

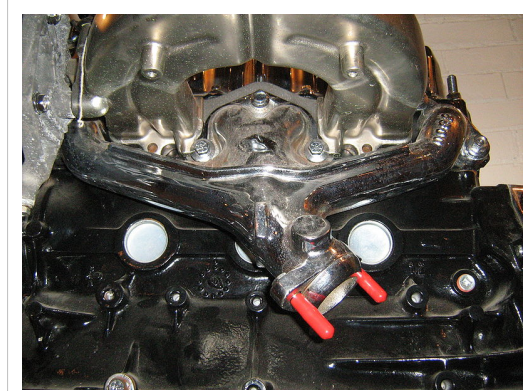
Exhaust system

An **exhaust system** is usually tubing used to guide reaction exhaust gases away from a controlled combustion inside an engine or stove. The entire system conveys burnt gases from the engine and includes one or more **exhaust pipes**. Depending on the overall system design, the exhaust gas may flow through one or more of:

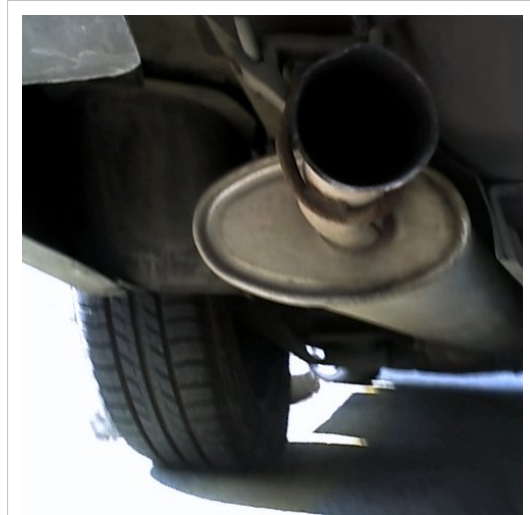
- Cylinder head and exhaust manifold
- A turbocharger to increase engine power.
- A catalytic converter to reduce air pollution.
- A muffler (North America) / silencer (Europe), to reduce noise.

Design criteria

An exhaust pipe must be carefully designed to carry toxic and/or noxious gases away from the users of the machine. Indoor generators and furnaces can quickly fill an enclosed space with carbon monoxide or other poisonous exhaust gases if they are not properly vented to the outdoors. Also, the gases from most types of machine are very hot; the pipe must be heat-resistant, and it must not pass through or near anything which can burn or can be damaged by heat. A chimney serves as an exhaust pipe in a stationary structure. For the internal combustion engine it is important to have the Exhaust System "Tuned" (refer to tuned pipe) for optimal efficiency.



Exhaust manifold (chrome plated) on a car engine



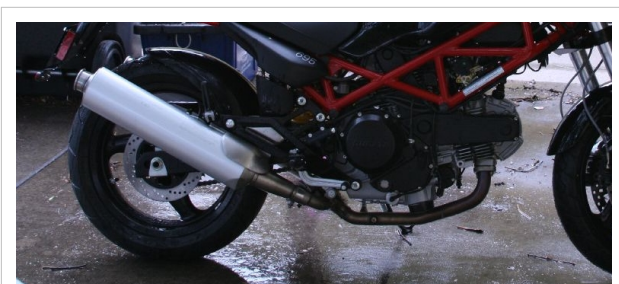
Muffler and tail pipe on a car

Motorcycles

In most motorcycles all or most of the exhaust system is visible and may be chrome plated as a display feature. Aftermarket exhausts may be made from steel, aluminium, titanium, carbon fiber or kevlar.

Motorcycle exhausts come in many varieties depending on the type of engine and its intended use. A twin cylinder may flow its exhaust into separate exhaust sections, such as seen in the Kawasaki EX250 (also known as the Ninja 250 in the US, or the GPX 250).

Or, they may flow into a single exhaust section known as a two-into-one (2-1). Larger engines that come with 4 cylinders, such as Japanese supersport or superbikes (such the Kawasaki ZX series, Honda's CBR series, Yamaha's YZF series, also known as R6 and R1, and Suzuki's GSX-R series) often come with a twin exhaust system. A "full



Ducati muffler

system" may be bought as an aftermarket accessory, also called a 4-2-1 or 4-1, depending on its layout. In the past, these bikes would come standard with a single exhaust, as seen on the Kawasaki ZX-6R 2000 and 2001 models. However, EU noise and pollution regulations have generally stopped this practice, forcing companies to use other methods to increase performance of the motorcycle. This has often led to a decrease in fuel economy, because of increased weight of the exhaust system and manufacturers forcing more fuel into the engine to gain extra power.

Trucks

In many trucks / lorries all or most of the exhaust system is visible. Often in such trucks the silencer is surrounded by a perforated metal sheath to avoid people getting burnt touching the hot silencer. This sheath may be chrome plated as a display feature. Part of the pipe between the engine and the silencer is often flexible metal industrial ducting, as in the image in the section "Terminology". Sometimes a large diesel exhaust pipe is vertical, to blow the hot noxious gas well away from people; in such cases the end of the exhaust pipe often has a hinged metal flap to stop debris and birds and rainwater from falling inside. Sometimes these exhaust pipes have a flex connector attached with it. This helps in minimising the vibration from the engine to be transferred into the exhaust system.

Two-stroke engines

In a two-stroke engine, such as that used on dirt bikes, a bulge in the exhaust pipe known as an expansion chamber uses the pressure of the exhaust to create a pump that squeezes more air and fuel into the cylinder during the intake stroke. This provides greater power and fuel efficiency. See Kadenacy effect.

Marine engines

With an onboard diesel engine below-decks on marine vessels:-

- Lagging the exhaust pipe stops it from overheating the engine room where people must work to service the engine.
- Feeding water into the exhaust pipe cools the exhaust gas and thus lessens the back-pressure at the engine's cylinders' exhaust ports and thus helps the cylinders to empty quicker.

Outboard motors

In outboard motors the exhaust system is usually a vertical passage through the engine structure and to reduce out-of-water noise blows out underwater, sometimes through the middle of the propeller.

Terminology

Manifold or header

In most production engines, the **manifold** is an assembly designed to collect the exhaust gas from two or more cylinders into one pipe. Manifolds are often made of cast iron in stock production cars, and may have material-saving design features such as to use the least metal, to occupy the least space necessary, or have the lowest production cost. These design restrictions often result in a design that is cost effective but that does not do the most efficient job of venting the gases from the engine. Inefficiencies generally occur due to the nature of the combustion engine and its cylinders. Since cylinders fire



Aftermarket exhaust manifold

at different times, exhaust leaves them at different times, and pressure waves from gas emerging from one cylinder might not be completely vacated through the exhaust system when another comes. This creates a back pressure and restriction in the engine's exhaust system that can restrict the engine's true performance possibilities.

A **header** (sometimes called **extractor** in Australia) is a manifold specifically designed for performance.^[1] During design, engineers create a manifold without regard to weight or cost but instead for optimal flow of the exhaust gases. This design results in a header that is more efficient at **scavenging** the exhaust from the cylinders. Headers are generally circular steel tubing with bends and folds calculated to make the paths from each cylinder's exhaust port to the common outlet all equal length, and joined at narrow angles to encourage pressure waves to flow through the outlet, and not back towards other cylinders. In a set of **tuned headers** the pipe lengths are carefully calculated to enhance exhaust flow in a particular engine revolutions per minute range.

Headers are generally made by aftermarket automotive companies, but sometimes can be bought from the high-performance parts department at car dealerships. Generally, most car performance enthusiasts buy aftermarket headers made by companies solely focused on producing reliable, cost-effective well-designed headers specifically for their car. Headers can also be custom designed by a custom shop. Due to the advanced materials that some aftermarket headers are made of, this can be expensive. Luckily, an exhaust system can be custom built for any car, and generally is not specific to the car's motor or design except for needing to properly connect solidly to the engine. This is usually accomplished by correct sizing in the design stage, and selecting a proper gasket type and size for the engine.

Header-back

Header-back (or **header back**) is to the part of the exhaust system from the outlet of the header to the final vent to open air — everything from the header back. Header-back systems are generally produced as aftermarket performance systems for cars without turbochargers.^[2]

Turbo-back

Turbo-back (or **turbo back**) is to the part of the exhaust system from the outlet of a turbocharger to the final vent to open air. Turbo-back systems are generally produced as aftermarket performance systems for cars with turbochargers. Some turbo-back (and header-back) systems replace stock catalytic converters with others having less flow restriction.

Screamer pipe

To regulate the boost pressure on turbo charged cars, a custom wastegate is fitted to allow exhaust gases to bypass the turbine and pass straight down the exhaust down pipe. This can cause turbulent airflow around the turbine so to overcome this problem gases can be re-routed down a separate pipe about thirty centimetres long and vented straight to atmosphere. The reason for the term screamer pipe is the phenomenally loud jet engine noise they produce which is popular and highly desirable for car modifiers. Due to the noise and the fact they miss out the catalytic converter these are not technically for street use.

With or without catalytic converter

Some systems (including in former time all systems) (sometimes nowadays called **catless**) eliminate the catalytic converter. This is illegal in some places if the vehicle is driven on public roads.

Cat-back

Cat-back (also **cat back** and **catback**) refers to the portion of the exhaust system from the outlet of the catalytic converter to the final vent to open air. This generally includes the pipe from the converter to the muffler, the muffler, and the final length of pipe to open air.

Cat-back exhaust systems generally use larger diameter pipe than the stock system. Good systems will have mandrel-bent turns that allow the exhaust gas to exit with as little back pressure as possible. The mufflers included in these kits are often glasspacks, again to reduce back pressure. If the system is engineered more for show than functionality, it may be tuned to enhance the lower sounds that are lacking from high-RPM low-displacement engines.

Tailpipe and tip

With trucks, sometimes the silencer is crossways under the front of the cab and its tailpipe blows sideways to the offside (right side if driving on the left, left side if driving on the right). The side of a passenger car on which the exhaust exits beneath the rear bumper usually indicates the market for which the vehicle was designed, i.e. Japanese (and some older British) vehicles have exhausts on the right so they are furthest from the curb in countries which drive on the left, while European vehicles have exhausts on the left. The petrol filler flap is normally on the opposite side to the exhaust tailpipe for reasons of packaging (keeping the filler pipe away from the hot exhaust) but also to position it closest to the curb.

The end of the final length of exhaust pipe where it vents to open air, generally the only visible part, often ends with just a straight or angled cut, but may include a fancy **tip**. The tip is usually chromed, and is often of larger pipe than the rest of the exhaust system. This produces a final reduction in pressure, as well as prevents rusting of the tips, and can be used to enhance the appearance of the car, like the one in the picture. These are the least expensive parts of the system.

In the late 1950s in the United States manufacturers had a fashion in car styling to form the rear bumper with a hole at each end through which the exhaust would pass. Two outlets symbolized V-8 power, and only the most expensive cars (Cadillac, Lincoln, Imperial, Packard) were fitted with this design. One justification for this was that luxury cars in those days had such a long rear overhang that the exhaust pipe scraped the ground when the car traversed ramps. The fashion disappeared after customers noted that the rear end of the car, being a low-pressure area, collected soot from the exhaust and its acidic content ate into the chrome-plated rear bumper.

When a bus, truck or tractor or excavator has a vertical exhaust pipe (called stacks or pipes behind the cab), sometimes the end is curved, or has a hinged cover flap which the gas flow blows out of the way, to try to prevent foreign objects (including droppings from a bird perching on the exhaust pipe when the vehicle is not being used) getting inside the exhaust pipe.

In some trucks, when the silencer is front-to-back under the chassis, the end of the tailpipe turns 90° and blows downwards. That protects anyone near a stationary truck from getting a direct blast of the exhaust gas, but often raises dust when the truck is driving on a dry dusty unmade surface such as on a building site.

Exhaust System Tuning

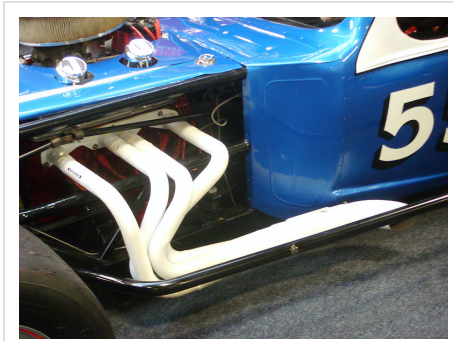
Many automotive companies offer aftermarket exhaust system upgrades as a subcategory of engine tuning. This is often fairly expensive as it usually includes replacing the entire exhaust manifold or other large components. These upgrades however can significantly improve engine performance and do this through means of two main principles:

- By reducing the exhaust back pressure, engine power is increased in four-stroke engines
- By reducing the amount of heat from the exhaust being lost into the underbonnet area. This reduces the underbonnet temperature and consequently lowers the intake manifold temperature, increasing power. This also has positive side effect of preventing heat-sensitive components from being damaged.

Furthermore, keeping the heat in the exhaust gases speeds these up, therefore reducing back pressure as well.

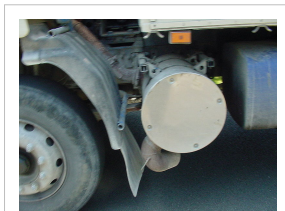
Back pressure is most commonly reduced by replacing exhaust manifolds with headers, which have smoother bends and normally wider pipe diameters.

Exhaust Heat Management is the term that describes reducing the amount of exhaust heat loss. One dominant solution to aftermarket upgraders is the use of a ceramic coating applied via thermal spraying. This not only reduces heat loss and lessens back pressure, but provides an effective way to protect the exhaust system from wear and tear, thermal degradation and corrosion.^[3]



Aftermarket exhaust system including headers and a white plasma-sprayed ceramic coating

Images



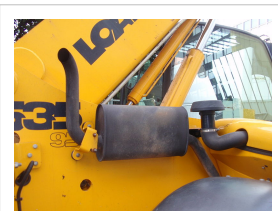
Large truck's diesel exhaust pipe



Waste collection vehicle's diesel exhaust pipe



Dual exhaust pipes attached to a car's muffler




Exhaust system of diesel telescopic-arm vehicle

See also

- Expansion chamber
- Aftermarket exhaust parts
- Automobile emissions control
- Nitrogen oxide sensor

External links

-  Media related to Automobile exhausts at Wikimedia Commons