other OEM engines or machines. Follow the manufacturer recommendations when using Cat filters on other OEM engines or machines.

Cat filters are extensively tested and validated to ensure that the filters meet all of the system and performance requirements of Cat equipment or engines the filters are designed for. Caterpillar does not verify whether Cat filters meet the system and performance requirements of other manufactures equipment/engines. Caterpillar expects the customers to utilize Cat filters on Cat equipment and engines to ensure optimum system performance and the best component protection. Other manufactures equipment/engines may have different performance parameters/requirements that demand specific filtration solutions.

Some customers may choose to use Cat filters on other manufactures equipment/engines. Additionally, Cat filtration products may fit non Caterpillar equipment/engines. Caterpillar parts warranty does not apply to the use of Cat filtration products on non Cat equipment/engines. Caterpillar has no control over how the parts are used by customers after the parts are purchased from Cat dealers.

Always refer to and follow your engines recommendations for filtration products.

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i05540463

# Contamination Control

**SMCS** - 1054; 108K; 1261; 1263; 1308; 5068; 7342

# Defining Contamination

Contamination is defined as the presence of unwanted foreign substances in fluid systems or fluid wetted parts. Contamination alters the properties of fluids, causes damage of fluid systems, and prevents systems and components from attaining the desired reliability and durability. Contamination is the primary cause of fluid system failures.

Contaminants include a wide variety of unwanted substances including but not limited to the following:

- Foreign and abrasive substances such as wear particles, fibers, dirt, and dust
- Chemical substances such as products of combustion that are suspended in the fluids
- Cross contamination of water, coolant, oil, and fuel
- Biological micro-organisms such as algae or fungi
- Physical/chemical contaminants such as products of oxidation and heat

Some contaminants are generated within the fluid system due to the normal operation of the system. Contaminants may be drawn into the system from the outside environment or contaminated fill fluids or improper maintenance and repair practices.

Particle contaminants are visible to the naked eye if the particles are approximately 40 µm (microns) and larger while smaller particles are not visible. Particle contaminants can cause damage even if the particles are not visible to the naked eye. The critical particle size for wear particles in a modern diesel engine fuel system is 4 µm.

Contaminants of all types can be controlled by following contamination control practices and using appropriate filtration. Refer to your Operation and Maintenance Manual and to your local Cat dealer for recommendations.

Controlling contamination is especially important for current machine systems. Current machine systems such as hydraulic systems and fuel injection systems are designed with close tolerances and operate at high pressures for enhanced performance. These design improvements emphasize the importance of higher performing fluids, enhanced fluid filtration, and greatly improved fluid cleanliness levels.

# Measuring Cleanliness

Fluid cleanliness can be measured by taking fluid samples from various machine compartments. Your Cat

dealer can analyze the samples. Particle contaminants are typically measured by particle counters. Chemical contaminants can be measured by specific analysis techniques such as oxidation, water, or soot tests. Some chemical contaminants, such as water in fuel, can interfere with the particle counters and can be counted as particles. Refer to your Cat S·O·S lab or to your Cat dealer for more information.

The number of particles in fluids is expressed in "ISO (International Organization for Standardization)" ratings. "ISO 4406" Standard classifies fluid cleanliness by the number and size of particles in 1 milliliter of fluid. "ISO 4406" Standard measures particle size in µm (microns) and reports the resulting count in three code ranges X, Y & Z. The three code range defines the size and distribution of particles in 1 milliliter of fluid:

- The first code range, X represents the number of particles equal to or larger than 4 µm per milliliter of fluid.
- The second code range, Y represents the number of particles equal to or larger than 6 µm per milliliter of fluid.
- The third code range, Z represents the number of particles equal to or larger than 14 µm per milliliter of fluid.

An example of an "ISO 4406" particle count is 18/16/13. Cat "ISO" cleanliness recommendations are expressed as two or three codes, depending on the machine system. The three code range follows "ISO 4406" definitions and is used for liquid fuels such as diesel and gasoline. The two code system, example "ISO -/16/13", is used for certain lubricant systems. In the two code system, the first number is the number of particles equal to or larger than 4 µm per milliliter of fluid. This number is not required and may be represented by a dash (-). The second number (Y) and the third number (Z) follow "ISO 4406" definitions. Cat reports the Y and Z codes for lubricating oils to keep consistency with older data and reports.

An example of the particle size and distribution of the "ISO 4406" codes is given in Table 1.

Table 1

| **ISO 4406 Code** | **Number of particles in 1 milliliter of fluid** | | |
|---|---|---|---|
| | **4µm and up** | **6µm and up** | **14µm and up** |
| "ISO 18/16/13" | 1300 - 2500 | 320 - 640 | 40 - 80 |
| "ISO 21/19/17" | 10000 - 20000 | 2500 - 5000 | 80 - 160 |

**Note:** Several factors affect the results of particle counts. The factors include the cleanliness of the equipment used to obtain the sample, sample techniques, the cleanliness, and type of sample container, particle counter accuracy (calibration, maintenance, and process), and the environment where the sample is procured. Samples should be taken at representative locations in the fluid circulation system or the fluid distribution system when possible. The sample should be protected adequately from contamination during transport to the lab for analysis.

In addition, particle counters may count water droplets and air bubbles as particulate contamination.

**Note:** American Society for Testing and Measurement has developed "ASTM D7619" "Standard Test Method for Sizing and Counting Particles in Light and Middle Distillate Fuels, by Automatic Particle Counter". This test procedure was developed in 2010 to count and measure the size of dispersed dirt particles, water droplets, and other particles in 1-D and 2-D diesel fuels when the specified particle

counter is used. "ASTM D7619" is also applicable to biodiesel fuels.

## Cleanliness Standards for Machine Systems

Cat recommends that machine systems be maintained at the factory defined fluid cleanliness targets.

Cat has established minimum fluid cleanliness targets for fuels and fill oils and for machine roll-off. Fluids filled into the machine or engine fill tanks are recommended to be at the target levels provided in Table 2 or cleaner. Cleanliness targets for applicable machine component systems are referred to as "Roll-off". Roll-off is defined as the cleanliness specification of the fluid that is to be obtained before the machine returns to work after maintenance and or system invasion repair. When system fill fluids and Roll-off are maintained at or cleaner than the "ISO" cleanliness targets, contamination-related effects will be reduced.

Table 2

| **Cat Recommended Fluid Cleanliness Targets** (1) | | |
|---|---|---|
| **Cat Recommended Cleanliness Targets for Fluids Dispensed into Machine or Engine Fill tanks** | Fill oils (2) (3) | ISO -/16/13 |
| | Dispensed fuels | ISO 18/16/13 |
| | Dispensed DEF | ISO 18/16/13 |
| **Cat Recommended Machine Roll-off Cleanliness Targets** | Hydraulic systems (Implement & Steering) | ISO -/18/15 |
| | Electronic Transmissions | ISO -/18/15 |
| | Mechanical Transmissions | ISO -/21/17 |
| | Differentials, Wheels, and Axles (4) | ISO -/18/15 |

(1) The fluids should meet or exceed the cleanliness requirements of the listed ISO levels.

(2) For engine oils, when filtering the oil prior to dispensing into the engine tank, use engine oil filters of 12 micron absolute efficiency and ensure that the oil temperature is 20° C (68° F) or higher. Refer to the details given in this article.

(3) For transmission, gear, differential and axle oils, additives and the viscosity of the oil may interfere with particle counting. An alternative is to use adequate filtration to ensure clean oils prior to filling in the machine compartment.

(4) This cleanliness standard applies only to the Series 700 family of rigid frame trucks, 777 size and larger.

The "fill" fluids cleanliness target is not a fluid "delivery" target. The level of cleanliness for delivered fluids is not specified by Cat. Customers can work with the distributors or carriers to determine the cleanliness level of delivered fluids. However, a more effective and economic means to achieve the fill cleanliness targets is to filter the fluids prior to filling into machine tanks as compared with specifying delivery fluid cleanliness level. Follow the guidelines provided in this Contamination Control article.

Although older technology machines may not be able to maintain the recommended cleanliness targets of advanced models, the same contamination control intervention measures such as filtration and subsequent service procedures should be used on all Cat products.

The viscosity and additives of powertrain oils including transmission, gear, differential, and axle oils can interfere with particle counting. An alternative option is to filter the oils using adequate filtration to ensure clean oils prior to filling in the machine compartments.

**Note:** When particle counting new multi-viscosity engine oils, there may be difficulties achieving cleanliness targets. Optical particle counters cannot distinguish between particulate contaminants and additives. Do not use optical particle count for the evaluation of used engine oils because soot levels render oil too dark for optical particle counters. Soot levels in used engine oils should be evaluated by using S·O·S Services Oil Analysis.

When filtering engine oil before dispensing into the engine tank or when engine oil kidney looping filtration is done, follow these recommendations:

- Use engine oil filters of 12 microns absolute efficiency. Cat Ultra High Efficiency Lube filter is recommended. Consult your Cat dealer for the most current part number.
- Ensure that the temperature of engine oil is 20° C (68° F) or higher.

Consult your Cat dealer for information and solutions to your oil and fuel analysis needs.

## General Contamination Control Recommendations or Practices

Maintaining a low contamination level can reduce down time and can control the maintenance cost of the machine. The productive life as well as the reliability of components and fluid systems is often increased as a result of proper contamination control practices.

The following are general guidelines for controlling contaminants.

- Refer to the Recommendations for Fuel Systems in this chapter for recommended fuel cleanliness levels and guidelines.
- Refer to the machine Operation and Maintenance Manual for the required maintenance for all machine compartments.
- When you add oil to a machine, use adequate filtration in order to clean the oil to meet the targets provided in Table 2.
- Perform scheduled S·O·S Services Oil Analysis for contamination in order to maintain the recommended ISO cleanliness level of fill and machine fluids. Refer to the S·O·S Oil Analysis section in this Special Publication. The particle count analysis can be performed by your Cat dealer. Particle count can be conducted during the scheduled S·O·S Services Oil Analysis for the compartment. Extra oil samples are not required for the particle count sampling.
- Use only coolants that are recommended by Cat for your machine. Follow the recommended maintenance procedure for the cooling system in the Operation and Maintenance Manual for your machine.
- Maintain the engine air filters and air intake system to avoid unwanted contaminant ingression.
- Follow contamination control practices for the shop area, component/machine disassembly areas, parts, shop tools, test setups, test areas, storage areas and waste collection areas, Keep components clean during inspection, assembly, testing, and filling machines with clean fluids. Good practices will enhance component life and reduce downtime associated with contaminants. Your Cat dealer

can provide details on proper contamination processes and practices.

- Follow contamination control practices for the workplace and for the worksite. Maintaining clean oil fill fluids saves time and effort and ensures that fill fluids are at the proper cleanliness levels.
- Use properly designed and maintained bulk storage fluids tanks.
- Protect the fluids storage tanks from dirt and water entry by using 4 µm or less absolute efficiency breathers with the ability to remove water.
- Keep the areas around the tanks filler necks clean of debris and water.
- Drain the storage tanks from water and sediments frequently. The draining schedule depends on use of proper inlet and outlet filters, the use of 4 µm breathers with the ability to remove water, and following recommended contamination control practices. Based on the contamination control program followed, and/or on the fuel supplier recommendations, the storage tank draining schedule may be as frequent as daily until no water is present, and then can be extended to longer periods.
- Install and maintain a properly designed and grounded filtration system. Filtration should include at the entry and at the dispensing point. Continuous bulk filtration may be required to ensure that dispensed oils meet the cleanliness target.
- Cover, protect, and ensure cleanliness of all connection hoses, fittings, and dispensing nozzles.

**Note:** Bulk fuel filtration units are available through your Cat dealer. Proper maintenance practices of the bulk filtration systems are available through your Cat dealer.

## Contamination Control Recommendations for Fuels

Fuels of "ISO 18/16/13" cleanliness level or cleaner as dispensed into the engine or machine fuel tank should be used. Reduce power loss, failures, and related down time of engines will result. This cleanliness level is important for new fuel system designs such as Common Rail injection systems and unit injection systems. Injection system designs utilize higher fuel pressures and tight clearances between moving parts in order to meet required stringent emissions regulations. Peak injection pressures in current fuel injection systems may exceed 30,000 psi. Clearances in these systems are less than 5 µm. As a result, particle contaminants as small as 4 µm can cause scoring and scratching of internal pump and injector surfaces and of injector nozzles.

Water in the fuel causes cavitation, corrosion of fuel system parts, and provides an environment where microbial growth in the fuel can flourish. Other sources of fuel contamination are soaps, gels, or other compounds that may result from undesirable chemical interactions in the fuels, particularly in Ultra Low Sulfur Diesel (ULSD). Gels and other compounds can also form in biodiesel fuel at low temperatures or if biodiesel is stored for extended periods. The best indication of microbial contamination, fuel additives, or cold temperature gel is rapid filter plugging of bulk fuel filters or machine fuel filters.

In order to reduce downtime due to contamination, follow these fuel maintenance guidelines. Also, follow the General Contamination Control Recommendations or Practices given above in this Chapter:

- Use high-quality fuels per recommended and required specifications (refer to the Fuel Chapter in this Special Publication)
- Fill machine fuel tanks with fuels of "ISO 18/16/13" cleanliness level or cleaner, in particular for engines with common rail and unit injection systems. When you refuel the machine, filter the fuel

through a 4 µm absolute filter (Beta 4 = 75 up to 200) in order to reach the recommended cleanliness level. This filtration should be located at the device that dispenses the fuel to the engine or machine fuel tank. In addition, filtration at the dispensing point should remove water to ensure that fuel is dispensed at 500 ppm water or less.

- Cat recommends the use of bulk fuel filter / coalescer units which clean the fuel of both particulate contamination and water in a single pass. Cat offers heavy-duty filter / coalescer units to accommodate fueling rates from 50 to 300 gpm (gallons per minute).
- Ensure that you use Cat Advanced Efficiency Fuel Filters. Change your fuel filters per recommended service requirements or as needed.
- Drain your water separators daily per the Operation and Maintenance Manual of your machine.
- Drain your fuel tanks of sediment and water per the Operation and Maintenance Manual of your machine or sooner as fuel condition indicates.
- Install and maintain a properly designed bulk filter / coalescer filtration system. Continuous bulk filtration systems may be required to ensure that dispensed fuel meets the cleanliness target. Consult your Cat dealer for availability of bulk filtration products.
- Centrifugal filters may need to be used as a pre-filter with fuel that is severely contaminated with gross amounts of water and/or large particulate contaminants. Centrifugal filters can effectively remove large contaminants, but may not be able to remove the small abrasive particles required to achieve the recommended "ISO" cleanliness level. Bulk filter / coalescers are necessary as a final filter in order to achieve the recommended cleanliness level.
- Install desiccant type breathers of 4 µm or less absolute efficiency with the ability to remove water on bulk storage tanks.
- Follow proper practices of fuel transportation. Filtration from the storage tank to the machine promotes the delivery of clean fuel to machine tank. Fuel filtration can be installed at each transport stage in order to keep the fuel clean.
- Cover, protect, and ensure cleanliness of all connection hoses, fittings, and dispensing nozzles.

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**NOTICE**

**In order to meet expected fuel system component life, 4 micron(c) absolute or less secondary fuel filtration is required for all Cat diesel engines that are equipped with common-rail fuel systems. Also, 4 micron(c) absolute or less secondary fuel filtration is required for all Cat diesel engines that are equipped with unit injected fuel systems. For all other Cat diesel engines (mostly older engines with pump, line and nozzle type fuel systems), the use of 4 micron(c) absolute or less secondary fuel filtration is strongly recommended. Note that all current Cat diesel engines are factory equipped with Cat Advanced Efficiency 4 micron(c) absolute fuel filters.**

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Consult your local Cat dealer for additional information on Cat designed and produced filtration products.

**Operation and Maintenance Manual**
**Caterpillar Filters Recommendations**
**Media Number -SEBU9208-00** **Publication Date -01/12/2013** **Date Updated -13/12/2013**

i05884756

# Reference Material

**SMCS -** 1054; 108K; 1261; 1263; 1308; 5068; 7342

The following publications are available for order through your Caterpillar dealer.

**Note:** The information that is contained in the listed publications is subject to change without notice. Consult your local Caterpillar dealer for the most current recommendations.

**Note:** Refer to this Special Publication, the respective product data sheet, and to the appropriate Operation and Maintenance Manual for product application recommendations.

# Filters

- For general Cat filtration products, refer to the following website:

*https://commerce.cat.com/en/catcorp/filters*

- Special Publication, PEWJ0074, "Filters and Fluids Application Guide"
- Special Publication, PEHP7046, "Fuel Contamination Control"
- Special Publication, PECP9067, "One Safe Source"
- Special Publication, SENR9620, "Improving Component Durability - Fuel Systems" (Package of 10)
- Special Publication, SEBF1018, "Improving Component Durability - Engines" (Package of 10)
- Special Publication, SEBF1020, "Improving Component Durability - Managing Fluid Cleanliness" (Package of 10)
- Special Publication, SEBF1015, "Improving Component Durability - Final Drives and Differentials" (Package of 10)
- Special Publication, SEBF1016, "Improving Component Durability - Powershift Transmissions" (Package of 10)
- Special Publication, SEBF1021, "Improving Component Durability" Boxed set (Includes one each of the 7 "Improving Component Durability" series.)

# Contamination Control

- Special Publication, PEBJ0002, "Caterpillar Dealer Contamination Control Compliance Guide"

- Special Publication, PEBJ0007, "Caterpillar Customer Contamination Control Compliance Guide"
- Special Publication, PEDP9131, "Fluid Contamination - The Silent Thief"
- ASTM D6469"Standard Guide for Microbial Contamination in Fuels and Fuel Systems"

## Lubricants, Coolants, and Greases

- Data sheets, specifications, and recommendations for Cat lubricants, coolants, and greases are available through your Cat dealer and at the following website:

*http://parts.cat.com/parts/machine-fluids*

- Special Publication, PEWJ0074, "Filters and Fluids Application Guide"
- Special Publication, PEHJ0149, "Cat Filters and Fluids Toolbox Update - Datasheet Set"
- Special Publication, REHS1063, "Know Your Track-Type Tractor Cooling System"
- Special Publication, SEBD0518, "Know Your Cooling System"
- Special Publication, PEGJ0035, "Grease Selection Guide"

## Fuel

- Special Publication, PEHP7046, "Fuel Contamination Control Data Sheet"
- Special Publication, SENR9620, "Improving Fuel System Durability"
- Special Publication, SEBD0717, "Diesel Fuels and Your Engine"
- "ASTM D6751 Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels"
- "EN 14214 Automotive fuels - Fatty acid methyl esters (FAME) for diesel engines - Requirements and test methods"
- "ASTM D7467 Standard Specification for Diesel Fuel Oil, Biodiesel Blend (B6 to B20)"
- "ASTM D975 Standard Specification for Diesel Fuel Oils" (includes requirements for B5 and lower biodiesel blends)
- "EN 590 Automotive fuels - Diesel - Requirements and test methods" (includes requirements for B5 and lower biodiesel blends)
- "EN 14078 Liquid petroleum products - Determination of fatty acid methyl esters (FAME) in middle distillates - Infrared spectroscopy method"
- "EN 14104 Fat and oil derivatives - Fatty Acid Methyl Esters (FAME) - Determination of Acid Value"
- "ASTM D664 Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration"

- "ASTM D6469 Standard Guide for Microbial Contamination in Fuels and Fuel Systems"
- "Facts You Should Know About Renewable Fuels, EMA (Engine Manufacturer Association)"
- "EMA Technical Position on Use of Biodiesel Position Statement, EMA (Engine Manufacturer Association)"

*http://www.truckandenginemanufacturers.org/articles*

## S·O·S Services

- Special Publication, PEHJ0191, "S·O·S Services Data Sheet"
- Special Publication, PEHP7052, "Making the Most of S·O·S Services"
- Special Publication, PEGJ0046, "Understanding S·O·S Reports"
- Special Publication, PEGJ0047, "How to Take a Good S·O·S Sample"
- Special Publication, PEGJ0045, "Reporting Particle Count by ISO Code"
- Special Publication, PEDJ0129, "Fuel Sampling Guide"
- Special Publication, PEDP7036, "S·O·S Fluids Analysis Cornerstone"
- Special Publication, PEHP7076, "Understanding S·O·S Service Tests"

## Miscellaneous

- Special Publication, SEBU5898, "Cold Weather Recommendations"
- Special Publication, AECQ1043, "Caterpillar Product Line Brochure"
- Special Publication, NENG2500, "Caterpillar Dealer Service Tool Catalog"
- Special Publication, PECJ0003, "Cat Shop Supplies and Tools" catalog
- Special Publication, SENR3130, "Torque Specifications"
- Special Publication, SEBF1017, "Improving Component Durability - Component Removal and Installation" (Package of 10)
- Special Publication, SEBF1019, "Improving Component Durability - Hydraulics" (Package of 10)
- Special Publication, SEBD0348, "Caterpillar Performance Handbook"

## Additional Reference Material

SAE J183"Classification" This document can normally be found in the SAE handbook.

SAE J313"Diesel Fuels" This document can be found in the SAE handbook. Also, this publication can be obtained from your local technological society, from your local library, or from your local college.

SAE J754"Nomenclature" This document can normally be found in the SAE handbook.

Engine Manufacturers Association" Engine Fluids Data Book"

*Engine Manufacturers Association*
*Two North LaSalle Street, Suite 2200*
*Chicago, Illinois USA 60602*
*http://www.truckandenginemanufacturers.org/articles*

For information on the American Petroleum Institute (API) engine oil categories, contact the API at:

*1220 L Street, NW*
*Washington, DC USA 20005-4070*
*http://www.api.org*

Diesel Engines

| | |
|---|---|
| ABS | Agco-Sisu |
| Akasaka | Baudouin |
| BMW | Bukh |
| Caterpillar | CHN 25/34 |
| Cummins | Daihatsu |
| Detroit | Deutz |
| Doosan-Daewoo | Fiat |
| Ford | GE |
| Grenaa | Guascor |
| Hanshin | Hatz |
| Hino | Honda |
| Hyundai | Isotta |
| Isuzu | Iveco |
| John-Deere | Kelvin |
| Kioti | Komatsu |
| Kubota | Liebherr |
| Lister | Lombardini |
| MAK | MAN B&W |
| Mercedes | Mercruiser |
| Mirrlees BS | Mitsubishi |
| MTU | MWM |
| Niigata | Paxman |
| Perkins | Pielstick |
| Rolls / Bergen | Ruggerini |
| Ruston | Scania |
| Shibaura | Sisu-Valmet |
| SKL | Smit-Bolnes |
| Sole | Stork |
| VM-Motori | Volvo |
| Volvo Penta | Westerbeke |
| Wichmann | Yanmar |

Machinery

| | |
|---|---|
| ABG | Airman |
| Akerman | Ammann |
| Astra | Atlas Copco |
| Atlas Weyha. | Atlet |
| Bell | Bendi |
| Bigjoe | Bobcat |
| Bomag | BT |
| Carelift | Case |
| Caterpillar | Cesab |
| Challenger | Champion |
| Claas | Clark |
| Combilift | Crown |
| Daewoo-Doosan | Demag |
| Deutz-Fahr | Dressta |

Machinery

| | |
|---|---|
| Drott | Dynapack |
| Extec | Faun |
| Fendt | Fiat |
| Fiatallis | Flexicoil |
| Furukawa | Gehl |
| Genie | Grove-gmk |
| Halla | Hamm |
| Hangcha | Hanix |
| Hanomag | Hartl |
| Haulpack | Hiab |
| Hidromek | Hino truck |
| Hitachi | Hyster |
| Hyundai | IHI |
| Ingersoll-rand | JCB |
| JLG | John-Deere |
| Jungheinrich | Kalmar |
| Kato | Kioti |
| Kleeman | Kobelco |
| Komatsu | Kramer |
| Kubota | Lamborghini |
| Landini | Liebherr |
| Linde | Link-belt |
| Manitou | Massey-Ferg. |
| Mccormick | MDI-Yutani |
| Mitsubishi | Moxy |
| Mustang | Neusson |
| New-Holland | Nichiyu |
| Nissan | OK |
| OM-Pimespo | others-tech |
| Pel-Job | PH-mining |
| Poclain | Powerscreen |
| Same | Samsung |
| Sandvik | Scania |
| Schaefer | Schramm |
| Sennebogen | Shangli |
| Shibaura | Steiger |
| Steinbock | Steyr |
| Still | Sumitomo |
| Super-pac | Tadano |
| Takeuchi | TCM |
| Terex | Toyota |
| Valpadana | Venieri |
| Versatile | Vogele |
| Volvo | Weidemann |
| Wirtgen | Yale |
| YAM | Yanmar |