

Selection of Air Filter for Automobile Engines

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Abstract: This paper concentrates idea about importance of air filter in automobile engines, it's influence on engine performance. Paper also deals with general guidelines and procedure for selection of air filter in automobile. Air filter can be defined as fibrous material device used to remove unwanted subtended particles from air like dirt, dust, pollen & many other undesired things. Many times, it may contain chemical agents like Absorbent or catalysts to improve air quality eliminate odors and active gaseous.

Keywords: Air filter, Engine, Contamination

I. Introduction

Air is very crucial thing for combustion in any engine because oxygen present in air helps to burn fuel. Proper quantity of oxygen required in complete combustion which has great impact on effluents, efficiency and life of engine too. ^[2] An average heavy-duty diesel truck engine requires 13,000 to 20,000 liters of air to burn 1 liter of fuel. ^[3] Air is polluted by many particulates like dirt, fumes, smog & other suspended particles. Though this contaminant are invisible but harmful to engine; even they are capable to damage engine components. Under normal condition air consumed by 16 liters engine contains almost 20kg of dirt per 100000 km. ^[3] air filter does not allow abrasive particulate matter to enter in to engine's cylinders. Where these particles can cause wear and oil contamination. Filter in its simplest form can be of pleated form i.e. flat panel form. It is kept in plastic casing and connected to throttle body of just above carburetor. The overall unit containing filter and housing together called as air cleaner. ^[1]

1.1 Types of Air Filters

There are many types of air filters are in use most common types are as follows:

A. Foam

Another automobile air filter element is Oil-wetted polyurethane foam. previously Foam was used as air cleaners on small engines like lawnmowers. Foam filters are widely used on air compressors for air tools up to 5Hp. Depending on the grade and thickness of foam used, this type of filter can offer minimal flow restriction. the dust is captured on foam filters, large amounts of dust trapped without major change in airflow restriction. Example: off-road rallying, motorsport.



B. Cotton

Oiled cotton cloth is employed in a growing number of automotive air filters to improve its performance. In old days cotton cloth saw limited use as automotive air filters. However, since the introduction of Abarth SS versions, the Fiat subsidiary supplies cotton cloth air filters as OE filters.

C. Stainless steel

Stainless steel mesh is another type of air filter which allow large quantity of air to pass through. Stainless steel mesh comes with different mesh sizes which gives different filtration standards. In some latest engine lacking in space for a cone based air filter forces designer to opt to install a simple stainless-steel mesh over the turbo to ensure no particles enter the engine via the turbo.

D. Oil bath

This follows labyrinthine path through which the air must travel in a series of U-turns: up through gap between the insert rims and the sump, down through the gap between the outer insert wall and the inner sump wall, and up through the filter media in the insert body. This U-turn set up helps air at higher velocity over the oil pool surface. Larger and heavier dust and dirt particles cannot make the turn due to inertia and eventually fall into the oil and settle to the bottom. Lighter and smaller particles are trapped by the filtration media in insert. It is used where high levels of dust are encountered without loss of filtration efficiency or airflow. Also gives an advantage of cleaning and servicing such air cleaners

Example: off-road equipment, earth moving equipments.

E. Water bath

Around 20th century water bath air cleaners were used applications like cars, trucks, tractors, and portable and stationary engines. They worked on the same principles as oil bath air cleaners.

II. Significance Of Air Filter

Air intake is kind of open loop system. The only way to avoid contaminants entry into engine is use of filter. Air which is inhaled by engine must be clean as much as possible. Contaminated air effects on performance of engine, increases fuel consumption, exhaust fumes which are harmful to the environment. A properly performing air filter resulting in to reduced wear and extended life. Air filter is expected to clean all pre-combustion air & supply it free from contaminants. filtration systems helps engine to perform more fuel efficient^[a];

The Organization for Economic Co-operation and Development [1981] report states that “excessive pressure across a dirty air filter” can cause a 1–15% increase in fuel consumption.^[b] In the Thornton [1976] studied “deliberate malfunctions,” defined as maintenance problems such as damaged spark plugs, poor idle mixture, improper idle speed, and “restricted air cleaners.” he tested six vehicles and out of those five were tested with clogged air filters.^[c]

Atkinson [1977] tested number of vehicles by masking the cross sectional area of air of cleaner and states that Two of the vehicles showed reduction in fuel economy by 1% , two others by 11% and 15% , and the fifth vehicle showed by 30% due to the clogged air cleaner.^[d]

2.1 Clogged Air Filter

Question may arise that at what condition an air filter is assumed to be clogged or said to be restricted. Technically defining a clogged air filter is very important from maintenance point of view. A well-designed air intake filter is associated with following general objectives:

1. Engine durability
2. Filtration
3. Flow management
4. Pressure or head loss constraints
5. Overall noise, vibration, and harshness standards
6. Service requirements
7. Packaging
8. Styling/appearance
9. Emissions

All above mentioned functions are to be performed by filter over stipulated period without failure. The standard service life of an air filter in light and medium duty applications at normal driving conditions, is about 48,300 km. ^[3] the service life of an air filter is defined as a level of clogging which results in a pressure drop

across the filter of approximately 2.5 kPa (10 in. water) more than the pressure drop of the clean filter. The “final pressure drop” when conducting tests to investigate filter cleaning procedures can be calculated by : Final pressure drop = initial clean pressure drop + 2.5 kPa. [8]

III. Procedure For Selection Of Air Filter

3.1 Finding air flow requirements

Mass of air flow required for a engine can be calculated from engine data sheet or communicating the engine manufacturer directly. By using the formula

$$\text{AirFlow (m}^3/\text{min)} = \frac{\text{SweptVolum e (ltr) * N (rpm) * Volumetric Efficiency * Pulsation Factor}}{1000 * (\text{CycleFactor})}$$

(1)

Volumetric Efficiency

- VE = can be greater than >2 for new engine designs
- VE = 1.3 to 1.8 for 4 stroke engine with turbocharger
- VE = 0.85 for 4 stroke engine that is naturally aspirated
- VE = 1.4 for 2 stroke engine with Roots blower
- VE = 1.9 for 2 stroke engine with Turbocharger

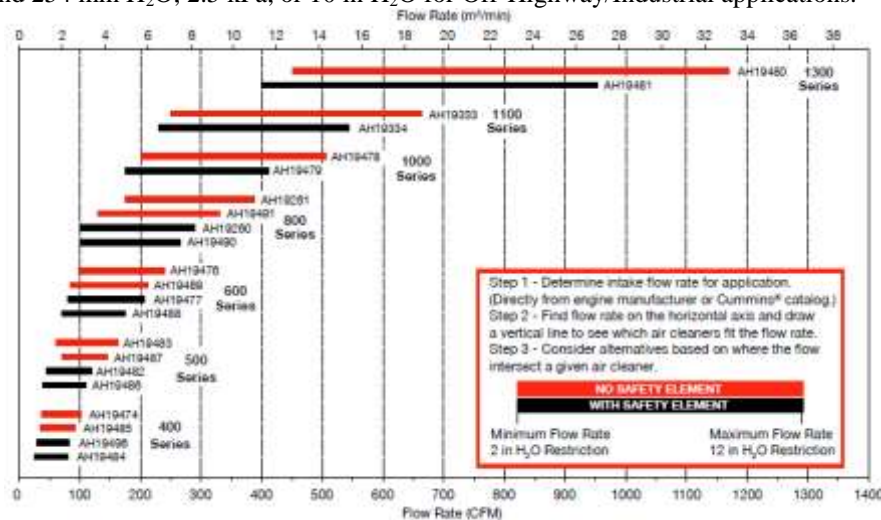
Cycle Factor

- CF = 2 for a four stroke engine
- CF = 1 for a 2 stroke engine

Pulsation Factor - only applicable to naturally aspirated engines with and having 3 cylinders or less

- PF = 2-2.1 if only 1 cylinder
- PF = 1.4-1 for two cylinders
- PF = 1.33 for three cylinder

If no data is available then one can use the 152 mm H₂O, 1.5 kPa, or 6 in H₂O as rule of thumb for On-Highway applications and 254 mm H₂O, 2.5 kPa, or 10 in H₂O for Off-Highway/Industrial applications.

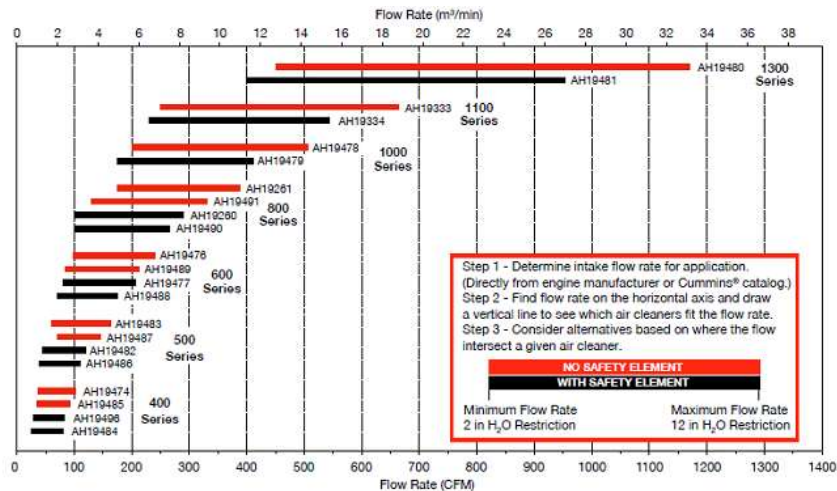


3.2 Finding out class of an air cleaner

Designer should think about what type of application or environment that filter will operate. For example

1. Under category of light dust concentration environment like highway, marine, residential, stationary equipments Single stage air cleaner single stage air cleaner is enough
2. Under category of medium dust concentration environment like on/off highway, asphalt equipment, forklifts, industrial vehicles two stage air filter is enough
3. Under category of heavy dust concentration environment like off road industrial, equipment with heavy dust, construction, mining, convey on road, agricultural vehicles two stage air cleaner with safety element will perform satisfactorily

If the working conditions are not clear, then over specifying of filter class should be recommended. For light dust environment dust quantity ranging from 1.5 to 3 g/CFM.



3.3 Select proper air cleaner

Designer should identify the flow versus restriction curves to find out the restriction at desired flow rate then one should check the dimensional data provided by engine manufacturer to ensure it fits into given space.

Also, Inlet and outlet size and pressure loss in ducting should be considered for example: Pressure loss through upstream and downstream ducting 0.75-1.25 kPa (3-5 in H₂O). Poor ducting designs can more than double this effect. Correct duct design and care taken to reduce initial restriction will help to improve the air cleaner capacity and increase service life.

The following are key terms to minimize pressure drop:

1. air intake openings are as large as possible. Utilize ideal openings to make flow path smoother.
2. Least number of turns, sharp angles and rough surfaces should be kept
3. Keep the duct diameter as large as possible throughout the system.
4. When merging two flows, use gradual “Y” angles. A gradual “Y” angle is preferred, as “T” style connections result in too much pressure loss due to turbulence.

Ducting Designs

Ideal Design



Marginal Design



Negative Design



IV. Conclusion

Above is the generalized design procedure for selection of Air filters of automobiles. As air filter is an important part of automobile power plant system. Inducted air must be clean so that the engine parts life is extended. It also affects the performance of engine, so proper steps should be adopted to select an air filter for an automobile engine.

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