The European Association of Internal Combustion Engine Manufacturers

EUROMOT

POSITION PAPER

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Comments regarding AMEC Draft Final Report of the study "Support for developing the definition of start-up and shut-down periods for LCPs under the Industrial Emissions Directive (2010/75/EU) (by AMEC, 1 July 2011)"

1. Background

Under Article 41 of the Industrial Emissions Directive the Commission is required to propose rules on the determination of start-up and shut-down periods for combustion plants under Chapter III of Directive 2010/75/EU on industrial emissions. In preparation of an implementing act, AMEC drafted the study "Support for developing the definition of start-up and shut-down periods for LCPs under the Industrial Emissions Directive (2010/75/EU)". This draft report analyses three different options for defining start-up and shut-down:

- "Threshold based",
- "Operational Parameters" and
- "Chronological or time-based" categories

and whether these options fulfil the criteria of being clear, generally applicable, consistent, relatively simple and externally verifiable methods for defining start-up (SU) and shut-down (SD) periods. Furthermore, the health and safety aspects of the combustion plant should not be jeopardized during these SU/SD periods.

EUROMOT would like to stress that it is important to ensure that any chosen option for defining start-up and shut-down periods is appropriate for all technologies regulated by Directive 2010/75/EU. EUROMOT has supported the drafting for the AMEC report by proposing a time-based approach which aligns with regulations in the US.

In this document EUROMOT will provide comments regarding the feasibility of further possible options described by AMEC for internal combustion engines.

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2. "Useful output approach" (preferred approach by AMEC study) combined with a "technology specific threshold.

In the AMEC study (page 17), "useful output" is defined in general terms as

- *The point at which it is safe for output of the LCP to be used productively, or*
- *The point at which the output of the LCP is actually is used productively.*

Furthermore, the authors state that for certain plant types (mainly gas turbines and boilers – however, engines are not listed!) a useful output threshold that is used for the SU/SD definition needs to be defined separately.

On page 34 of the AMEC study, the authors recommend further (i) support or objections to the adoption of a zero threshold (for the useful output) and (ii) on the values or formula that could be used in practice, specifying for each fuel type and/or technology type.

EUROMOT Comment

If a useful output approach is chosen, a stationary engine plant specific SU/SD approach needs to be developed with minimum load thresholds in combination with parameters for determination of the stable operating point, etc) reflecting the combustion process and conditions of internal combustion engines.

Technical Aspects

During start-up operations of internal combustion engines, flue gas exhaust temperatures (including catalyst temperatures, etc.) are very low and fluctuating and load conditions are transient. As can be seen in **Annex I**: Internal combustion engines are often synchronized quickly (it might take up to several minutes in some cases depending on starting condition preparations: "cold", "normal" or "fast start") to the electrical grid and start to export electricity in an early stage to consumers while engine still is ramping up to the set load point. The emission profile of an engine during the transient uploading sequence (after synchronization to the grid) is fundamentally dissimilar to the emission profile of an engine operating at the load points typical for its intended (design) application and work. If secondary abatement technique such as catalysts are installed for emission compliance the flue gas temperature will be too low (see **attachment II** for typical temperature profile of a SCR for a big medium, speed engine during a cold start) for effective functioning of the catalyst based emission control system.

Emissions in power plants are measured at **steady state conditions** and in our opinion there are no available and repeatable test methods or procedures for measuring the emissions during the transient load ramp up to set value after engine is synchronized and starting to feed electricity to the grid, ditto for the unloading (shut down) sequence. Needed start up times will vary significantly depending on the engine type (small/big), fuel (gas/liquid), catalyst type used, ambient conditions, application and rated load. To be noted is that an emission measurement standard has to be tied to a validated, accurate, repeatable and cost-effective test method. When set loading point is reached the engine operation is still to be stabilized before emission measurements (before reaching "stable export conditions") are conducted.

Stationary (internal combustion) engine plants are often comprised of several engine units and thus the individual engine units are operated at their optimum efficiency conditions. I.e. individual units operate at high loads and at lower plant loads engines are one by one closed down while remaining units still operate at their optimal operation conditions. This is reflected in most emission rulings around world which generally cover "normal operation conditions". More information is provided below

3. Fall-back approach

The AMEC study (page 35) describes the need for a fall-back position for two situations and additional feedback is recommended:

(i): " .. idle in quick reserve mode"

(ii) "… operator does not (and cannot) monitor and record export of electricity or heat

A possible *"[..] fall back approach should be based on parameters sufficiently robust, easily monitored and applicable to the installed technology type"* .

For gas turbines following options are described.

- *"The point at which the combustion mode switches to fully premix combustion mode or premixed steady-state combustion mode"*
- *" .. threshold flame temperature that has to be reached before switching the combustion mode .."*
- *" …point at which it becomes technically possible to start or end water/steam injection into the turbine .."*

I.e. a minimum load factor seems at least to be needed. Furthermore the Amec study notes the load threshold up to 70 % for gas turbines which can be found in Annex V of Directive 2010/75/EU.

According to AMEC the general principles of the fall-back position should include:

- *"The time spent between initiation of SU and the beginning of normal operations should be minimised as fas as is possible [..]*
- *The burden of responsibility should be with the operator to provide justification to the relevant competent authorities for a proposed SOP."*

EUROMOT Comment

EUROMOT would like to highlight the lack of treatment of internal combustion engines in this regard, which differs significantly from other techniques like boilers and gas turbines (the stationary engine utilises a batch combustion process and not a continuous combustion process).

Defining SOP for stationary engines

Stationary reciprocating engines need to achieve a certain boost pressure (rated output) and temperature (be warmed up) conditions before the cylinder combustion and as consequence the emission profile stabilizes. As stated above engines are designed for a certain loading profile at which emissions and other performance parameters such as fuel consumption are optimal. This is also reflected in world engine regulations[1].

Following operational parameters could be applied to define a stable operating point (SOP) stationary engine plant:

- Load factor (or minimum threshold) and flue gas temperature (especially in plants equipped with a secondary abatement technique).
- When cylinder combustion has been stabilized also the flue gas temperature of the engine stabilizes. Fuel flow rate illustrates the engine load.

Especially, in case of a cold start with a secondary abatement technique, the heating up time of the equipment needed before proper function is crucial. Big engines (especially in start up from cold conditions) need also some heat up time in order to reach stabilized combustion conditions in the cylinders.

4. EUROMOT proposal for Start-up (SU) and shut-down (SD) period for stationary internal combustion engines engines

SU (plant with primary abatement techniques) is ended when a minimum threshold loading of MCR (maximum continuous rating) and flue gas temperature out of the engine stabilizes (and stable burning conditions are achieved).

The set minimum load threshold should reflect the engine design and existing emission limit figures (on what design conditions these were originally created). As an example can be mentioned that the unburned gaseous and particulate emissions and specific fuel consumption start to increase steeply at loads < 85 % MCR (outside optimum design area) of a bigger liquid fired CI engine.

In footnote 1, we show typical minimum load thresholds seen around the world. For big CI engines, EUROMOT proposes a minimum threshold of 85 % of MCR. For other type of engines another minimum threshold could be chosen depending on engine size & configuration and fuel in use.

Time: The Minimum Operating Temperature (MOT) is crucial especially in context with secondary abatement techniques such as SCR for a proper function of the equipment. Exhaust gas temperature should be measured before/after the SCR. In cold start up conditions a long lead time is needed for heating up the equipment to the working conditions (see figure 1 in **Annex 2**). The stationary engine unit needs also time to (heat up and) reach stable combustion conditions in the cylinders.

The SD is vice versa to SU, time needed (might vary between different engine types) for SD is also shorter.

[1] Worldwide examples:
USA /2/ , /3/: the emission compliance (loading) area to reach emission compliance for big CI (Compression Ignition) and SI (Spark ignition) stationary engines is defined as .. " Each performance test must be conducted within 10 percent of 100 percent peak (or the highest achievable) load "
India /4/: " .. Measurement shall be performed at steady load conditions of more than 85% of the rated load."
France /5/: Emission compliance is to be achieved at 70 .. 100 % of MCR.
General approach: In many countries the emissions of the reciprocating engines are measured on the typical load range engine is operating. I.e. typically at high steady state conditions 90 .. 100 % MCR.

EUROMOT proposes that SU should be a combination of (minimum) needed start-up time, (minimum) output threshold and (stable) flue gas temperature. The combination of these parameters, which are easily verifiable, provides a good indication of the minimum continuous stable operation. (MCSO).

The “chronological or time based” approach originally proposed by Euromot (see AMEC study page 29), which is based on the US emission ruling, is in fact a “simplification” of above proposal, the minimum load threshold (as is the case in the U.S.) should be added. In fact, similar SU/SD definitions are in place in states where stationary engines are widely used, such as Cyprus. Malta and Greece proposes for stationary engines an approach close to above proposal in the AMEC study.

5. Conclusion

EUROMOT strongly recommends that a possible “useful output approach” should be combined with a minimum load threshold (reflecting the prime mover design and normal operation conditions) and with some operational parameters such as flue gas temperature out of the engine (for describing stable operation) and minimum lead time (for heating-up in order to have functional “hot” equipment).

Alternatively, the “time-based” approach in combination with some operation parameters such as minimum load threshold (e.g. 85 % of MCR) and exhaust gas temperature would provide a simple and cost-effective option for the SU/SD definitions of the stationary (internal combustion) plant.

6. Sources

/1/ EU Industrial emissions Directive (IED) 2010/75/EU, annex V

/2/ US CI NSPS at http://www.epa.gov/ttn/atw/nsps/sinsps/fr28jn11.pdf (June 2011)

/3/ US SI NSPS at http://www.epa.gov/ttn/atw/area/fr18ja08.pdf (January 2008)

/4/ India Gazette 318 at http://www.envfor.nic.in/legis/eia/epr_amd_489.html

/5/ France Arrete Ministeriel 2910

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ANNEX 1

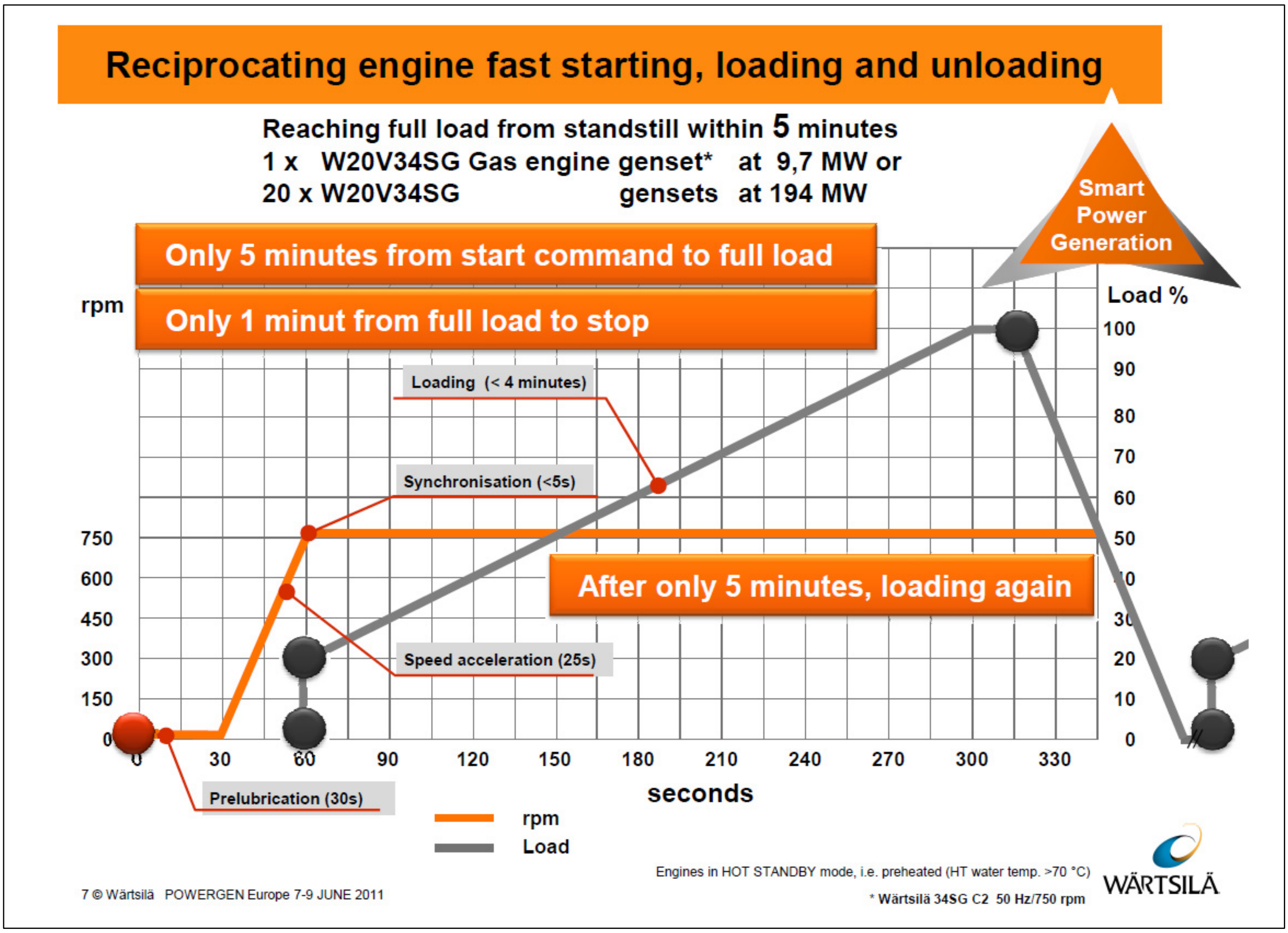

Figure 1: Fast Start: “Hot stand by” conditions

ANNEX 2

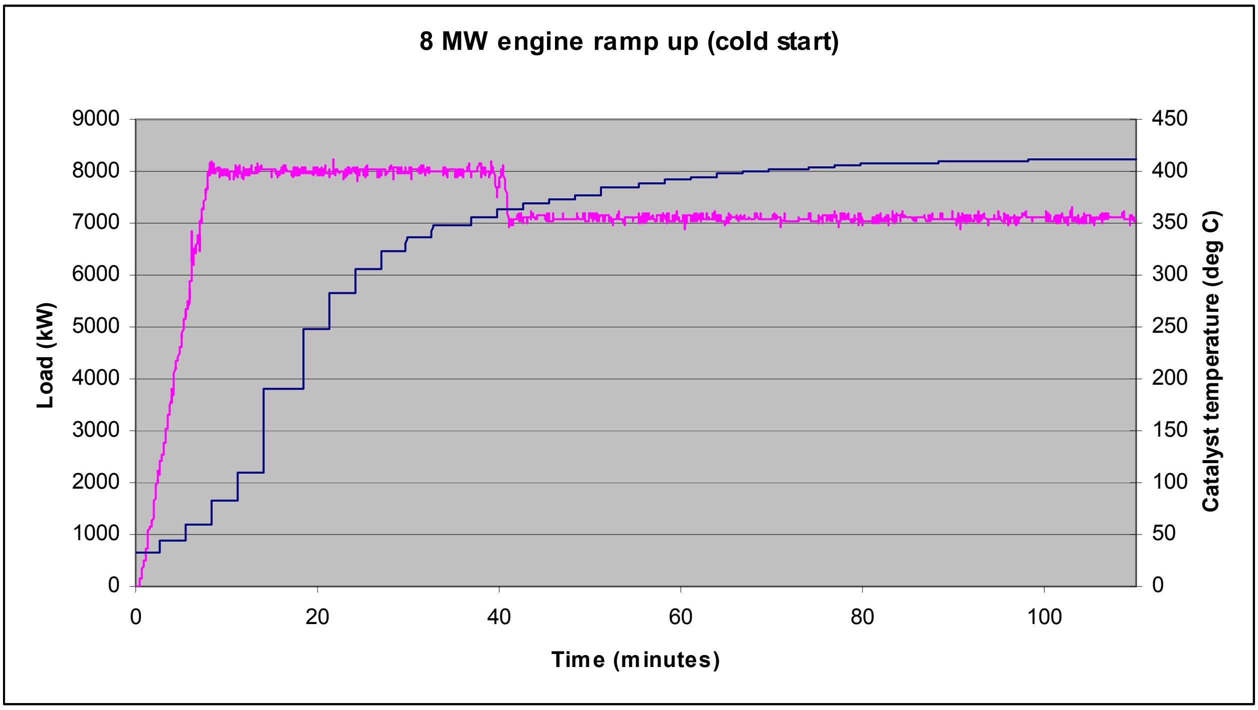

Figure 1: Load/Temperature Start-Up Profile

Temperature

Load

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