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POSITION-PAPER

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ABOUT THE INFLUENCE OF AMBIENT CONDITIONS ON PERFORMANCE OF GAS ENGINES

1. Some general information about the influence of ambient conditions on Gas engine performance

The performance of an engine is influenced by the ambient conditions. The most important ambient conditions influencing gas engine performance are:

- Air humidity
- Inlet air temperature
- Altitude

Ambient conditions depend on the geographical location and may vary with time of the year. Engine controls may compensate for some effects of these variations, but engine performance deviations are to be expected.

Regarding gas engines, and in particular the lean burn types, their reaction to changes in ambient conditions is different to that of diesel engines or gas turbines. Lean burn gas engines are generally more sensitive to ambient conditions - especially in comparison to diesel engines - although the level of sensitivity may depend on combustion and control concept. Any given performance data of an engine refers to the specified ambient conditions. If the site ambient conditions deviate from these, actual engine efficiency and emissions will differ from the specified values as well.

Stoichiometric gas engines are generally less sensitive to ambient conditions because of their different combustion concept, but as most current gas engines are of the lean burn type, only these engines are addressed in this position paper.

2. The effect of humidity

The absolute air humidity has an influence on the combustion since an increase in humidity is slowing down the combustion speed as well as reducing the maximum combustion temperature. On the one hand this will influence the knock margin and the NO_x emissions in a positive way, but on the other hand the efficiency of the engine is affected negatively.

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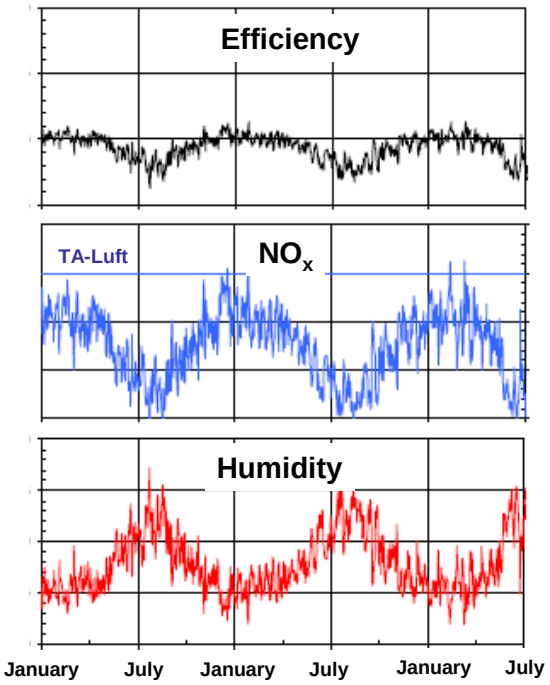
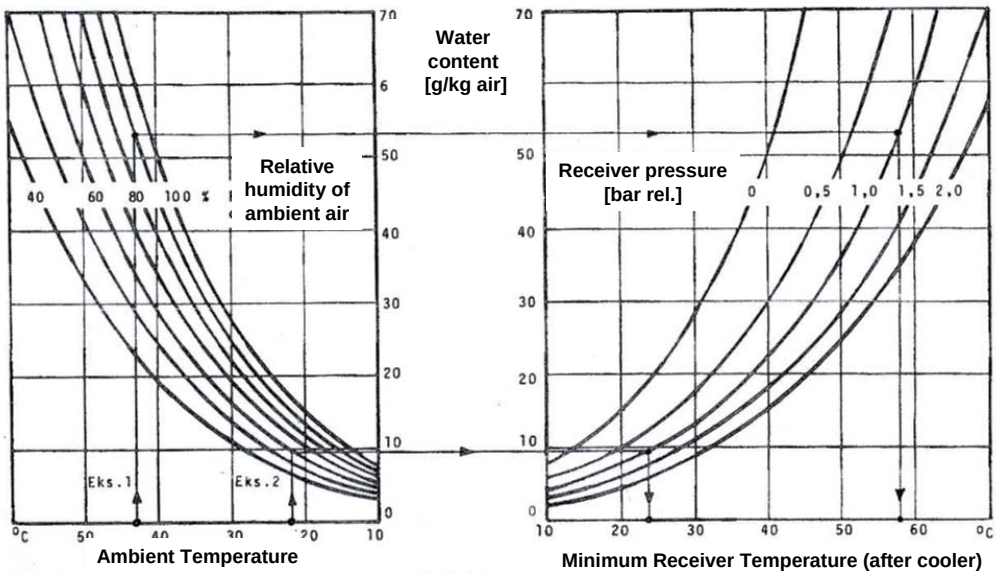
Although different engine types and sizes may show different sensitivity to air humidity fluctuation, the general trend is much the same for all.
The graph below shows typical trends from a lean burn gas engine running in Europe without compensation for ambient humidity variations over the year. The influence on the NO_x emissions is particularly strong and must be considered when measurements are made.



Another effect of high humidity is the possible condensation of water in the charge air cooler if the temperature drops below the dew point temperature at the given pressure. Without drain, this can have harmful effects on the engine operation and must be avoided.

The diagram below gives an indication about the minimum receiver temperature required for avoiding condensation in the charge air system, as a function of relative receiver pressure and ambient air conditions.



3. The effect of altitude

The altitude influences mainly the turbocharging, as higher altitude requires an increased compressor pressure ratio to maintain the power output. If the receiver pressure is not controlled, then it will naturally drop at higher altitude.

Also, the turbocharger speed may exceed the rated one if the turbocharger is not matched to the higher altitude.

Clogging of the air filter during operation causes increased pressure losses before the turbocharger compressor and effects engine performance in the same manner as engine operation at high altitudes.

4. The effect of inlet temperature

There are different definitions for ambient air temperature, air inlet temperature and receiver temperature in use. Here, the following definitions are used:

- Ambient air temperature is the temperature that is measured outside of the engine building.
- Air inlet temperature is the temperature that is measured at the inlet of the turbocharger.
- Receiver temperature is the temperature of the air or mixture entering the cylinder (also called intake manifold temperature). This temperature is measured after the charge air cooler and is directly influenced by the charge air coolant temperature. It may be controlled by the engine control system.

The ambient temperature is not influencing the engine performance as such, but in most cases the ambient temperature will have an influence on the air inlet temperature before the turbocharger and the engine cooling system.

The air inlet temperature has an influence on the turbocharger performance. A high inlet air temperature is influencing negatively its performance and this can result in lower engine efficiency and lower power as well as higher loading of the charge air cooling system. Low air inlet temperature may bring the turbocharger into surging.

The receiver or manifold temperature is the temperature that directly influences combustion. If the control system does not keep it to the value specified by the engine manufacturer, any change of this temperature can adversely affect efficiency, knock margin and NO_x emissions.

An increase of the receiver temperature occurs if the temperature level of the charge air cooling system is set above the level in the engine specifications.

6. What to do - Recommendations

From what has been explained above, it is of great importance to consider the reference ambient conditions when making and comparing any performance or emission measurements, particularly at the site.

Further, checking how ambient conditions could have changed during the year is necessary when making any summaries or calculating annual average figures for fuel consumption and emissions.

It is required to check the sensitivity to changes in ambient conditions before specifying an engine for an installation where significant variations may be expected.