What goes in must come out: motor vehicle ventilation systems from a vapour sampling perspective

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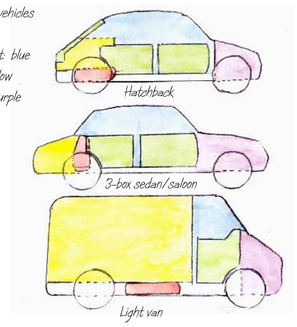
Aside from attacks on aircraft, the most destructive terrorist incidents have involved vehicle-borne improvised explosives devices or VBIED's. A motor vehicle can carry large amounts of explosives to a target and be detonated by a timer, remote control or a suicidal occupant and cause massive destruction and loss of life. Additionally, terrorists use motor vehicles to transport explosives for other kinds of attack, so vehicle search is an important part of counter-terrorist operations. Electronic vapour and trace detection systems, and detection dogs, are often deployed for this use.

To make good use of this technology we need to understand the structure of a vehicle and how air moves through it, as this will determine how explosives vapours and particles will be transported inside the vehicle and where they can best be sampled.

Main spaces in typical vehicles

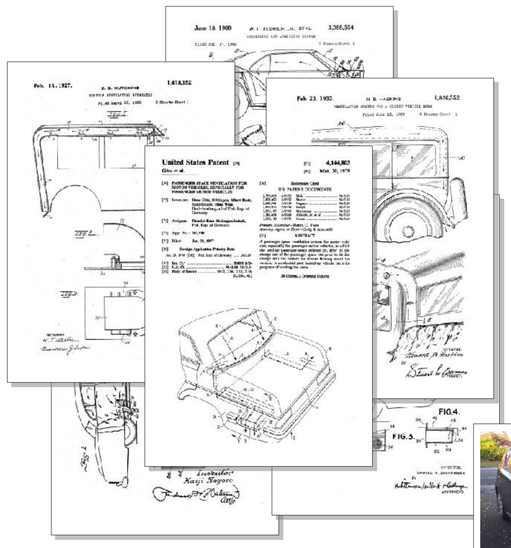
Key:
Passenger compartment: blue
Load compartment: yellow
Engine compartment: purple
Doors: green
Fuel tank: red



Most road vehicles are divided into three main compartments: the engine compartment, the driver/passenger compartment and the load compartment. Additionally there are other voids, such as the inside of the doors and the space between the inner and outer skins of the bodywork, which need to be ventilated.

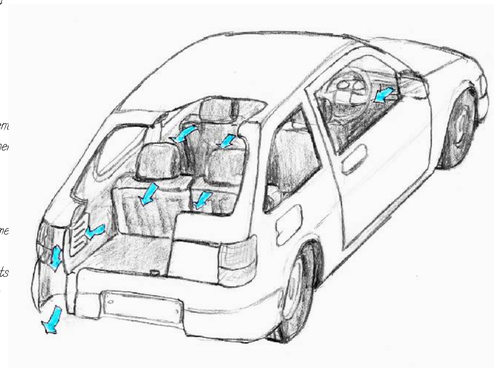
Normally, the engine compartment is separated from the other compartments by a bulkhead called the firewall. It is open to the outside air through the radiator grille and is often open on the vehicle underside but it is isolated from the other compartments.

The passenger compartment and load compartment may be separate, as in a traditional "three box" sedan/saloon car which has a bulkhead behind the passenger compartment, or combined, perhaps seaprated only by seatbacks, as in a hatchback or MPV/people carrier. In many large goods vehicles, the load compartment is a separate construction.



The method of ventilation of vehicles has developed over the years, but by the 1970s manufacturers had mostly settled on a flow-through system. A fan forces air into the passenger compartment and it escapes through vents.

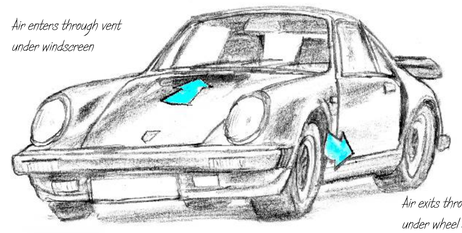
In a typical hatchback car, the inlet vents are in or under the dashboard. Air then passes freely through the passenger compartment and into the load compartment. It then passes through vents at the rear of the load compartment into the space between the inner and outer body panels, and out though vents hidden under the car, behind the back bumper. In older cars the air exited through vents behind the rear side window.



Stale air exit vent under the rear of a small hatchback. Usually they are not this obvious

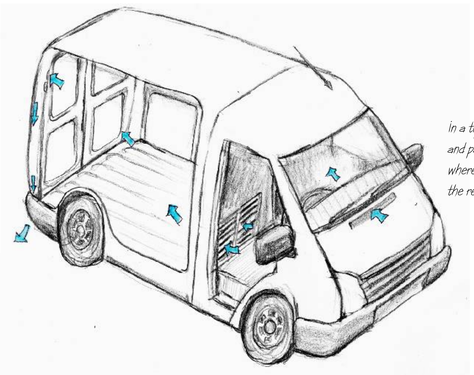
In a "three box" car, air from the passenger compartment has to pass through vents into either the load compartment or directly into the pace between the inner and outer body panels. Often it passes around the fuel tank which is located behind the bulkhead. Although the inter-panel space is open to the load compartment, there may be less of a flow through the load compartment itself.

Air enters through vent under windscreen



Air exits through vent under wheel arch

This arrangement does not work with a rear engined car. The stale air outlet vents have to be somewhere else. In the Porsche 911, for instance, they were under either the front or rear wheel arches, depending on model, and sometimes were closed by a rubber flap to prevent air going the wrong way.



In a typical light van, vents in the bulkhead behind the driver and passenger seats allow air into the load compartment, where it entens the rear structural pillars and exits under the rear of the van.

Doors form separate compartments, big enough to hide a considerable amount of explosives. They usually have drain holes at the bottom and these exit outside of the rubber door seal. Air can sometimes be drawn out through the door handle assembly, but this will come mostly from inside the door, not the passenger compartment. Sampling near the drainholes may also be worthwhile.

On vehicles with an entirely separate load compartment, the ventilation system will vary considerably according to type and use.

Even a small sample of buses shows a a very varied arrangement of roof vents

In modern buses arrangements vary considerably. Most do not have flow through ventilation but may have extractor fans, sometimes mounted in the roof. Many buses still rely on opening windows. Heating systems often use cabin air, rather than drawing in air from outside. Because of this, the size of the vehicle, the constant opening and shutting of doors and movement of passengers and their baggage, it is difficult to envisage sampling the passenger comparment without going inside and taking multiple samples.

In coaches for long-distance travel the passenger cabin is often more enclosed, windows do not open and doors are rarely opened. Flow-through ventilation is provided, often using "eyeball" vents controlled by passengers, air being vented usually through the roof. Air-conditioning may be installed and the equipment is often roof mounted. There are luggage compartments under the passenger compartment, and these are connected to the outside air.

General Comments

In sampling vehicles it is worthwhile understanding how they are laid out internally and how they are ventilated. The quickest way to improve practical capability is usually to make better use of equipment you already have and trust rather than wait for something new to come along.

Passenger cars are fairly consistent in ventilation design but larger vehicles are much more variable.

Passenger car bodywork divides into up to eight separate volumes: engine compartment, passenger and luggage compartments combined, two to five doors and the fuel tank.

There are many uncertainties that can only be resolved by studying large numbers of vehicles and by experiment, for instance:

- how is air best extracted from each compartment?
- is it better to sample static air, or to create a draught?
- what are the practical effects of vapour pressure, temperature, wrapping or enclosure of the explosive charge?
- do particles of explosives move along the air flow paths and where are they deposited?
- does this affect the way dogs work, or should work?

References:
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