BC Abatement Methods + Ratings

An update to *BLG17 - INF7*

Investigation of appropriate control measures (abatement technologies) to reduce Black Carbon emissions from international shipping.

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2012 IMO Commissioned Report

- BC Abatement technology
  - Which technologies
  - What BC abatement potential
- Short list of technologies
- Assessment of cost for implementation

2017 Update

- Just BC abatement technologies and potential.
- Same methodology as 2012 report.
- Literature reviewed → peer reviewed research, industry reporting, online materials.
- Focus on studies with marine engines.
  - Some guidance taken from other sectors.
- Inclusive of all available methods of BC measurement.
  - Direct BC, fuel consumption, particle size/mass
- All data included unless some obvious bias or error.
- Additional focus on BC link to fuel quality parameters.
- Recommendations for BC measurement.

2012 Findings

Technology	BC Reduction
LNG	93.5%
Diesel Particulate Filters	85%
Water in fuel emulsion	70%
Scrubbers	60%
HFO to distillate fuel	45%
Slow Steaming with de-rating	15%

*** Important to realise these numbers are the result of an average of all studies.***

For most abatement options there was no more than 5 studies to draw from.

2017 Findings

BC Reduction Strategies	***BC Reduction***
LNG	93.5%
DPF – Low Sulphur Fuel	≥99%
DPF – High Sulphur Fuel	85%
WiFE	70%
Scrubbers	45%
HFO – Distillate	30%
Slow Steaming – De-Rating	15%

Significant changes to:

1) DPF – Low and high sulfur fuel
2) Scrubbers
3) Fuel Switching

Diesel Particulate Filters

85% → 99% (low S fuel)

- Most studies on DPF with low sulfur fuel show removal rates >=99%.
- Studies on DPF with high sulfur fuel show removal rates from 80 – 90%.
- 2 studies advancing high sulfur DPF technology.
- Numerous commercial suppliers and in-service demonstrations.

Scrubbers

60% → 45%

- Limited progress due to minimal use of explicit BC measurement.
- Two studies showed BC removal of ~30% → combined with 2012 data → downgrade to 45% mid range abatement.
- Range is as large as 20 – 90% depending on technology.
- Post 2020 implications of 0.5% fuel S cap.

HFO – Distillate

45% → 33%

- 16 studies, 57 data points (all 2012 data re-analysed).
- 2017 assessment compares "residual" to "distillate" fuels.
- 85% of data showed BC ↓.
- Other 15%, majority were test bed engines with some showing inconsistencies with in service operation.

Fuel Parameters and BC Emissions

- BC emissions from biodiesel show a link to O_2 content of fuel.
  - e.g 20% biodiesel blends → 10-30% BC reduction
- Research from other sectors show BC emissions increase as poly-aromatic content increases.
- Recent studies show BC reductions are linked to a change from residual to distillate fuels (rather than a shift to low sulphur residuals).
- An analysis of BC link to aromatic content was limited by lack of data.

Conclusions – BC Reductions

- LNG: 93.5%
- **DPF: 85% → 99% low S fuel**
- DPF: 85% → 85% high S fuel
- WiFE: 70%
- **Scrubbers: 65% → 45% high S fuel**
- Scrubbers: 37.5% low S fuel
- **HFO – Distillate: 45% → 33%**
- Slow Steaming: 15%

Conclusions - Post 2020 Implications

- DPF → technology needed for <0.5% sulphur fuel.
- Scrubbers → good removal rates for all fuels, better for high sulphur fuel.
- Mixing of high sulphur residuals w/ low sulphur residuals to achieve <0.5% fuel

Conclusions – Other Findings

- Still very limited data sets for most technologies.
- Test on scrubbers require explicit BC measurement.
  - BC reduction for high S fuel is likely larger but need BC measurement.
- Need reporting of fuel parameters for any BC measurement campaigns.
- Encourage use and refinement of BC measurement protocols.
- HFO – Distillate findings are more robust due to an increase in data points.
  - This is significant due to the complexity and variability of the system.
- Link of BC emissions to aromatic content in other sectors is robust. Recommend experiments on residual and distillate ship fuels.