PFEIFFER VACUUM

EMISSION STANDARDS AND TIGHTNESS TESTS

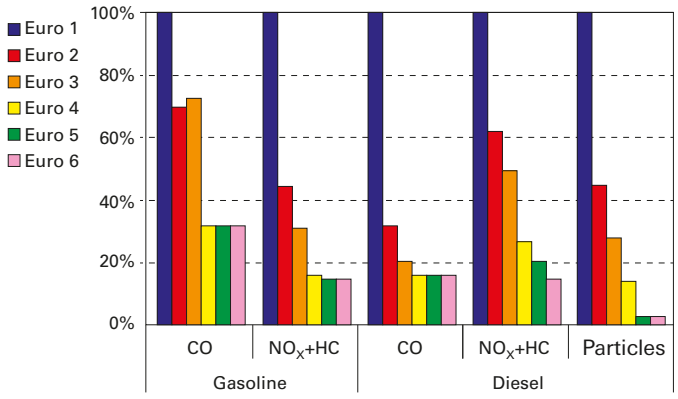
EU standards as a requirement for fuel and exhaust gas components

Rising ozone levels, smog, acid rain - modern life and technical progress take their toll on the world around us. Over a billion cars are registered worldwide, and together they blast endless amounts of exhaust into the atmosphere each day. This not only pollutes the environment but also has adverse effects on the people who live in it. Nitrogens (NOx) – particularly nitrogen dioxide (NO_2) – are one of the main culprits in this respect. Nitrogen dioxide irritates and impairs the respiratory organs, promotes cardiovascular disease, allergies and bronchitis, and encourages the development of lung cancer. Above certain concentrations in the air, this substance negatively affects the function of the human lung. It is also the cause of acid rain which wreaks havoc on forests and woodland. Low-level nitrogen oxides produce the ozone formation known as summer smog under the influence of the sun's UV radiation.

Against this background, reducing emissions is one of the greatest challenges in the field of environmental protection. Statutory caps and regulations on emissions become increasingly important – the European Union is one of the forerunners in this area.

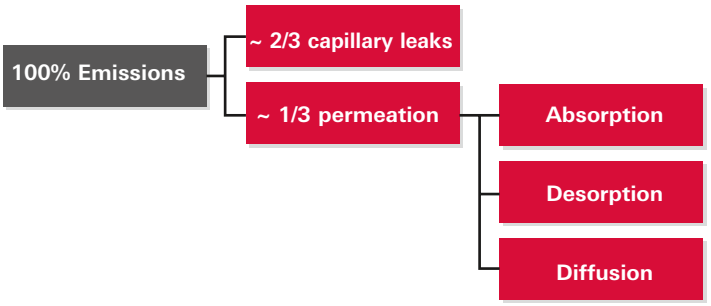
Measures to improve air quality

Improving the quality of the air we breathe has long been one of the declared goals of the European Union and represents an important focus of its environmental policy. Since



	Effective from	Gasoline			Diesel			
		CO	NO_x	HC	CO	NO_x		
		in g/kg						
Euro 1	1.7.1992	3.2	HC+NO_x 1.3		3.16		1.13	0.18
Euro 2	1.1.1996	2.2	HC+NO_x 0.5		1.0		0.7	0.08
Euro 3	1.1.2000	2.3	0.15	0.2	0.64	0.5	0.56	0.05
Euro 4	1.1.2005	1.0	0.08	0.1	0.5	0.25	0.3	0.025
Euro 5	1.9.2009	1.0	0.06	0.1	0.5	0.18	0.23	0.005
Euro 6	1.9.2014	1.0	0.06	0.1	0.5	0.08	0.17	0.005

Source: www.lubw.baden-wuerttemberg.de
Figure 1: Development of EU exhaust emission limits for cars



Definitions:
Capillary leak = microleak through fine elongated cavities
Permeation = substance penetrates solid
Absorption = substance taken in by free volume
Desorption = substance exudes from surface of solid
Diffusion = autonomous intermixing of various substances

Figure 2: Definition of different leak types

restrictions were put in place for the first time in 1970, the European Union has continued to lower the ceiling on car exhaust emissions. For car manufacturers, the environmental friendliness of their vehicles is thus understandably an important issue: With the aid of ever new technology, they work towards keeping emissions to a minimum. The accompanying statutory framework for these efforts are the European exhaust emissions standards, also known as euro standards (figure 1). They define emissions ceilings.

The euro standard defines permitted leak rates

Since the first uniform regulations on maximum emission levels were laid down by the European Community in 1970, approved emissions ceilings for carbon monoxide, hydrocarbons, nitrogen oxides, particulates and less volatile methane-free hydrocarbons (NMVOC) have been lowered even further. Euro 5 and euro 6 are standards that define emissions ceilings for motor vehicles. These standards also set the limits for automotive assemblies and components that carry liquids or gases. Even before they are fitted inside a car, the fuel tanks or injection systems are required to be tested to ensure they comply with the leak rates stipulated by the standard. This procedure is supposed to minimize the environmental impact of motor vehicles. Each supplier must rigorously monitor and document the tightness of the assemblies.

Use of leak detectors to ensure compliance with leak rate limits

A leak is defined as an opening through which a liquid or gaseous substance flows from the side with higher pressure to the lower pressure side. The effects of leaks on the emissions are determined by the type of leak (see figure 2). It is not possible to completely stem the flow of these substances. In view of this, the aim is first and foremost to use the maximum permitted leak rate to define how leak tight an object needs to be for it to fulfill its specification and function. Otherwise, above a certain size, leaks hinder technical products from working properly, or considerably restrict their use. In addition to that, leaks in certain objects can also cause environmental pollution: refrigerant circuits in refrigerators and air conditioners, fuel-carrying components such as tanks, pumps, hoses, or filters for the automotive sector, for example. Manufactured products might be unable to meet defined quality standards if assemblies and components did not demonstrate a high level of leakproofness in the production process.

Against this background, strict leak tightness standards apply also for automotive assemblies and components. These must be met to ensure that motor vehicles comply with European standards. These standards require that automotive components precisely meet the defined leak rate limits in the manufacturing process and that this is also documented. Difficulties are frequently encountered with automotive assemblies produced outside Europe: Euro standard specifications are often ignored or only partly adhered to, which means that many

Automotive fuel system component	Helium test pressure (in bar)	Leak rate in range (in hPa l/s)			Available supplier solutions
		Euro 4 standard	Euro 5 standard	Euro 6 standard	
Fuel tank	0.1 – 0.25	After the euro 4 standard expired in the year 2009, the limits indicated in the next column became established within the scope of use of the standard. It is expected that this standard will also become established outside Europe in the foreseeable future.	$5 \cdot 10^{-6}$ - $5 \cdot 10^{-5}$	The euro 5 leak rate limits are adequate for meeting the requirements of the euro 6 standard.	Leak detectors, e.g. ASM 310/340 (for pre-development and small series; otherwise helium leak detection systems)
Fuel pumps	0.4		$1 \cdot 10^{-5}$		Helium leak detection systems (customer-specific)
Fuel filter	max. 6		$1 \cdot 10^{-3}$		
Level sensors	max. 0.2		$1.0 \cdot 10^{-5}$		
Surge tanks	max. 0.4		$5 \cdot 10^{-5}$		
Injection systems	max. 180		$1 \cdot 10^{-6}$		
Activated carbon filter	0.1		$3 \cdot 10^{-5}$		

Table 1: Maximum leak rates for automotive components

assemblies only comply with the euro 4 standard. These assemblies are not allowed to be used in vehicles that meet the euro 5 or euro 6 standard. There are leak detectors and leak detection systems available for determining the leak rate of these assemblies in an easy and reliable way. This enables a high production yield to be attained during the manufacture of these components.

Table 1 shows the leak rates prescribed by the euro 4, euro 5 and euro 6 standards for automotive components in fuel systems.

Since the euro 4, euro 5 and euro 6 standards apply only for fuel-carrying assemblies, non-fuel-carrying components are generally not subject to tests based on the European emissions standards. However, as a result of permeation and diffusion, they indirectly influence overall emissions and so, in practice, are also tested for leaks (table 2).

Non-fuel relevant automotive components	Helium test pressure (in bar)	Leak rate in range (in hPa l/s)	Available supplier solutions
Air conditioner hoses	35 – 40	$9 \cdot 10^{-6}$	Helium leak detection systems (customer-specific)
		- $9.3 \cdot 10^{-5}$	
Air conditioner compressors	30 – 40	$1 \cdot 10^{-5}$	
Airbag cartridges	n.s.	$1 \cdot 10^{-8}$	
Air suspension struts	2 – 12 with 10 – 100% Helium	$1 \cdot 10^{-7}$	

Table 2: Maximum leak rates for non-fuel relevant automotive components

Virtually all leaks can be detected and localized with carrier gas leak detectors. All leaks are reliably found, irrespective of whether water, oil, fuel, refrigerant, gas, vapor, air or vacuum leaks are involved. Leak detection measurements using helium can be conducted in the 10^{-1} to 10^{-12} hPa l/s detection range due to the low helium background of only 5 ppm in the air. These measurements are extremely precise, dependable and reproducible.

Pfeiffer Vacuum solutions for testing the leak tightness of fuel-carrying and emissions components

With its wide-ranging leak detection portfolio, Pfeiffer Vacuum has the right solution for leak testing every assembly and component in the automotive sector. Thanks to their compact size and light weight, portable leak detectors are the ideal solution for mobile use and for testing small test objects. High-performance modular leak detectors for all-around use are also included in the range. No leak is too small or too big to slip through the net when tested with Pfeiffer Vacuum leak detectors. These detectors ensure conformity with the euro standard when automotive applications are involved. In addition, Pfeiffer Vacuum experts are extremely knowledgeable where leak detection is concerned. This expertise is a great advantage when it comes to offering advice on the design, layout and assembly of complete leak detection systems.

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