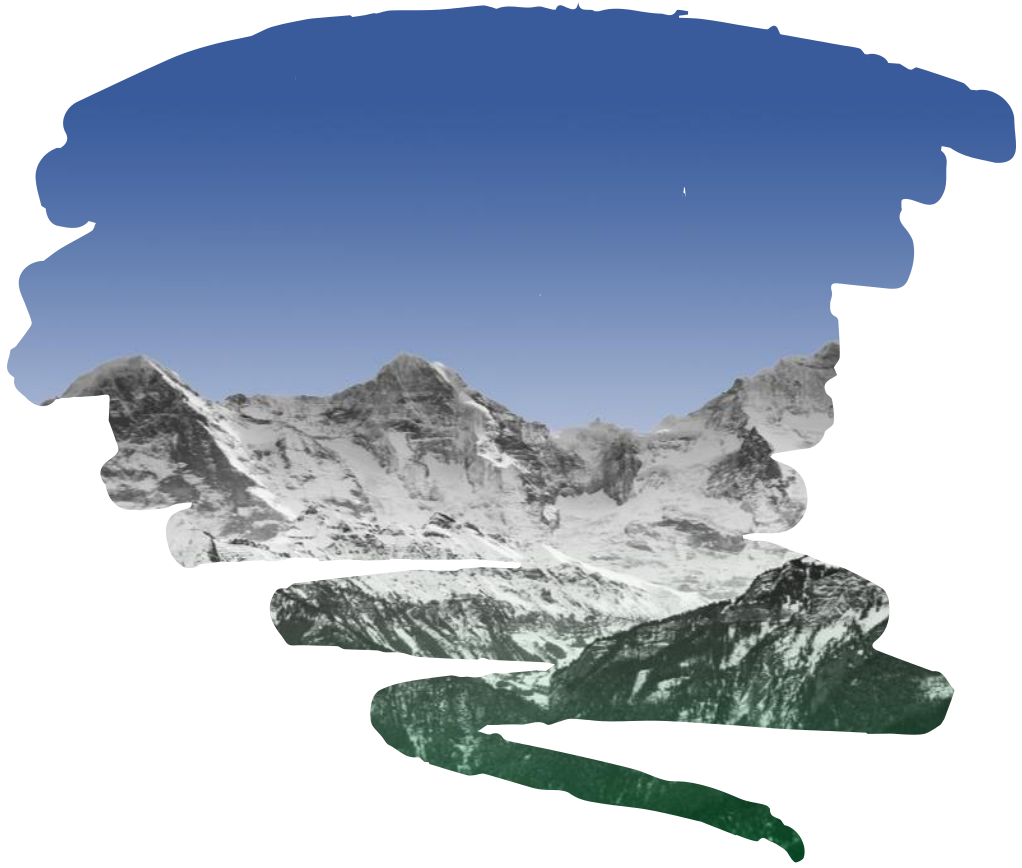
資料３２－１１



PM EMISSIONS OF MEDIUM SPEED ENGINES

CIMAC WG EMISSIONS

Daniel Peitz

26.06.2019

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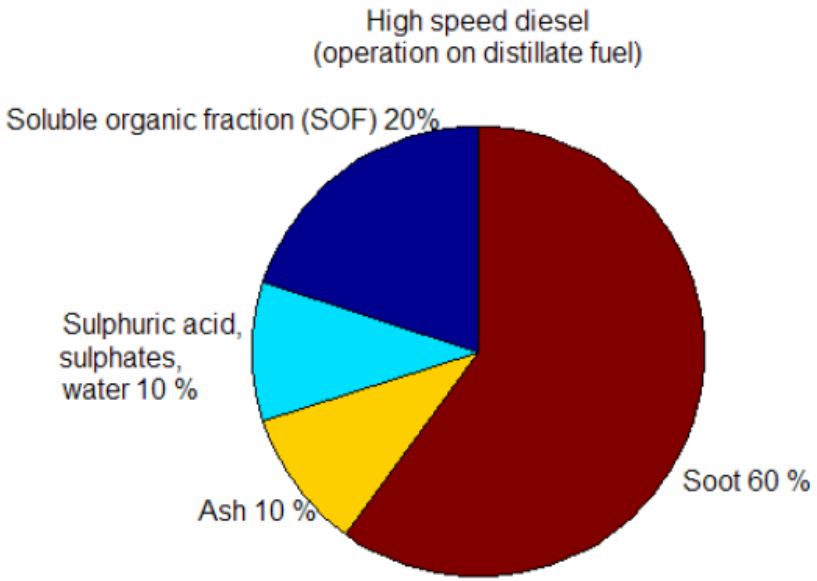
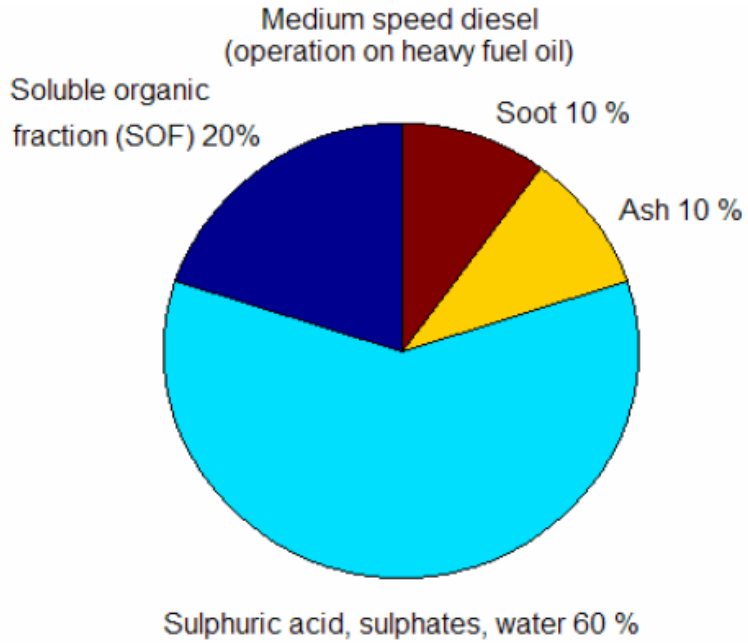
PM COMPOSITION





PM of medium speed engines typically not dominated by soot & ash (ISO 8178 measurement)

→ IMO regulation for S-content

G. Hellen, J. Ristimäki, Wärtsilä, CIMAC 2007 paper #56

BLACK CARBON
IMO REGULATION

- Black carbon (BC) increases global warming
- BC emission combustion dependent (unlike other PM)

Today:

- Bond et al. BC definition approved by IMO
- Measurement still discussed (PAS, FSN, LII as options)
- Still no information about future limit or timing

→ Commercial projects referring to other regulation

PARTICLE COLLECTION

Direct or «dry dust» method

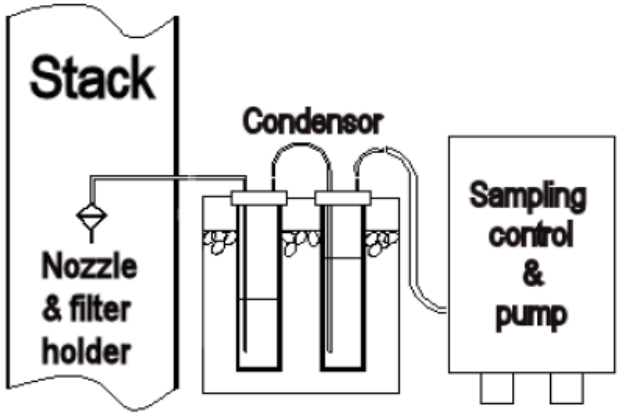


Figure 7. Example of equipment for direct measurement method according to ISO 9096 and US-EPA Method 17

dilution method

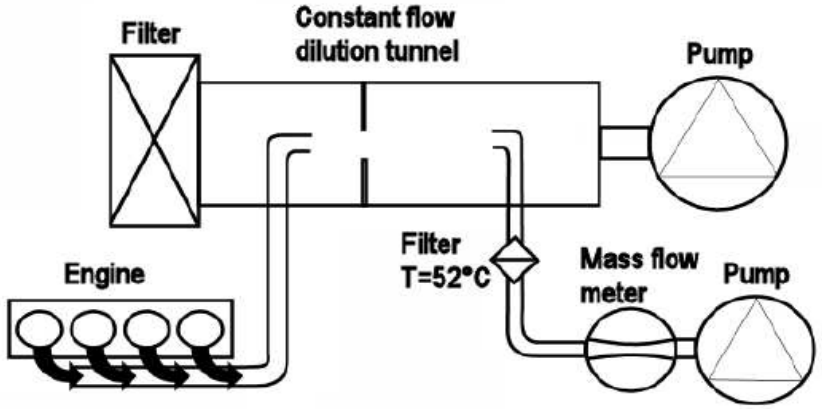
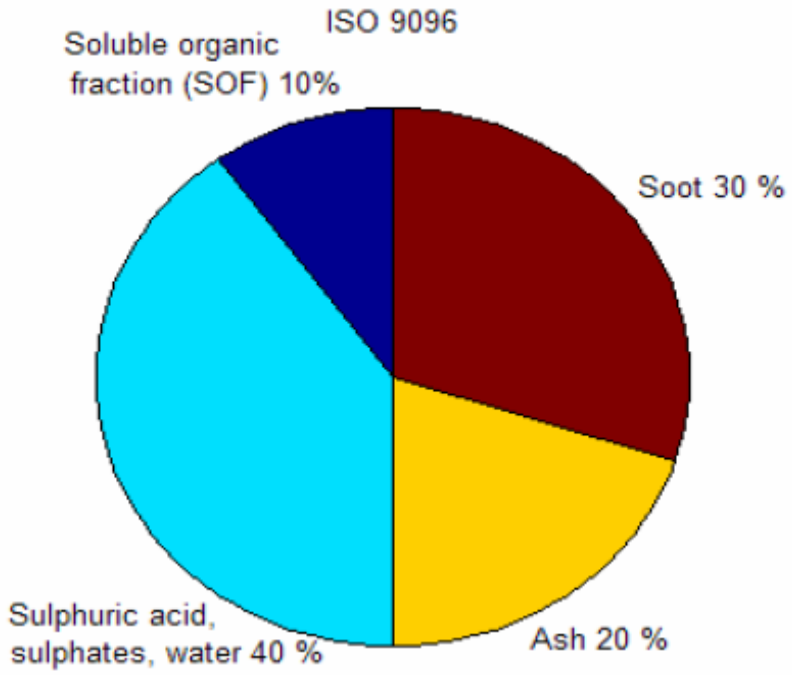
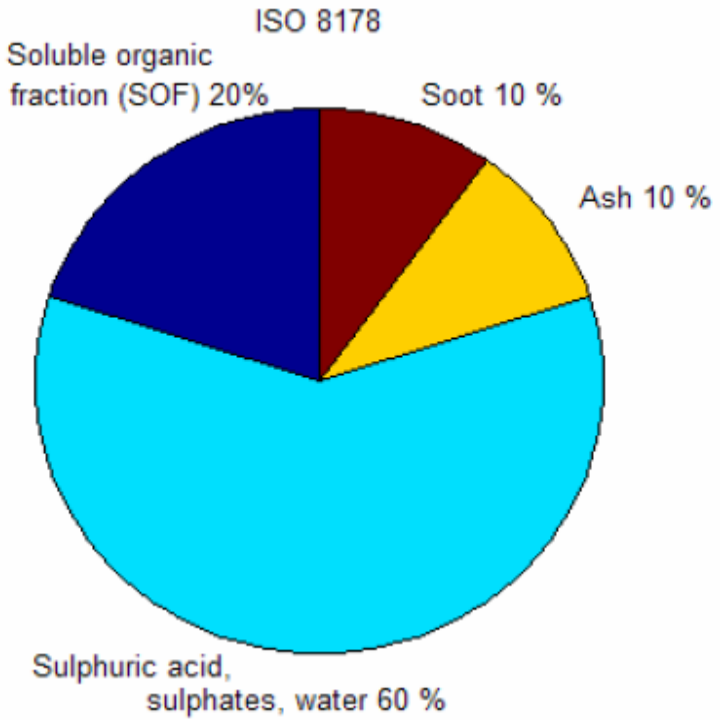


Figure 10. Equipment for dilution measurement method according to ISO 8178 – Full size dilution tunnel (CVS).

G. Hellen, J. Ristimäki, Wärtsilä, CIMAC 2007 paper #56

ISO 9096 VS. 8178





Operation on 100% load with HFO

G. Hellen, J. Ristimäki, Wärtsilä, CIMAC 2007 paper #56

ISO 8178 LFO

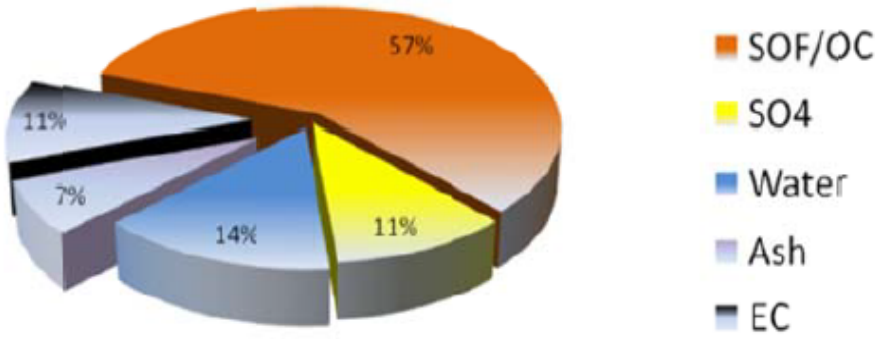


Figure 4. Particulate emission composition of a large 4-stroke medium speed diesel engine running on LFO at steady state high load. Sampling according to ISO 8178. Total particulate emission level in this case is 144 mg/kWh(shaft). Elemental carbon emission is about 15 mg/kWh(shaft). Thermal carbon determination with optical correction for pyrolysis of organic carbon (OC) to elemental carbon (EC). Adapted from Ristimäki et al. [xxvi]

CIMAC WG5 ìnformation on black carbon emissions 2012

ISO 8178 PITFALLS

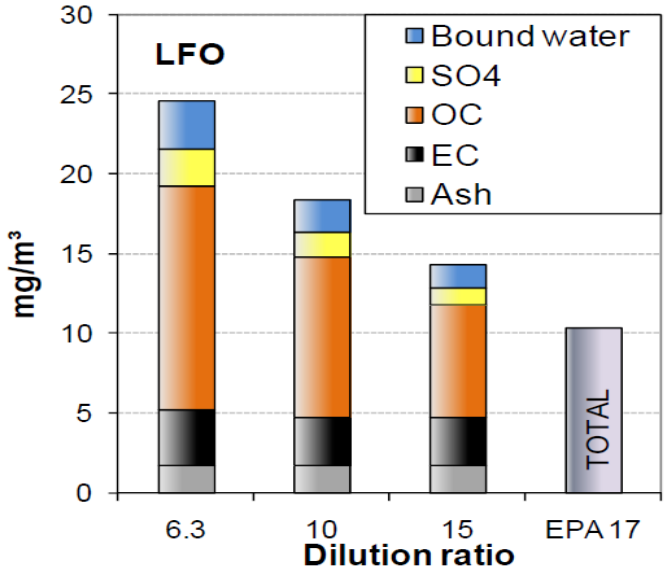
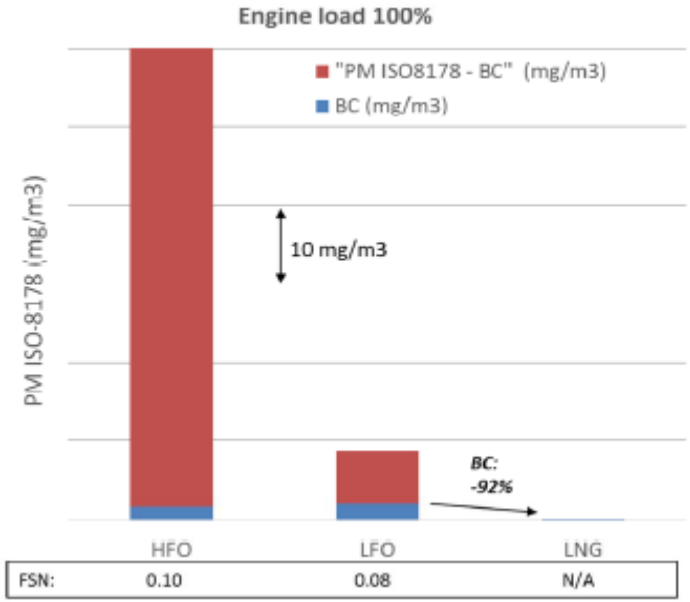


Figure 5 The effect of dilution ratio on the ISO8178 particulate measurement result with LFO operation compared to total mass of EPA 17/ISO 9096 in-stack measurement. The fuel sulphur content was below 0.05 w-%. SO_4 stands for sulphate, OC for organic carbon and EC for elemental carbon.

J. Ristimäki et al., Wärtsilä, CIMAC 2010 paper #73

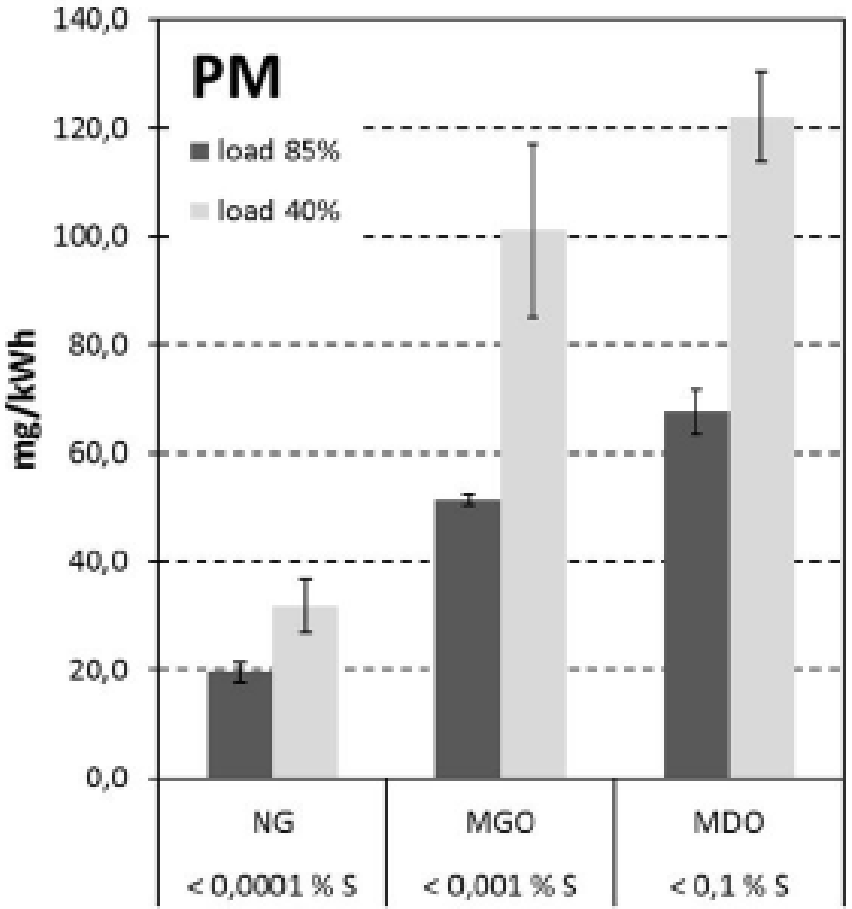


J. Heikkilä, S. Ingo, Wärtsilä, CIMAC 2016 paper #110

Dilution ratio affects PM value

not sensitive for BC

PARTICLE MASS



PM are exceeding EU Stage V by ISO 8178 even for DF engine

K. Lehtoranta, P. Aakko-Saksa, T. Murtonen, H. Vesala, L. Ntziachristos, P. Karjalainen, T. Rönkkö, N. Kuittinen, J. Alanen, ETH Nanoparticle Conference (2018)

CIMAC RECOMMENDATIONS

4.3.1.2 Direct Measurement Method – All Fuel Qualities

Measurement after engine and before heat recovery boiler, before flue gas cleaning system, etc - Recommended methods:

- ISO 9096: 2003: *Stationary source emissions – Manual determination of mass concentration of particulate matter.* In-stack filtration
- EN 13284-1: *Stationary source emissions – Determination of low range mass concentration of dust – Part 1: Manual Gravimetric method.* In-stack filtration.
- VDI 2066 Blatt 1 (Germany): *Particulate matter measurement. Measuring of particulate matter in flowing gases. Gravimetric determination of dust load.*
- EPA Method 17 (USA): *Determination of particulate emissions from stationary sources*
- JIS Z8808 (Japan): *Methods of measuring dust concentration in flue gases*

In order to assess PM abatement dry dust measurements should be advocated

CIMAC WG5 guide to diesel exhaust emission control 28/2008

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Thank you for your attention.

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