

Donaldson provides this technical reference as a collection for those who want to gain a better understanding of air filtration for engines.

Good filtration needs to be an integral part of the system to ensure the long life and proper operation of the vehicle and engine components. Today diesel engines are very sophisticated with many precision systems working together. These systems require optimum filtration to ensure their performance.

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What is Airflow Restriction?

The resistance to the flow of air through the air cleaner system; typically measured in inches of H₂O or kPa.

Restriction across the air cleaner is the difference in static pressure between the atmosphere and the outlet side of the system being measured. *Analogy: trying to pull liquid through a straw that is kinked versus one that is not. Obviously, the greater the kink, the harder it is to move liquid through.*

Air in an intake pipe acts much the same way. Any time the direction of the air is changed, there is a resulting pressure that increases the restriction of the system. While we can't totally avoid direction changes, they should be minimized.

Include Entire Airflow System When Calculating Initial Airflow Restriction

Any intake system design should incorporate the best protection at the lowest initial restriction possible. Because each intake component contributes to the total restriction of the system, it is recommended that the position of the air cleaner be as close to the engine as possible. It is also important to minimize the elbows, bends and long runs of duct work.

Changing the direction of the intake air movement causes restriction, which causes the engine to work harder.

While this is something we like to avoid, the reality is that it cannot be avoided totally . . . but just how much is too much, and what can be done about it?

Conversions:

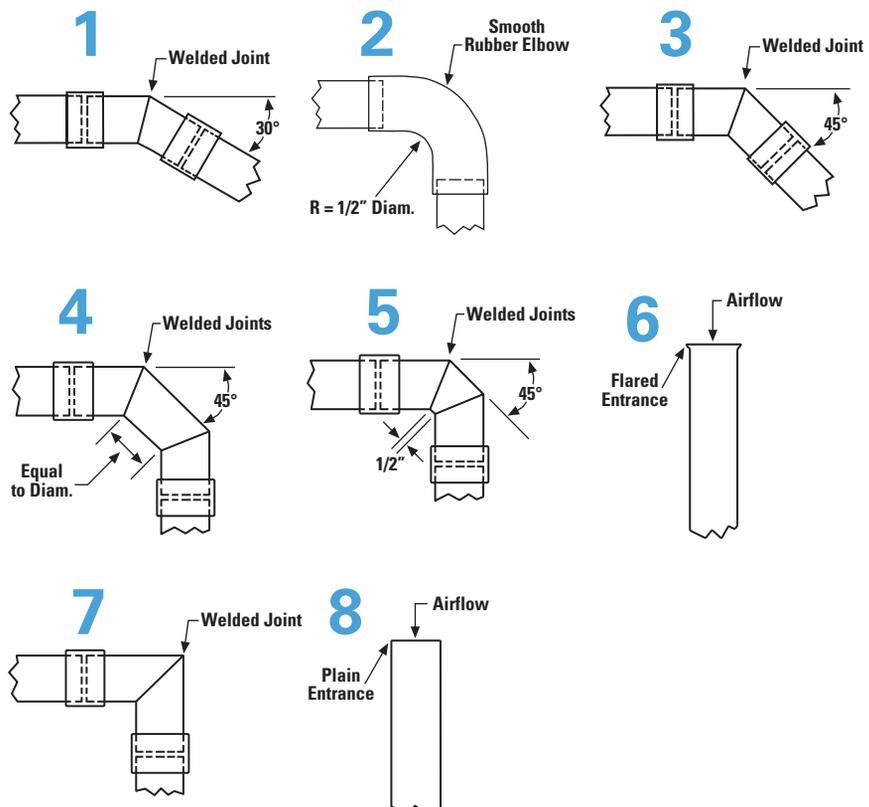
- 1" H₂O = 0.0361 psi = 0.249 kPa
- 1 cfm = 0.0283 M³/minute
- 1" = 25.4 mm
- 1 lb-ft = 1.35 N•m

The Affect of Elbows & Entrance Diameters on Air Cleaner System Restriction

Generally, the smoother the direction change, such as radiused tubes versus mitered bends, the lower the restriction. A 30° bend (figure 1) adds the least amount of restriction, while the 90° bend (figure 7) adds significantly more.

Remember that even straight pipe causes restriction and pipe with a cut-off blunt end will add much more than one with a flared inlet end. The slight flare makes a major difference in air turbulence, and consequently, in restriction.

Not only bends, but *length* of pipe is also a factor. For further details on the amount of restriction added to the system by piping and bends, see the next page.



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The Goal: Minimize the number of bends AND use bends that cause the least amount of restriction

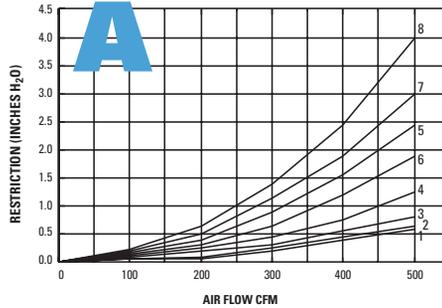
Graphs A, B, C, D and E show the amount of restriction of different piping diameters, with various types of bends (illustrations 1 – 8 as shown on opposite page), at various airflow levels. You will notice that the smoother the direction change, such as radiused tubes versus mitered bends, the lower the restriction. A 30° bend (shown in illustration 1) adds the least amount of restriction, while the 90° bend (shown in illustration 7) adds significantly more.

You may think it odd that straight pipe (shown in illustration 8) causes the highest amount of restriction. This is because of the blunt end. Compare the restriction curve to illustration 6, which shows a flared end. The slight flare makes a major difference in air turbulence, and consequently, in restriction.

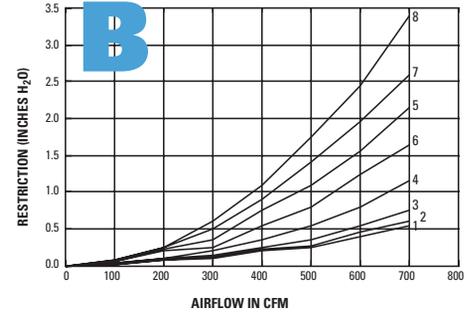
Length of pipe is also a factor, as shown in graph E. Find the line that represents your pipe diameter at the airflow level you're running to give you a restriction figure for each foot of pipe length; then multiply by the length (in feet) of your plumbing and you have the amount of restriction added by that length of pipe. (See example below graph E.)

These curves should allow you to do a quick calculation on the plumbing you are planning for your system. Add this figure to the restriction of your air cleaner (and pre-cleaner when used) to know if your system is too restrictive for the engine. Many engine manufacturers specify restriction limits for new, "clean" engine air intake systems.

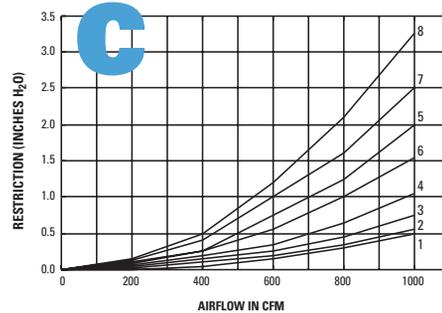
4" Diameter Piping



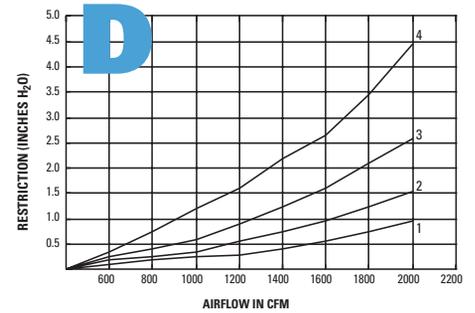
5" Diameter Piping



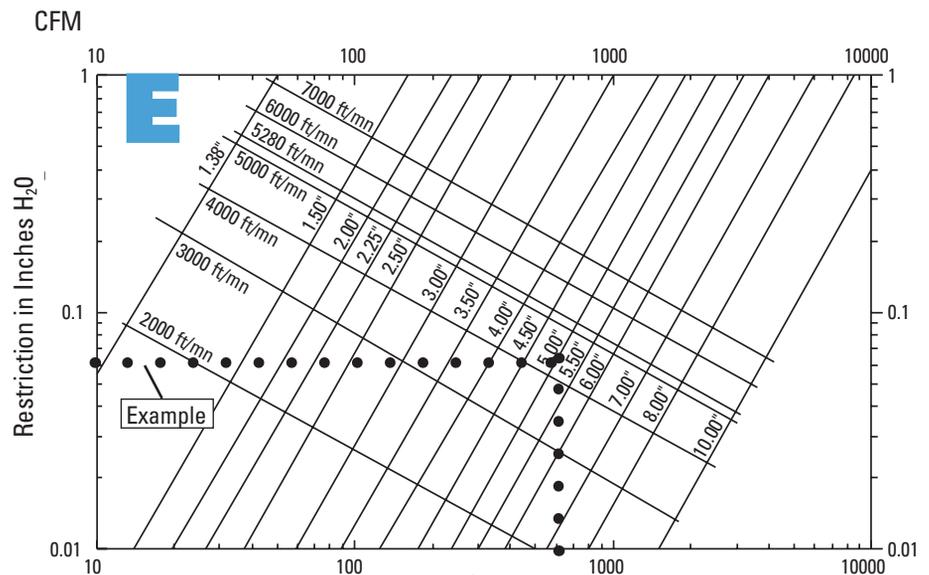
6" Diameter Piping



7" & 8" Diameter Piping



Straight Piping of Various Diameters



Example (Assuming a 600 cfm system with 5" piping)

1. At 600 cfm on horizontal axis, draw a line up to the 5" diameter line.
2. Draw a line from that intersection point over to the vertical axis to find the restriction point, in this case .06 H₂O.
3. Calculate: .06 x 10 feet of piping = .6" H₂O. This means that the 10 feet of 5" diameter piping add .6" H₂O of restriction to the engine air intake system.

Air Filter/ Air Cleaner

Device which removes particles suspended in the airflow as it is drawn into the engine.

Airflow Requirements

Air is critical to the operation of an engine. The amount of air required by the engine depends on the type of engine, if it has a turbocharger, and the engine horsepower (kilowatt) rating. The engine airflow requirement or specification is set by the engine manufacturer. Airflow requirements from the engine manufacturer should be requested for any changes or upgrades made to the air system.

Axial Seal

The axial seal sealing method requires a force between the air filter and air cleaner that provides enough compression on the gasket between the parts to create the seal.

CFM

CFM means cubic feet per minute. This is the unit of air flow measurement. An engine requires a flow of air for combustion.

Differential Pressure

Difference in static pressure measured immediately upstream and downstream of the unit under test.

Dust Capacity

Dust capacity is the amount of contaminant that will be collected on a filter before a specified restriction level (set by the engine manufacturer) is reached.

Dust Concentration

Dust concentration expresses the mass of dust in a specified volume of air. Typical ambient conditions are around 0.1 milligrams per cubic meter. Off-road conditions are around 100 milligrams per cubic meter.

Filter Media

Filter media is the material in the filter that removes the contaminant. Filter media in primary filters is made from cellulose and various combinations and blends of fibers combined with resins to keep the fibers together.

Manometer

A manometer is a device that can be used in-field for testing of a filter's initial restriction and confirming its remaining filter life. A manometer, or clock-type gauge, can be a more accurate method of restriction measurement.

Overall Efficiency

Overall efficiency is the percentage of dust that the air cleaner with a filter removes from intake air. Donaldson air cleaners, with a Donaldson air filter, have a 99.99+% overall efficiency.

Primary Filter

The primary filter is the filter in the air cleaner that removes around 99.9+% of the air's dust. The air flows through the primary filter first.

RadialSeal™ Technology

RadialSeal refers to filter sealing technology that uses the urethane end cap and the cleaner's outlet tube to create the seal. This has become the preferred method of sealing over older axial seal designs.

Rated Air Flow

Flow rate specified by the user or manufacturer; to be the maximum airflow required by the engine.

Restriction

Restriction represents the resistance to the flow of air through the air cleaner system. The static pressure is measured immediately downstream of the unit under test.

Typical units are inches of water ("H₂O) or kilopascal (kPa). Air cleaners with clean filters should have restrictions between 6-10"H₂O or 0,5 and 4 kPa

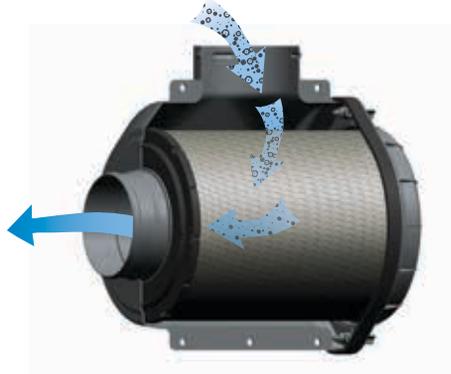
- 1 H₂O = 9,80665 Pa (Pascal)
- 1000 PA = 1 kPa (kilopascal)
- 100 Pa = 1mbar (milibar)
- 10 Pa = 1 daPa (decapascal)

Restriction Tap

This is the point on an air cleaner where a port exists to add a filter service indicator. Air filter service indicators measure air restriction and trip or engage depending on the airflow pressure on the inlet side of the housing.

Single-Stage Air Cleaner

A single-stage air cleaner is a dust removing system for intake air with a filter and no pre-cleaner.



Safety (Secondary) Filter

The safety (or secondary) filter is an optional filter that protects the engine during servicing of the primary filter and in case of a leak in the primary filter.

Multi-Stage Air Cleaner

Air cleaner consisting of two or more stages, the first usually being a pre-cleaner followed by one or more filters. If two filters are employed, the first is called the primary filter and the second one is called the safety or secondary filter.



Pre-cleaner

Device usually employing inertial or centrifugal means to remove a portion of contaminant prior to reaching the filter.



Test Air Flow

Measure of quantity of air drawn through the air cleaner outlet per unit time. The flow rate shall be expressed in cubic meters per minute or cubic feet per minute (CFM).

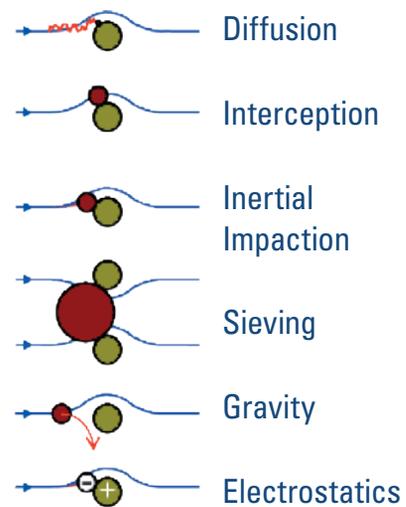
The Science of Air Filtration

Filtration & Separation Mechanisms

Filtration and separation mechanisms are integrated into the design tools used by Donaldson personnel in the development cycle of new products.

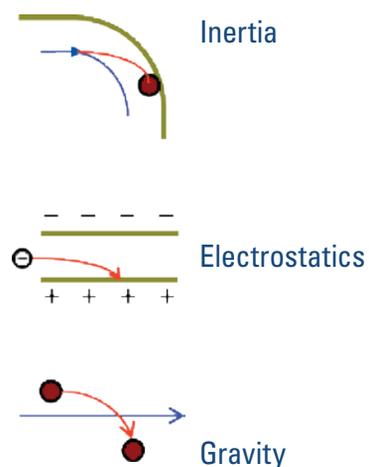
Filtration Mechanisms

Primary



Separation Mechanisms

Primary



Filter Media

Filtration media represents the central point of any filter design. Mastering this science is a key focus at Donaldson. While our users may not need to share this same level of understanding, some basics are always helpful. With the media representations below we hope to educate our customers on some of the more commonly used media types in this ever changing industry.

Today's engines are built to more stringent specifications and finer tolerances. Engine components require cleaner air to achieve better combustion and lower emissions. Your air intake system filter media and service practices can make the difference between engine power and engine problems.

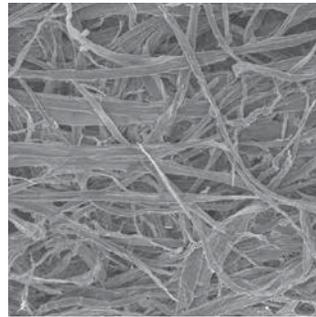
Cellulose (traditional media)

Primary dry filter media is a cellulose base material and used in the majority of our air filter applications. It is used primarily in two types of engine intake systems — single- or two-stage. Applications include off-road, on-highway trucks, buses, and underground mines.

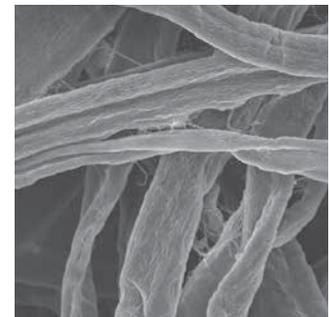
How it Works



SEM 100x



SEM 600x



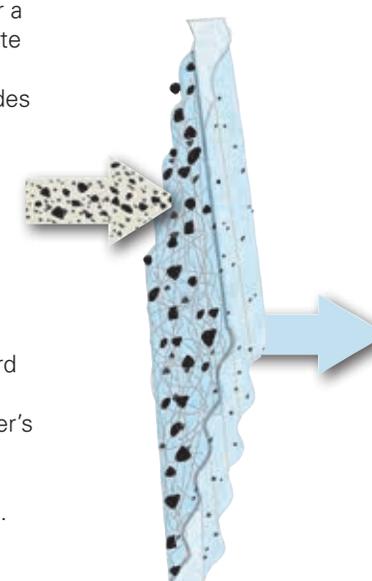
Media Image



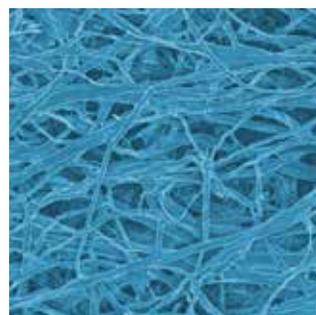
Ultra-Web® Nanofiber Technology

Ultra-Web® filter media is composed of a cellulose or a cellulose/synthetic substrate with nanofibers applied to one side. This media provides a durable filtration solution in the high temperature and humid environments experienced by diesel, turbine, hybrid, and other powered engines.

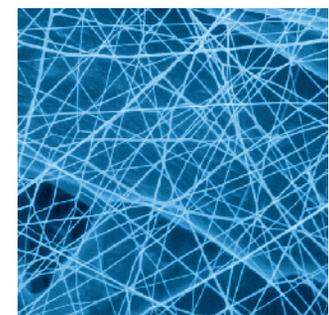
How it Works



SEM 100x



SEM 600x



Media Image



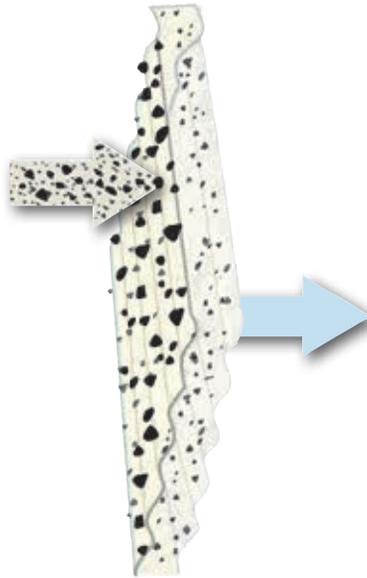
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Vibration Resistant Media

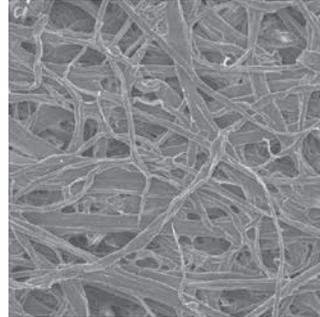
Vibration resistant filter media is a cellulose base material that offers maximum filtration protection and withstands high pulsation/vibration situations that would normally destroy other filter medias.

Applications include, but are not limited to, one, two and three cylinder engines and piston compressors.

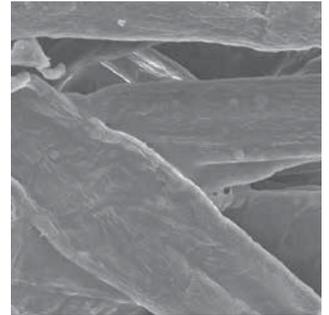
How it Works



SEM 100x



SEM 600x



Media Image

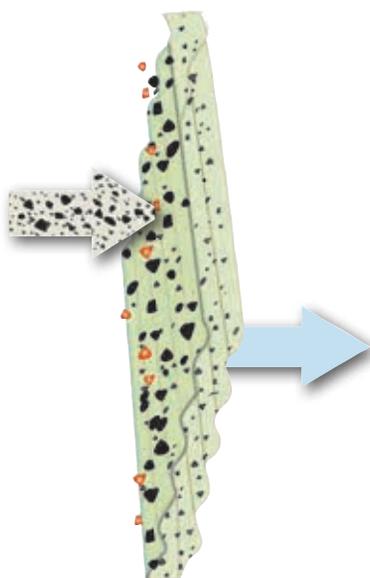


Flame Retardant, UL-approved Media

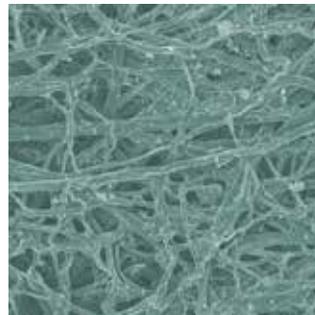
Flame retardant/UL-approved filter media is a cellulose base material specially treated for use on vehicles operating in industrial applications where sparks or flames from backfiring through the intake system create a fire hazard.

Grain elevators and warehouses are good examples of UL-approved filter media applications.

How it Works



SEM 100x



SEM 600x



Media Image

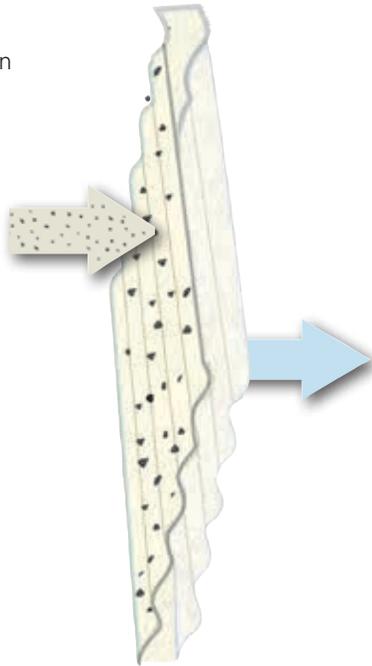


Safety Filter Media

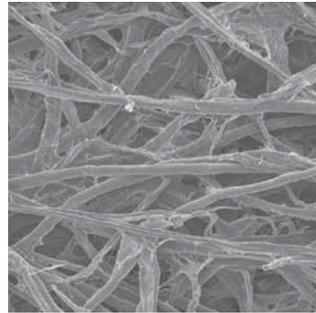
Pleated safety filter media is designed for heavy duty air cleaner systems with high velocity airflow and is used in safety filters — both single- and two-stage air cleaner systems. The safety filter protects the intake system while servicing the primary filter and in the event the primary filter is damaged.

The same media may be used for ventilation panel filters to remove dust, chaff and pollen from air entering vehicle cabs in construction, agricultural, industrial and mining applications.

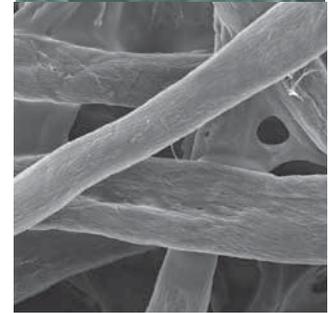
How it Works



SEM 100x



SEM 600x

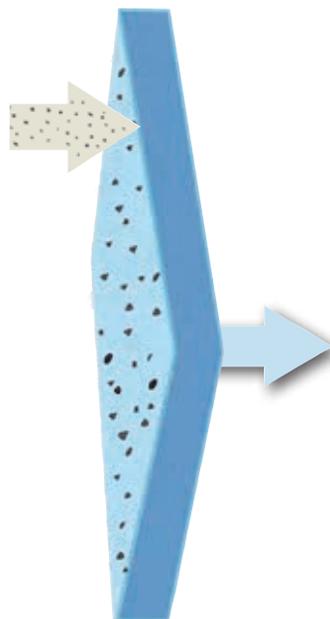


Media Image

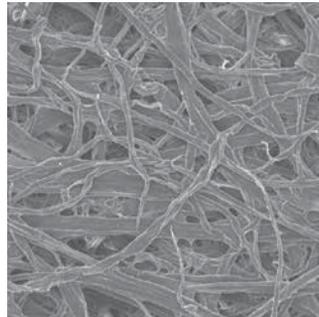


Non-pleated safety filter media has a synthetic base. It is primarily used in light to medium duty intake system two-stage air cleaners, e.g., Donaldson F Series or Cyclopac™ type air cleaners. The safety filter protects the intake system while servicing the primary filter and in the event the primary filter is damaged.

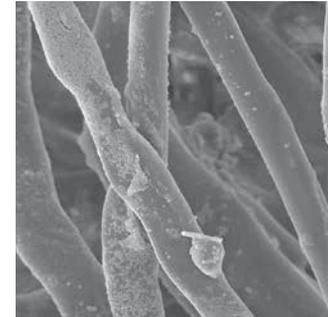
How it Works



SEM 100x



SEM 600x



Media Image



AIR FILTRATION TECHNICAL REFERENCE

Filter Efficiency: Donaldson air filters in Donaldson air cleaner housings have a 99.9+% minimum overall efficiency.

Questions often arise about the micron ratings and test procedures on air cleaners and replacement air filters. Typically, air cleaners and air filters are not assigned a “micron rating.” Micron rating is a term used in liquid filtration. Air filters are evaluated for life and efficiency using an industry-wide standard (ISO 5011). The following should clarify the questions surrounding this issue.

Filter life is measured in total grams fed or in hours of lab life and is determined by testing at a standard test dust concentration of 1 g/m³ (0.028 g/ft³) for single stage air cleaners or 2 g/m³ (0.056 g/ft³) for multistage units at either a constant or variable airflow. The end of the life testing is determined using the restriction method. When the predetermined restriction service point is reached, the test is stopped and the filter is weighed. The amount of test dust held by the filter is considered the capacity or life of the filter. The life of an air cleaner requires some additional consideration. Many air cleaners have inertial separators included in the housing. These inertial separators remove up to 98% of the dust that is fed during one of these tests. Therefore, the inertial separator efficiency must also be evaluated.

Filter efficiency is calculated by determining the increase in weight of an absolute filter (an absolute filter captures any dust that passes the test filter) located downstream of the test filter versus the weight of the total dust fed.

Table 1 details the particle size distribution of the standard test dust used for life and efficiency evaluations (ref. ISO 12103-1).

Table 2 lists common contaminants found in field environments, as well as their particle size ranges. Although field conditions vary from one location to the next and from time to time, this test allows for a standard means of comparison and a laboratory method of evaluating air cleaner life and efficiency.

Table 1 — Particle Size Distribution by Weight %

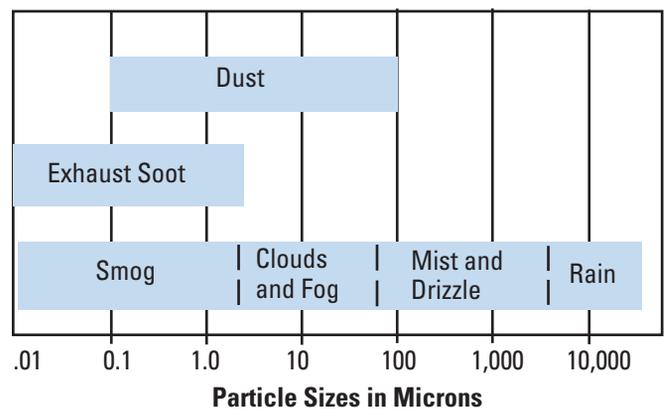
Fine test dust is used for testing primary dry air cleaners that are most often used in on-road and automotive applications, and coarse dust is used for multi-stage air cleaners that typically use inertial separators and operate in very dusty applications.

Particle Size Range (in microns)	Weight %*	
	Fine (on-road)	Coarse (off-road)
0 - 5 μ	39 %	12 %
5 - 10 μ	18 %	12 %
10 - 20 μ	16 %	14 %
20 - 40 μ	18 %	23 %
40 - 80 μ	9 %	30 %
80 - 200 μ	0%	9 %

* Percentage of weight can vary by ±2-3 % in each particle range



Table 2 — Common Contaminants and Micron Sizes



Reference: FMCTSB 04-03

Filter Cleaning:

Donaldson recommends servicing air filters by monitoring the airflow restriction levels in the intake system.

Some vehicle owners and maintenance supervisors, concerned with lowering their operating costs, will clean and reuse their heavy-duty air filters. Before you decide whether cleaning or washing of air filters is appropriate for your vehicle or fleet, please consider these factors:

- Heavy-duty air filtration manufacturers do not recommend any type of cleaning process be used on their products. Donaldson, like other heavy duty air filter manufacturers, does not warrant the air filter once it has been cleaned.
- Filter dirt holding capacity is reduced 20 – 40% with each cleaning.
- Rather than cleaning or reusing filters, consider upgrading to an extended service filter (i.e., Donaldson Endurance™ air filters) and service the filter by restriction.
- There is a risk of dirt reaching the clean side of the filter while cleaning, plus possible filter damage from high pressure water or compressed air, making cleaning or washing a gamble. Be sure to add the potential cost or risk of filter damage to the cost of cleaning when determining the value of a filter cleaning process.
- Damaged filters should not be cleaned or reused. If a filter is damaged in service, investigate the source of damage and make corrections to avoid future damage.
- Reusing a cleaned heavy-duty filter increases the likelihood of improper air cleaner servicing because of the shortened service life. Each time the air intake system is serviced, it is exposed to the chance of contamination.
- Never attempt to clean a safety filter. Replace it after three primary filter change outs.



Reference: FMC Technical Service Bulletin 89-4R2.

What is the Purpose of a Safety Filter?



Safety filter . . . Secondary element . . . Inner filter . . .
Spare filter? These filters go by many names . . .

At Donaldson we prefer to call it a “safety” filter. A safety filter backs up the primary (main) filter and protects the engine while the primary filter is out of the housing during servicing. The engine should never be run with only a safety filter in place.

The safety is NOT a spare filter! Its purpose is to protect the engine if something goes wrong with the primary (main) filter. Until then, it quietly does its job.

Compared to a primary filter, the safety filter is more open for lower restriction and is less efficient. A safety filter does not increase the overall operating efficiency of an air cleaner.

A safety filter is there to protect the engine against hidden damage to a primary filter — damage from cleaning, mis-installation, a “will-fit” that doesn’t quite fit, or the installation of the wrong size filter. A safety filter is never to be used as a “spare” filter.



Switching from a Scheduled Maintenance Air Filter to an Extended Service Filter?

Interested in switching your scheduled maintenance air filter to Donaldson Endurance™ extended service air filter?

- Use only Donaldson Endurance™ Air Filters
- Maintain accurate records of current competitive cellulose media change intervals
- Keep accurate track of miles driven with Donaldson Endurance™ air filters and maintenance records
- Provide filter for inspection
- Rely on your filter service indicator to tell you when to change out your primary filter.
- Standard Donaldson warranty terms and conditions apply



Installation Guidelines for STB Strata System

Positioning the Strata™ Pre-Cleaner

- It is usually best to have the pre-cleaner positioned above the hood of the vehicle so that cleaner air (above the dust cloud) can be drawn into the unit.
- The pre-cleaner section should be below the exhaust stack. Be careful NOT to mount the Strata™ pre-cleaning section in such a way that it draws in exhaust gases from the exhaust stack.

If the pre-cleaner cannot be positioned according to the above guidelines, consider adding an extension to put the intake point at a higher level.

- The extension should be added above the Strata tube section, below the inlet hood.
- Do NOT mount the Strata pre-cleaner on top of the extension as its weight would make the arrangement top heavy and unstable.

Scavenge Hose

The scavenge line between the air cleaner and the exhaust ejector should be kept as short and as straight as possible. The ideal scavenge hose length for a Strata system is under five feet and should never be longer than 10 feet.

Minimize bends and be sure that the hose is supported properly. (Unsupported lengths of hose should not exceed five feet.) Bend radii of the hose should not be less than 15 inches. Minimize the number of 90° bends — preferably two or fewer.

Donaldson recommends three-ply silicone hose for the scavenge line. All Donaldson hose is supplied in 3-foot lengths (do not use flexible metal nor rigid tubing).

STB Model	Scavenge Outlet OD	Hose Part No	Hose ID
B160071	2.0"	P171381	2.0"

Connecting Scavenge Hose to Pre-cleaner

A check valve is built into the Strata Pre-cleaner. Connect the scavenge hose directly to the outlet tube with a clamp. A Donaldson lined hose clamp is recommended (see Intake Accessories section).

Connecting Hose to Ejector

When connecting the scavenge hose to the exhaust ejector, leave 2" (52 mm) between the end of the hose and the body of the ejector.

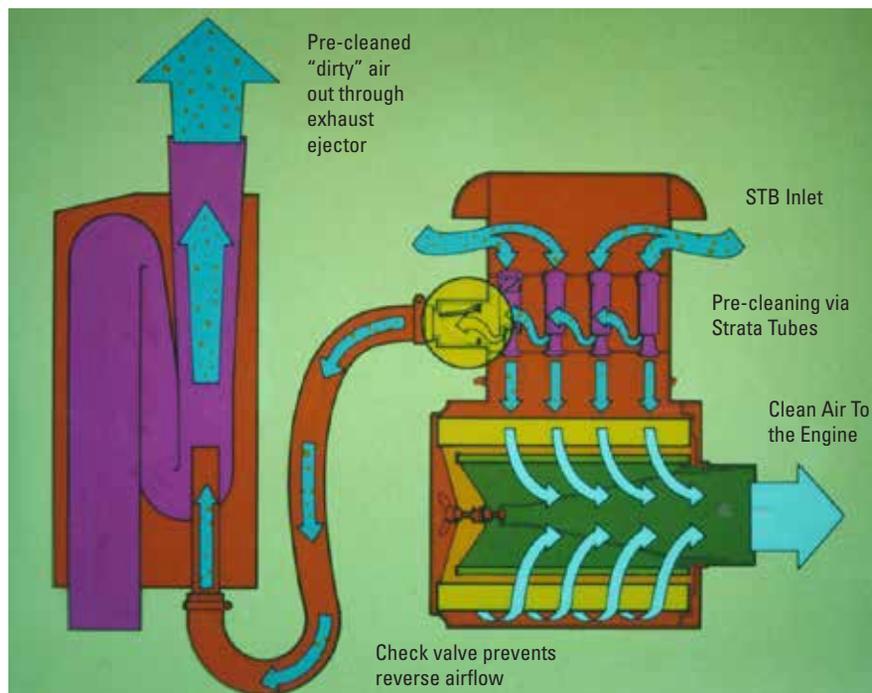
Exhaust Ejectors

See the accessories section for details on our exhaust ejector product offering.

Do not add or create any additional back pressure downstream (e.g., at the exhaust outlet) of the Strata pre-cleaner. Doing so may cause exhaust back flow to the pre-cleaner.

Examples of what NOT to do: mount a spark arrestor on top of the ejector, or operate with a stuck or frozen rain cap on the exhaust ejector.

How the Strata™ System Works



Note: Scavenge Hose, Exhaust Ejectors, Clamps Sold Separately

Q: Why am I experiencing short air filter life?

A: The amount of dirt an air filter can hold before servicing depends on many variables. The environment must be considered (severe dust, soot, and moisture) as it is crucial to know how much contaminant reaches the filter. This depends on the severity of the environment and whether the air cleaner is a one- or two-stage design. Another factor is the size of the air cleaner and filter relative to the airflow requirement. How long a filter lasts is largely a function of the Original Equipment Manufacturer's intake design.
Reference FMC TSB 89-3R3 and 06-2 for further details.

Q: What is the micron rating of my air filter?

A: Typically, air cleaners and air filters are not assigned a "micron rating." Micron rating is a term used in liquid filtration. Air filters are evaluated for efficiency using an industry-wide standard ISO 5011. Efficiency is the percentage of contaminant that a filter removes from the intake air relative to its capacity.
Reference FMC TSB 04-3 for further details.

Q: What do inches or millimeters of H₂O have to do with an air cleaner?

A: In an intake filtration system the resistance to airflow is called restriction. Restriction is typically measured in units called inches or millimeters of H₂O vacuum, and is defined as the difference in static pressure between the atmosphere and the outlet side of the system being measured. The higher the restriction the harder an engine has to work to obtain clean air for combustion. Engine manufacturers specify a restriction level at which the air filter should be serviced.
Reference FMC TSB 89-3R3 for further details.

Q: Why do some air filters require U.L. approval?

A: Some engine air filters utilize flame retardant filter media to meet UL safety requirements. The U.L. rating covers fire safety and backfire resistance aspects of industrial trucks with internal-combustion engines, such as tractors, platform-lift trucks, fork-lift trucks, and other specialized vehicles for industrial use. These requirements do not cover other possible safety aspects of such equipment. Additional information can be found in UL 558 specification.

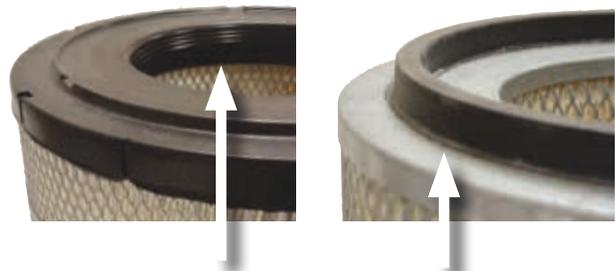
Q: Can you judge air filter service life by visual inspection?

A: Visual inspection is not a recommended method for determining an air filter's service condition. Measuring intake system restriction is the most reliable determination of filter life. Service by restriction allows the filter to remain in service until the maximum allowable restriction limit for the application is reached. Various restriction indicating devices are available for this purpose.
Reference FMC TSB 89-3R3 for further details.

Q: Can I replace my axial seal filter with the new RadialSeal™ design?

A: Axial seal and RadialSeal air filters are designed to seal differently. "Radial" sealing design filters cannot be fitted into a housing design for axial sealing replacement filters without the use of a conversion kit.

Reference FMC TSB 97-3R2 for further details.



RadialSeal™ Technology
RadialSeal filters slip easily on and off the outlet tube during installation and service. This design eliminated the separate gaskets used with metal endcap filters.

Axial Seal
Axial seal style filter has a metal endcap with an attached gasket. This design requires housing cover pressure on a gasket to create the critical seal.

Q: Can heavy duty air filters be cleaned or reused?

A: Most heavy duty air filter manufacturers do not recommend any type of cleaning process to be used on their products. Furthermore, they do not warrant their product once it has been cleaned.

Donaldson does not recommend cleaning filters. Cleaning a filter in any way, will void the filter warranty.
Reference FMC TSB 89-4R2 for further details.

Q: Will more frequent servicing of my air cleaner extend my engines life?

A: Just the opposite, over-servicing will cause increased service cost, time and material and dust contamination of the engine due to:

1. Filter damage, due to excessive handling,
2. Improper installation of filter,
3. Increased initial inefficiencies.

Reference FMCTSB 89-3R3 for further details.

Q: What is a scavenged intake system?

A: Some intake system pre-cleaners are inertial separating devices that require a scavenge flow of air to function properly. The scavenge flow is required to expel the inertially separated dust particles from the pre-cleaner assembly. Scavenge flow is typically provided by a vacuum from an exhaust ejector that may be designed in as a function of the exhaust system muffler or as an add-on exhaust ejector stack.

Scavenged systems are typically specified on severe-duty applications to increase airflow and extend primary filter life.

Q: What's the best type of pre-cleaner for a given application?

A: Intake system pre-cleaners are typically inertial separating devices intended to work in conjunction with the air cleaner to clean intake air prior to the final filtration stage provided by the filter. Separating some of the contamination from the intake air prior to reaching the filter provides an increase in filter service life. The type of pre-cleaner recommended for an application typically will depend on the severity of the environment. To maximize filter service life, choose the pre-cleaner design that provides the best efficiency within space and weight limits of the application.

Q: When should I service an air filter?

A: The filter in any air cleaner should be serviced when the maximum allowable restriction, established by the engine manufacturer, has been reached. The filter should not be serviced on the basis of visual observation because this will generally lead to over-servicing.

Over-servicing will cause increased service cost, both time and material, and may cause dust contamination of the engine due to:

1. Filter damage from excessive handling,
2. Increased chance of improper installation of filter,
3. Increased initial inefficiencies.

Achieving Maximum Air Filter Efficiency

The efficiency of an air filter increases as it is used. As soon as the air filter is put into operation, it begins to remove harmful dust particles. As these particles accumulate throughout the filter media, the microscopic openings in the media become obstructed. This on-going reduction in the size of the openings helps the filter stop increasingly finer dust particles, thus resulting in a more efficient filter. As the filter continues to plug with contamination, the restriction to air flow will increase. Most engine manufacturers establish a maximum degree of vacuum in the air induction system that the engine can tolerate and still operate efficiently.

Measuring Restriction in Air Cleaners

As a dry air cleaner filter becomes loaded with dust, the vacuum on the "engine side" of the air cleaner (at the air cleaner outlet) increases. This vacuum is generally measured as restriction in "H₂O or Kpa.

The engine manufacturer often places a maximum allowable limit on the amount of restriction the engine can withstand without loss of performance before the filter must be serviced.

Mechanical gauges, warning devices, indicators, and water manometers are available to inform the operator when the air cleaner restriction reaches this recommendation limit. These gauges and devices are generally reliable, but the water manometer is the most accurate and dependable.

To use the manometer, hold vertically and fill both legs approximately half full with water. One of the upper ends is connected to the restriction tap on the outlet side of the air cleaner by means of a flexible hose. The other end is left open to atmosphere. With the manometer held vertically and the engine drawing maximum air, the difference in the height of the water columns in the two legs — measured in inches — is the air cleaner restriction.



A restriction indicator's "lock-up" restriction level is generally marked on the indicator itself. A quick method to check a visual indicator is to remove it, wipe the base clean, then suck on the indicator with your mouth. If the indicator locks up, it is operational, if not, replace indicator. A more accurate method is to check the calibration against a water manometer.

Q: Why Service?

A: Proper air cleaner servicing will result in maximum engine protection against the ravages of dust. Proper servicing can also save you time and money by increasing filter life and efficiency.

Two of the most common servicing problems are:

- 1) Over-servicing — new filters increase in efficiency as dust builds up on the media. DON'T BE FOOLED by filter appearance, it should look dirty. By using proper filter restriction measurement tools you will use the full life of the filter at maximum efficiency.
- 2) Improper servicing — your engine is highly vulnerable to abrasive dust contaminants during the servicing process. The most common cause of engine damage is due to careless servicing procedures. By following the steps shown in this catalog, you can avoid unnecessary dust contamination to the engine.

Q: Why Would a Heavy-Duty Diesel Engine Air Filter Collapse

A: Most reputable filter manufacturers design their air filters to operate well beyond the recommended engine intake restriction service points. In fact, there is usually a safety factor of at least 2 – 3 times over the stated service point. However, there are circumstances when filter collapse can take place. When an engine is operating with a collapsed filter, there is a good chance that unfiltered air is getting to it, which could result in costly repairs. Most of the time poor maintenance is the cause, but there are some operating conditions to consider as well.

Collapse of a heavy-duty air filter is defined as a permanent deformation of the unit after airflow is removed. This occurs when the pressure drop across the filter exceeds the design limit of the device. Because of the safety factors built-in when the filter is engineered, this is an unusual event and is normally preventable.

A common cause of filter collapse is not paying attention to the service point recommended by the engine manufacturer. Diesel engines typically have an intake filter service point of 20-30" H₂O (5-7.5 kPa), depending on the manufacturer. As stated above, exceeding this by an incremental amount won't cause the filter to collapse, as they are designed to withstand



a much higher level of restriction. However, because filters tend to load very quickly after a certain point, not servicing them soon after the maximum allowable restriction is reached (as recommended by the engine manufacturer) can end up causing a very high level of pressure drop across the filter, and may result in a collapse condition. The best way to avoid this is to install and monitor a restriction measuring device (gauge, pop-up indicator or dash light), and replace the filter when it indicates the service point has been reached.

Another possibility of filter collapse is sub-standard filter construction or remanufacture. Generally, obtaining air filters from a reputable manufacturer will avoid this issue. Quality heavy-duty air filters are made with materials that can withstand high levels of pressure drop and resist collapse, while sub-standard filters may not. It is also important to inspect all filters before installation. Dented liners or end caps may result in a loss of structural integrity and filter collapse.

Damage may be present but not very visible. If the filter shows any sign of damage, don't use it. This is especially critical when using cleaned filters. Couple the possibility of damaged filters with weakened media (if it were washed or cleaned with too high of a pressure) and the filter may have a much lower resistance to collapse. Operating conditions should be considered as well. For example, high levels of soot (generally from diesel engine exhaust) can plug an air filter rapidly, which may shorten the life of a filter dramatically. If a restriction indicating device isn't monitored closely, an extremely high pressure drop across the filter could occur, which could cause it to collapse. If high levels of soot are experienced, the cause of the ingestion should be investigated and, if possible, corrected. These include (but are not limited to) proximity of the intake to the exhaust; exhaust leaks near the air intake; vehicles operating or idling in close quarters; and operating in certain areas where exhaust concentrations are high.

Extremely high levels of water ingestion can be a concern, too. Although most filters can take a certain amount of moisture with no problems, large amounts of water can weaken and plug the filter media long enough to cause collapse. However, this is an unusual situation because most vehicles that are likely to be used in these types of conditions have a water separation device installed. One possible cause of excessive water ingestion not often accounted for is the introduction of high levels of moisture during the washing of the vehicle. The best practice is to ensure the engine is not operating during washing and water is not sprayed directly into the engine air intake.

In summary, following the engine manufacturer's service recommendations, using quality undamaged products and using a restriction indicating device are the best practices to prevent air filter collapse. If a filter collapse occurs, it is important to ascertain whether lack of maintenance caused the problem or if the vehicle is used in conditions that dramatically shorten filter life, and then take corrective action to keep it from happening again.