O_2 Reference Point In Exhaust Emission Legislation

The Euromot Position

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EUROMOT
Engine-in-Society

Euromot is the **European Association of Internal Combustion Engine Manufacturers**.

We represent the leading manufacturers of internal combustion engines used in a broad range of nonroad and marine applications (construction, mining and material handling equipment, trucks and buses, agricultural and forestry equipment, commercial marine and seagoing vessels, workboats and pleasure boats, rail traction, lawn/garden and recreational equipment, power generation).

Euromot has been working for many years with international regulatory bodies, eg European Union, the UN Economic Commission for Europe (UN-ECE), the UN International Maritime Organizations (IMO) and the Central Commission for the Navigation on the Rhine (CCNR). In addition, we are seeking an open and fair dialogue with national governments to provide reliable know-how on advanced internal combustion engine technologies in general and, in particular, on the feasibility of environmental as well as cost-effective product regulations. To achieve a pro-active engagement of all stakeholders in international harmonisation of regulations affecting engines and equipment, we coordinate our activities worldwide with trade associations of the non-road and marine industry sector.

For further information about our Association please refer to our Annual Report 2001 or pay us a virtual visit at **http://www.euromot.org** – your bookmark for engine power worldwide.

General

The market for reciprocating engines has increased rapidly in the last years and today the world wide market is annually (for units **bigger than 1 MWe**, new power plants) more than 11000 MWe (in the year 2000). This makes it the third biggest power technology with bigger annual deliveries than hydro and nuclear power. Both bigger base load engine driven power plants with an output up to 150 MW electricity and decentralized smaller simultaneous heat and power (CHP) production plants are common today.

The advantages of the reciprocating engine for this kind of applications are many: high thermal efficiency (low fuel consumption), optimal matching of different load demands, fast load response and good load following characteristics, short construction time, flexible fuel choice, easy maintenance and robust design.

Nowadays the Kyoto Protocol is in focus. Carbon dioxide is in focus due to its´ expected impact on the global warming. One practical way to decrease the CO_2 emission is to increase the total efficiency of the power plant or/and (lower Carbon/Hydrogen-ratio of the fuel) to use oil instead of coal and natural gas instead of oil. Other measures to reduce he carbon dioxide emissions are increased combined heat and power (CHP) production of simultaneous electricity and heat.

Engine driven plants are well suited for the CHP-approach. These plants can be located close to the heat and electricity consumer and thus the need for transmission lines is reduced. Associated energy losses and land need can be minimized. The CHP-plants are well suited for e.g. industry applications, local utility companies, residential and commercial buildings, the heat can be recovered e.g. as steam, hot water for district heating/cooling, desalination processes, etc. In CHP-mode total efficiencies, when producing hot water typically up to 85 % in liquid and up to 90 % in gas mode are achieved. The electricity efficiency at alternator terminals is typically up to about 45 % for big engines and lower for small engines.

Emission limit reference oxygen

General:
In the following typical flue gas oxygen contents of some well-known prime-movers are listed:

- Gas turbine (oil/gas fired): 12 - 16 vol-% O2
- Boilers:
  - Oil fired: 2 - 5 vol-% O_2
  - Gas fired: 2 - 6 vol-% O2
  - Coal fired 5 - 8 vol-% O2

- Big size reciprocating engines (stationary power plant engines, typically > 1500 kWe):
  - Oil operated: 13 - 16 vol-% O2
  - Gas operated: 11 - 15 vol-% O2

The secondary cleaning equipment (such as a SCR, etc.) “sees” the pollutant at the “actual” concentration and the reference O_2 is therefore to be close to this value to ensure an optimal design. This is also seen in most legislation for boilers and gas turbines: a gas/liquid fired gas turbine has a reference point of 15 vol-% O_2 and a gas/liquid fired boiler a reference O_2 of 3 vol-% O_2, (close to the actual O_2-values (“real”) in the flue gas).

United Kingdom (UK), India, World Bank 1998 (“Thermal Power-Guidelines for New Plants”), etc. are following the above approach for engine driven plants, i.e. the emission limit reference point is 15 vol-% O_2. In Japan the reference emission reference point for oil fired diesel engines is 13 vol-% O_2. Surprisingly in some other national legislation big engine plants are not treated equally with above mentioned techniques and some “artificial” O_2 references are used for instance 5 or 8 vol-% O_2 mainly due to historically reasons **not** representing today´s technology status of high power output/efficient engine generation, but rather “old” small size rich burn engines with a low flue gas “actual” oxygen content, etc.

Consequences:
In the following the technical requirements of a secondary emission reduction system: e.g. an electrostatic precipitator (ESP) are highlighted in the respect of the oxygen reference point for the emission. The “actual conditions” the secondary flue gas cleaning equipment is facing is depending on “real” flue gas temperature and the oxygen content.

Boiler (liquid fuel):

Typical “real conditions” of the flue gas conditions are: temperature about 170 degree C and 3 vol-% O_2. European Union (EU) stipulated in the new Large Combustion Directive (LCP) 2001/80/EC following strict dust emission limits for liquid fired boilers 50 … 100 MW_{th}: 50 mg/Nm^3 (3 % O_2) and 30 mg/Nm^3 (3 % O_2) for bigger boiler plants. This means that an ESP situated after the boiler has to “clean” the flue gas of particulate down to about 31 mg/”actual m^3” or 18 mg/”actual m^3” depending on plant size.

Big diesel engine:

Typical “real conditions” of the flue gas are dependent on engine type: temperature 350 … 400°C, 13 … 15 vol-% O_2. In UK[*)] the particulate emission limit (oil firing) is 50 mg/Nm^3 (dry, 15 vol-% O_2). The secondary flue gas cleaning device such as an ESP is to be situated after the engine before the SCR (if used) and boiler in the flue gas train, in order to protect these from fouling. For a diesel engine having 13 vol-% O_2 and a temperature of 350 degree C of the flue gas this means that the ESP is to clean the flue gas down to about 29 mg/”actual m^3”.

If the stipulated emission limit of 50 mg/Nm^3 is given e.g. at an <u>artificial</u> oxygen content of 5 vol-% this means that the ESP is to work down to 11 mg/”actual m^3”, which is much stricter than requirement set for big oil fired boiler plants (see above).

[*)] Achievable Releases to Air, HM Inspectorate of Pollution: Processes Subject to Integrated Pollution Control, Chief Inspector´s Guidance Note, Series 2 (S2), S2 1.03 Combustion Processes: Compression Ignition Engines 50 MWth and Over (September 1995

Conclusion:

From above examples the importance of using "actual conditions" for the stipulated emission limits can be seen. This sets **equal** requirements on the secondary flue gas cleaning equipment for the different prime movers, which is a fair approach. By expressing the emission limit reference point close to "actual conditions" the real performance of the secondary cleaning device is best described.
The approach to have the emission reference point close to the "actual conditions" is widely accepted for boilers (liquid/gas fuels 3 vol-% O_2) and gas turbines (liquid/gas fuels, 15 vol-% O_2). Using the same approach for **reciprocating internal combustion engine driven plants** as for the above mentioned prime movers means that the **reference oxygen point is to be at 15 vol-% O_2**, which is also the case in some existing legislation. Using artificial reference points such as 5 vol-% O_2, etc. for the emission limits from big engine driven plants is not a logical approach, as this will set very different requirements towards other competing different prime movers and it is not describing the required performance requirement of the secondary cleaning equipment.

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