EMISSION CONTROL TECHNOLOGIES AND CERTIFICATION TEST METHODS FOR INLAND VESSEL ENGINES

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Abstract. *New stringent emission limits require the drastic reduction (80 to 95%) of harmful emissions of NOx and PM. Due to the special characteristics of vessels (long engine lifetime, small series, greater variety of technical configurations) also retrofit after-treatment solutions, or solutions where new engines and after-treatment systems are purchased separately are necessary. For these options economical and effective certification procedures are needed.*

Keywords: *emissions, certification, vessel engines, EU regulations*

1. INTRODUCTION

The focus of the work package certification and monitoring, is to develop and test well-designed procedures for certification and monitoring of stringent emission limits in the near future for a range of different vessel types, operating profiles and type of situations (new engine, engine overhaul, retrofit). This includes certification, (real life) verification, and portable measurements on the spot and continuous on-board monitoring. The options for collection of on-board monitoring results in a central database will be investigated, both for enforcement of air pollutant emissions (NOx, PM) as well as to create an incentive for the ship owner to benchmark and demonstrate the performance with respect to CO2 emissions. For this latter purpose, on-board monitoring data will be combined with open-source data such as AIS and waterway characteristics. Progress in developing engine technologies and exhaust after treatment systems led to the achievement of PM and NOx reduction rates of up to more than 90 percent of the levels delivered by the engine technology available at the beginning of exhaust emission regulation. For application cases with shorter lifecycle times than that of inland shipping, the renewal of system brings this progress into fleet faster. To improve the emission behavior of the inland shipping fleet, the use of retrofit technologies beyond the normal renewing cycle is a necessary option. In Europe, all engine systems and, of course, all retrofit systems need to have a type approval before entering the market.

2. METHODOLOGY FOR APPROVAL OF NEW ENGINES

The European IWT fleet consists of approximately 18,000 vessels (and 40,000 crew members) and plays a crucial role in major transport chains. The sector has a large potential to become more environmentally friendly (i.e. reduction of Green House Gases and pollutants) and transport chains can also be improved by shifting more cargo to the IWT sector, which reduces congestion on the European roads. The European way of approving engines is based on the type-approval principle. This implies that:

- the performance of the system to be certified is tested

- a detailed description of the tested system is provided. After a successful type approval, the owner of the type approval is allowed to produce and sell systems as described and tested. In accordance to most of the current emission regulations, a 'system' in this case refers to the combination of a combustion engine (or engine family) and an exhaust after treatment system (if needed).

A second way of obtaining the approval for a new engine is the "New Approach", which is e.g. applied for recreational crafts with 94/25/EC. In that case, the manufacturer declares compliance with the regulations.

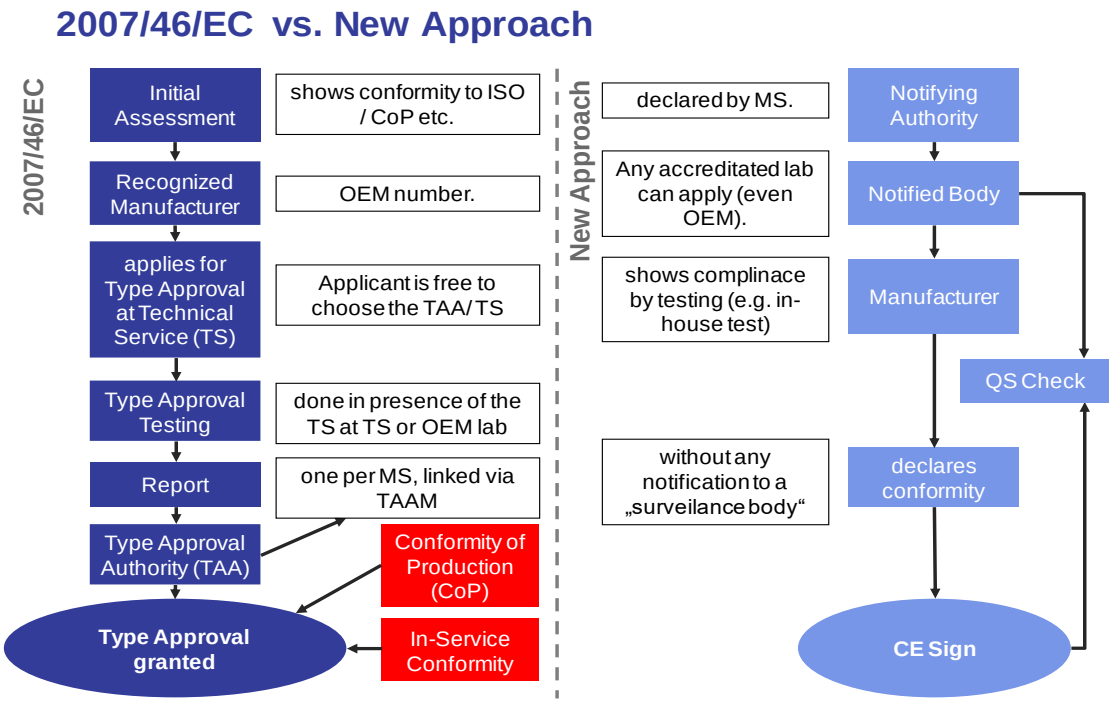

Fig. 1 2007/46/EC vs New Approach

There three approaches considered in regards with European type approval methodology presented below:

- Approval of an engine (or an engine and an exhaust after treatment system) according to current regulations

This kind of approval is the normal way to go for new engine/engine family-types. 'Engine' in this case also refers to the combination of a combustion engine and an exhaust after treatment system, if the latter is necessary to meet the imposed requirements.

- Approval of an exhaust after treatment system (efficiency check)

For retrofitting of existing engine systems with exhaust after treatment systems, only one regulation is available in Europe within the scope of Heavy Duty Vehicles (HDV), Non-road Mobile Machinery (NRMM) and agricultural and forestry tractors (ECE 132). In many EU member states, national regulations exist. However, this kind of approval does not deliver the absolute amounts of emissions of a retrofitted engine. It only shows the effectiveness of the after treatment system and does not specify the effect this system has on the engine emission out-performance.

- Individual approval on a vessel by evaluating real world emissions

To modernize or retrofit the engines of inland waterway vessels, it must be assumed that system layouts may be very individual and not covered by any type approval. Furthermore, many vessel engines are so old, that no type approval was ever performed and no emission data is available. In order to evaluate the emissions output for this case, measurements on board of vessels must be performed with a portable emission measurement system (PEMS). For this way of approval, an approach is yet to be developed.

3. CERTIFICATION POSSIBILITIES FOR NEW ENGINES AND RETROFIT DEVICES

There are taken into consideration two ways for the certification of the inland vessel ship engines: certification possibilities for new engines and for retrofit devices. For new engines, the owner of the approval (normally the engine manufacturer) is responsible for the complete type-approved system including the exhaust after treatment system. The manufacturer of the exhaust after treatment system as owner of the type approval will be forced to become engine

manufacturer of the used engine type with all duties of a type approval, which means CoP (Conformity of Production), duration warranty and so on. The certification of retrofitted systems, in Europe is just one regulation (ECE R132), dealing with the approval of retrofit exhaust after treatment systems. Very old engines on vessels without any approval regarding emissions will not be present in ranges of use. For this situation, it would be very helpful to have a procedure that allows certification to be granted on basis of real world emission measurements.

4. FUTURE TECHNOLOGIES AND FUELS FOR IWT

Diesel-Water Emulsions
Diesel/Water-Emulsions are being researched because of their theoretical potential to simultaneously reduce NOx and particulate (soot) emissions. The substitution of fuel by water leads to a loss of power. This may be possible by using capability reserves or modifying the injection devices. Safety issues like engine restart after a shut down during emulsion operation need to be tested and certified during a classification check. Long term durability performance of in-service engines seems to –still- be an issue with diesel-water emulsion technology.

LNG technology
Engine concepts for LNG use are developed for various applications. These are working as SI-engines (Spark Ignition), which have advantages in terms of emissions reduction of about 20% CO2, 80 – 90% NOx and nearly 100% of particulates. Due to the relative high fuel consumption it is not expected that stoichiometric LNG engines will be adopted by IWT. Compression ignition engines can be modified for diesel-LNG operation (dual fuel) but there is a big concern regarding methane emissions. THC limit value for certain LPG /CNG/LNG applications is 6.19 g/kWh. In case of a specific engine fuel consumption of 200 g/kWh, this implies a waste of fuel of 3 %.

Alternative fuels CNG and LPG
CNG (Compressed Natural Gas) is stored as a gas and transported under high pressure to increase density and reduce storage volume. LPG, a result of crude oil refining, is a liquid mixture of propane and butane.
Using these alternative fuels will brings advantages especially for CO, HC (up to 80%) and PM emissions (up to 30%). In general, the NOx emissions reduces slightly (0-12%).

Dual fuel applications
Due to the cost advantage natural gas holds against diesel, the demand for the former use led to the development of dual fuel applications (i.e. diesel-LNG) for different uses. Dual fuel applications need hard- and software modifications, which result in a change of the engine emission behaviour. In this case, methane emissions in particular should be monitored: diesel combustion at low loads is relatively cold, which may lead to high methane emissions because a good combustion of methane requires a relative high combustion temperature level.

Hybrid applications
Hybrid application entails the combination of at least two principles in a powertrain, i.e. a diesel engine and an electric engine with separate energy storages. For hybrid applications, various setups are possible (in series or parallel). For new vessels, hybrid applications are used to optimize the point of operation of the combustion engine.

5. CONCLUSIONS

New stringent emission limits require the drastic reduction (80 to 95%) of harmful emissions of NOx and PM. Due to the special characteristics of vessels (long engine lifetime, small series, greater variety of technical configurations) also retrofit after-treatment solutions, or solutions where new engines and after-treatment systems are purchased separately are necessary. For these options economical and effective certification procedures are needed. Some conclusions and questions for further answres can be extrapolated as following:

- Are the boundaries of a new technology covered by current regulations or are there parameters which need to be adapted (like definitions of new fuels)?
- Are existing testing procedures applicable to new technologies?
- Is it possible to transfer operation strategies of new technologies to a representative test bed procedure?
- Are costs of type approval reasonable for small serial production to be expected for new technologies for vessel applications?
- Is there a need for an easier approval approach due to costs and administrative efforts for small manufacturers and single applications?
- A lot of future technologies like alternative fuels and new combustion principles - like dual fuel applications, are not covered by the actual state of current regulations

- All future technologies based on the exclusive use of fuels other than diesel (EN590), are covered by existing regulations if the fuel is described as reference fuel.
- Dual fuel applications are not covered by the current NRMM regulations but it is planned to be included in the future Stage V legislation.
- Hybrid applications require adapted test procedures.
- On board certification is needed

6. REFERENCES

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