The European Association of Internal Combustion Engine Manufacturers

EUROMOT

2011 YEARS Promoting Engine in Society

EUROMOT POSITION

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EU LCP BREF –
Feedback on Liquid Fuel Engines

With a view to the forthcoming discussion at the final TWG meeting in Seville in June 2015, the member companies of EUROMOT want to raise the following concerns on the proposed Chapter 10 "Best Available Techniques (BAT) Conclusions for Large Combustion Plants":[1]

10.3.2.1 BAT 35 - Energy Efficiency

Current text of the LCP BREF BP Document:

Table 10.19: BAT-associated energy efficiency levels (BAT-AEELs) ~~in~~for the combustion of HFO and/or gas oil in reciprocating engines

Type of combustion plant	BAT-AEE~~P~~Ls (1) ~~(yearly average – LHV basis)~~ Net electrical efficiency (%) (2)	
	New plant	Existing plant
HFO- and/or gas oil-fired reciprocating engine	~~45 to above 48~~ > 48	~~40–48~~ 39.4–48

(1) These BAT-AEELs do not apply in the case of plants operated in peak- or emergency-load modes.
(2) Net electrical efficiency BAT-AEELs apply to CHP plants and to plants generating only power.

{This BAT conclusion is based on information given in Section 6.3.3.1}

[1] Document TL/JFF/EIPPCB/Revised LCP_Draft of 1 April 2015

Proposal for modification:

Type of combustion plant, HFO /Gas Oil fired reciprocating engine	BAT AEEL net * electrical efficiency **** - New plant -	BAT AEEL net * electrical efficiency **** - Existing plant -
Single Cycle**	39.7 … 44.2 %	36.9 – 44.2 %
Combined Cycle***	46.9– 48.1 %	N/A

*Efficiency is design efficiency at MCR, ISO 3046-I conditions. Not applicable for peak/emergency plants.
** Highest values are for big 2-stroke type, a new 4-stroke type typically up to 43.9 % /1, 3/. Efficiency is also dependent on engine unit size.
*** Efficiency is dependent on cooling water temperature for steam turbine condenser, if radiator cooling of turbine condenser used efficiency might be lower.
**** Typical own consumption range is **case specific** 0.9 … 4 % of produced power depending on plant configuration (secondary emission abatement technologies installed, etc.) /3,4/.

Justification:

- Efficiency levels to be divided into single/combined cycles as done for e.g. gas turbines. The current proposal for the reciprocating engines is not built like this.
- EPPSA report /1/ states on page 7: ".. *Bigger units have higher efficiencies than smaller ones. Two stroke engines are more efficient than 4-stroke engines* ..". On same page is stated: "*In case of engines some inconsistencies could occur* ..": E.g. efficiencies for a single unit < 50 MWth: A check in BATIS showed - table 7.2.b: No. 181 (2-stroke) has a net 44.2 % (not 44.5) and in table 7.3.b. gross electrical efficiency for no. 181 is 45.1 % (not 47 %) to be replaced by no. 176 (2-stroke) with a 45.7 gross-% (43.9 net-%). Efficiencies for the range 50 .. 100 MWth in these tables are for a new combined cycle, a check in the BATIS database /2/ shows that the range should be set to net electrical efficiency of 46.9 – 48.1 %. Tables 6.2.b (48.5 net-%) / 6.3.b. (51.8 gross-%) for no. 428-7, No. 428-7 efficiency in BATIS are based on **erroneous information** /2, 4/. For no. 691 only gross value reported in the BATIS questionnaire.
- Plant 179 (anno 2009) is relative new with a net electrical efficiency of 39.7 %. For typical design values for new 4-stroke liquid fired engines and typical parasitic loads see Euromot paper /3/.
- It is to be noted that global stricter environmental requirements (lower NOx emissions) of diesel engines have had negative impact on the efficiency. With the technical development engine manufacturers have succeeded to restore/recover old efficiency levels on most engine types –> Graph 4.4 /1/ is not necessarily true.
- For existing plants, no. 428-8 (commissioned 1997) and no. 181 (2-stroke commissioned 1988) were used for lower – higher thresholds.

10.3.2.2 BAT 36 - NOx emissions

Current text of the LCP BREF PB Document, Table item c:

c.	Water/steam addition ~~injection~~	See description in Section 10.8	~~Not applicable during water shortages~~ Applicable within the constraints of water availability. The retrofit to existing engines may be constrained due to major modifications to the fuel injection system

Proposal for modification:

Add in right-hand column text: "*Only applicable to engine models for which water/steam addition methods are available on the market*."

Justification:

EUROMOT (BREF LCP BATIS-final-comments _D1_2013-10, comments 8340, 8396) on applicability restrictions. Certain techniques are engine manufacturer specific (only suitable for certain engine types of a single engine manufacturer), some methods are not in use anymore.

10.3.2.2 BAT 37 – CO and VOC emissions

Current text of the LCP BREF PB Document, Table item d:

d.	Oxidation catalysts	See description in Section 10.8	Not applicable to combustion plants operated in emergency-load mode ~~plants~~

Proposal for modification:

Add in righthand column text: "*Oxidation catalysts are not recommended in context with liquid fuels containing sulfur*"

Justification:

LCP BREF 2006 chapter 6.5.5.5 "CO and hydrocarbon emissions". Application limitation due to sulphur content of the fuel also mentioned in: BAT 54 of the BP draft Final Conclusion BREF document.
Sulfur oxides in the diesel flue gas are one of the major factors contributing toward deactivation of emissions aftertreatment catalysts.

10.3.2.2, Table 10.20

Current text of the LCP BREF PB Document:

Table 10.20: BAT-associated emission levels (BAT-AELs) for NO_X, ~~NH_3 and~~ CO and TVOC emissions to air from the combustion of HFO and/or gas oil in reciprocating engines

Combustion plant total rated thermal input (MW_{th})	BAT-AELs (mg/Nm^3)							~~Monitoring frequency~~
	NO_X				CO	~~NH_3 (1)~~	TVOC	
	Yearly average		Daily average or average over the sampling period		Yearly average (2)	~~Yearly average~~	Average ~~of samples obtained during one year~~ over the sampling period	
	New plant~~s~~	Existing plant~~s~~ (2)	New plant~~s~~	Existing plant~~s~~ (3)	New or existing plant~~s~~			
All sizes ~~but emergency plants~~	115–~~<~~140	~~90~~125–625~~250~~	~~120~~ 145–160 ~~260~~	~~120~~ 150–750 ~~310~~	50–175 ~~100~~	~~1–<5~~	10–40	~~Continuous measurement~~

~~(1) Ammonia emissions are associated with the use of SCR.~~
(2) These BAT-AELs do not apply when plants operate in peak- or emergency-load modes.
(3) The BAT-AEL range for plants operating in emergency- or peak-load modes is 1150–1900 mg/Nm^3.

The associated monitoring is in BAT 3 ter.

A. NOx

Proposal for modification NOx (calc. as NO2):

- All peak plant (for new ones max. 1500 operating h/year) engines shall be excluded from NOx limits requiring usage of secondary abatement techniques: 1300 .. 1850 (2000 old ones) mg/Nm3 (15 % O2) NOx (daily average)
- Emergency engines to be excluded (might have higher NOxs than normal engines due to set emergency ratings).
- New plant: NOx (daily average values):
  Diesel and Dual fuel engines in liquid mode: 190 … 225 mg/Nm3 (15 % O2)
- Existing plant: NOx (daily average values):
  Diesel and Dual Fuel Engines in liquid mode: 1000 … 2000 mg/Nm3 (15 % O2)

Justification NOx:

EUROMOT input notes NOx limits, see Comment 8342 of Comments on the BREF D1 (BREF_ LCP _BATIS:_Final Comments file) seems to have been completely ignored.
Equipping emergency engines with SCR or other complicated NOx abatement methods could compromise life and safety and exemptions need also to be given for new emergency engines in BP current text.

– New Plant:

Upper span yearly average is based on plant 363 (Delimara) with SCR and lower span limit on reference 497 assumed with SCR with 90 % NOx reduction . Daily span upper value on the same engine (363) in Maltese plant and lower span is said to be set on the same average difference between measured yearly and short emissions in an existing plant (same in the Maltese plant ?).

Reference 497 appears to be an old gas oil fired nuclear plant emergency engine (operating hours in year 2010 according to BATIS sheet only 64 hours). It is reported on BATIS sheet 3; engine unit size 23 MWth and, in sheet 1 “General Information” unit size is given as 12.5 MWth < 15 MWth (threshold). Engine unit size is to be rechecked. In a bigger diesel engine NOx emission is when operating on gas oil (LFO) is typically about 10 % lower than HFO mode due to a lower nitrogen content of gas oil. → Unit 497 is not a typical representative of a stationary engine and should be replaced by a normally operated HFO engine such as reference 179 → lower threshold: 190 mg/Nm3 (15 % O2), if 90 % NOx reduction with SCR is the benchmark.

Maltese plant was the only field reference (found in BATIS questionnaires) which supplied measurement results for a complete year (2013). References no. 691 and 429-4 were also equipped with SCR. EUROMOT made a thorough analysis of these measurements and submitted a document to BATIS /5/. There is a balance between the NH_3 and NOx achievable emission levels, i.e. more NH3 fed to the SCR (associated with a higher NH3-slip especially if SCR is operating on or close to its´ NOx reduction capacity upper limit) enables lower NOx. Simultaneous NOx and NH3 emissions are to be reported otherwise it is no meaningful information.

In EUROMOT paper /5/ the “fault” and “operational hours” of the SCR units calculated from year 2013 obtained field data can be found. If /5/ set frame conditions for NOx (50 … 185 mg/Nm3) and/or ammonia (=< 15 mg/Nm3) were not met “Fault” was marked. From this the availability of the specific exhaust train and OTNOC can be judged. I.e. “Exhaust Gas Train (SCR) 6A”:

- Hours in emission data sheet: 8524 -4 = 8520 hors
- “Fault hours”: 809 h
- No operation: 2067 hours
- → **Availability: 1 – 809/(8520-2067) = 0.8746 i.e. about 87.5 %**

If the NH3 slip limit is set stricter to =< 10 mg/Nm3 (15 % O2) from < 15 mg/Nm3 the “Fault” ratio increases with 1322 h → Totally: 809 + 1322 = 2131 h (based on the obtained excel sheets EEB submitted to BATIS in December 2014).

→ **Availability: 1 – 2131/(8520-2067) = 0.6698 i.e. about 67 %**

Technical availability calculations for all the SCR units should be done. **Figures vary a lot between the different (“6A”, “6B”, “6C”, “6D”) exhaust gas trains.**

From document /5/ it can be seen that the technical availability of the SCR:s in the plant has been rather low: depending on the exhaust gas train “faults” (outside set filtering limits,” case > 15 mg/Nm3 (15 % O2) NH3-slip”) occurred 7.1 .. 32.2 % of the total operation time (see graphs in annex of the EUROMOT document), with a lower set ammonia slip higher exceedence frequencies occur, i.e. **SCR systems showed frequent instability in their operation due to too strict set limits.**

Worldwide practice is that all of the set maximum levels should be achieved for at least 95 % of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours, **i.e. the Maltese SCR unit performance values shall not be used when setting NOx/NH3 BAT-limits for a oil fired reciprocating engine plant.**

BREF BAT shall conclusions shall be based on (preferable several) well-functioning plants which the Maltese plant (362, 363, 364 and 365) SCRs are NOT in light of above information. Measurement data from no. 362, 363, 364 and 365 indicate strongly that low NOx limits only can be reached if NH3 slip is high. Thus either proposed NH3 slip limit (see discussion below, item “NH3” (“BAT 4 bis”)) to be steeply raised or NOx limit (or both the NOx and NH3 limits) to be adjusted upwards.

References no.691 (La Reunion) and 429-4 (Madeira) are showing higher NOx values, indicating a need for higher limits… Thus in regard of NOx we propose to use the Gothenburgh Process results (results after a many year process where several stakeholders participated, including the EU Commission gave their input), these daily NOx limits were finalized in December 2012 /8/ (see reference list: “/5/ UNECE”/ link).

Cost is part of the BAT definition: “available” (“.. *under economically and technically viable conditions* ..”). In document /6/ the huge impact is shown of the SCR reagent cost have on the produced electricity cost, impact can be up to 25 % higher in remote cases. Thus flexibilities granted in the recently updated Gothenburgh Protocol (see link info above) should be considered as part of a cost-effective meaningful BAT approach after consideration of authorities provided that ambient air quality is fulfilled. I.e.: “Where SCR cannot be applied for technical and logistical reasons like on remote islands … a transition period of 10 years … may be applied ..” with leaner limits: 1300 .. 1850 mg/Nm3 (15 % O2) NOx depending on engine size

It takes up to ½ hour or a longer time depending on engine unit to heat up the SCR (SCR will not operate efficiently before it has reached a minimum operational temperature (chapter 6.1.10.3.3 /18/) to the operational temperature after a longer stand still. Thus peaking plants should have reasonable limits such as in Gothenburg Protocol, same emission limits as above “remote plants” , see also “SCR limitation availability” (see page 254 /2/ in “Sources” list of /8/).

In obtained material not enough information available for determining yearly NOx emissions – only daily average limits.

– <u>Existing plant:</u>

Plant unit 362 (used as lower limit of yearly span) is part of the Maltese plant (and thus a new plant), thus should NOT be used in this context at all. Higher end yearly limit is obtained by assuming a 75 % reduction on 2500 mg/Nm3 NOx. Daily span seems to be derived from yearly value calculations..

In order to keep the size of SCR (in existing plants often lack of space) and operating cost a moderate NOx limit is to be set. In the Lampdusa case (available in BATIS) retrofit SCR achieved 52 .. 62 % NOx reduction efficiency. I.e. a NOx limit of of 2500 (used in BP as the starting point for SCR NOx reduction point in existing plant) * 0.4= 1000 mg/Nm3 (15 % O2) is proposed for cases which could be retrofitted with SCR.

In BAT 36 table item “e” (SCR) “*Retrofitting existing plants may be constrained by the availability of sufficient space*”. I.e. the upper limit is to be raised to take these plants also into consideration to at least 2000 mg/Nm3 (15 % O2) NOx (taken from obtained field measurement data gathered into BATIS). These plants should upgrade with primary methods kits in order to achieve better NOx-levels.

No yearly average NOx limit to be given, see above “Maltese text”. Only daily average should be used in light of existing material.

B. CO

Proposal for modification CO in Heavy Fuel Oil Operation:

CO: 100 – 190 mg/Nm3 (15 % O2) at 100 – 90 % engine design load, for emergency and peak load installations no CO limits.

Justification CO:

In the header of the table is proposed that limits shall apply for both HFO and gas oil. EUROMOT members informed: high efficient big diesel/dual fuel engines in liquid mode have very different CO emissions in gas oil and HFO modes. In fact (in BATIS) almost all field data obtained for this process regarding liquid fired diesel engines were based on HFO, only (emergency unit) reference 497 was reported to operate on gas oil. In fact following references with fuel marked as “light fuel oil (gas oil”) are in fact using a fuel which is HFO: e.g. references 428 – 5 ... 428-10; 427-1 … 427-10; 429-1, 429-2, 429- 4; 176 (light fuel-HFO) is a HFO; 177/181 is a HFO. References no 543-1 and 543-2 have reported a blend of HFO low sulfur fuel (gas oil), CO emissions measured seem to be for HFO fuel mode when taking into account reported particulate value.

Only reference 497 (nuclear emergency unit) has reported to be on gas oil mode and corresponding CO emission of 134 mg/Nm3 (15 % O2). We have discussed with members producing bigger HFO diesel engines and they indicate that CO there might be an upto 200 % difference in CO emissions (higher for gas oil) if a bigger engine is operated on HFO and gas oil. **I.e. there are not sufficient data in BATIS to support CO BAT ranges in gas oil mode.**

When comparing the obtained measurement data one can see that usage of SCR (Reference 691 average CO about 192 mg/Nm3 (15 % O2) (missing in BATIS summary table /4/) and Maltese plant (362, 363, 364 and 365) (with CEMS) had amongst highest measured CO values. No. 429-4 had only a periodic measurement of 2 samples and is thus less reliable. → SCR will increase the CO emission, i.e. the lower level of CO is to be raised to 100 mg/Nm3 (15 % O2). Lower threshold to be raised, SCR increases CO emission. See also above BAT 37 proposed conclusion about oxidation catalyst in context with fuels such as HFO

Measured data seem to have been measured at high engine loads > 90 % of MCR, at lower loads the CO emission will increase steeply. Now is proposed that CO shall be measured by CEMS, i.e. lower engine loading points either to be excluded or higher values to be given for this range than the present high engine load range.

C. TVOC

Proposal for modification TVOC:

To minimize air emissions, good maintenance of the engine is regarded as BAT, i.e. delete current TVOC span limit proposal)

Justification TVOC:

A review of BATIS shows: NMVOC and sometimes TOC measurements have been made only in some Portuguese stations, namely no 427-1 … 427-8; 428-5 …428-10, 430, only in reference 427-7 a TOC a meaningful typical value (74 mg/Nm3 (15 % O2), if “reference molecule C”)) for a HFO fired engine was measured. In the same plant e.g. 427 -6 versus 427-7 between different similar engine types (of the same manufacturer) measured TOC varied even more than 500 %. No information is available on engine load, TVOC emission increases at part loads. Measurement method (periodic measurements: 1-4 samples only) in these plants was US EPA Method 25 A (a FID). No reference molecule is mentioned either for the measurements. To note is that proposed measurement method EN 12619 (in BAT 3) has a different minimum sampling line temperature than US EPA Method 25 A (used in the Portuguese plants) which might lead to very different TVOC measurement results.

We have in an e-mail /7/ to EIPPCB in May 17th pointed out that in our opinion measured NMVOC/TOC are erroneous (by far too low) and need a recheck (we never got any feedback on this). We have also discussed with our members manufacturing big diesel engines and they also agree that measured data is erroneous. We have also been informed by our members that in gas oil mode the NMVOC/TOC emissions are different (HIGHER) compared to HFO mode.

Thus in light of above we propose that the TVOC BAT range is deleted and the current LCP BREF 2006 BAT /18/ approach is maintained for TVOC, see chapter 6.5.5.5, when available data seems to be erroneous and very limited. See also comment 8385 on BREF D1 (BREF_ LCP BATIS:Final Comments file) and EUROMOT Position paper on HFO /8/.

BAT 4 bis: NH3

Proposal for modification NH3:

Both NOx limit and NH3 limit ranges are to be raised in light of the Maltese plant measurements (SCRs seem to be in unstable operation). Set NH3 –slip limit is dependent on set NOx-limit (see discussion in “A” above).

Justification NH3:

The Maltese plant (units 362, 363, 364 and 365) is the only plant which provided CEMS NH3 data. EIPPCB proposes now a BAT-AEL of 5 .. 10 mg/Nm3 (15 % O2) NH3 to be continuously measured (CEMS). EUROMOT's thorough analysis /5/ shows however that the SCRs in the plant are not operating satisfactorily, e.g. frequent high (>10 mg/Nm3 (15 % O2)) NH3 slips (see graph 3). This is a clear indication that the NOx and NH3 limits are not set in a proper balance, either one is to be raised in order the other emission shall stay within set limits. Graph 3 indicates clearly that proposed NH3 slip limit of 10 mg/Nm3 (15 % O2) is too low, with set NOx limits in the plant. The low availability (high “Fault”-ratio) of many of the Maltese plant SCR references also indicates that the plant is not yet mature enough to be a BAT candidate. See also discussions in section “A” above.

10.3.2.2 BAT 38 - SOx emissions

Current text of the LCP BREF PB Document: Table item c and d

c.	Duct sorbent injection (DSI) ~~with bag filter~~	See description in Section 10.8. The technique is used in combination with a dust abatement technique	~~Not applicable to emergency plants~~ Generally applicable
d.	Wet flue-gas desulphurisation (Wet FGD)	See description in Section 10.8.	Not applicable to combustion plants operated in emergency-load mode. There may be technical and economic restrictions for retrofitting existing plants operated in peak-load mode

{This BAT conclusion is based on information given in Section 6.3.3.3}

Proposal for modification:

Modify in right hand column text:

- "c":
  - Delete “Generally applicable”.
  - Add text: “Appropriate cooling of the flue gas needed due to used bag filter material. Plant to have a sufficient heat recovery need. Space availability may be a restriction in existing plants. Cyclic operation of the plant detrimental for the bags”.

- "d": Add text: “There may be technical and economic restrictions for applying the technique to combustion plants < 300 MWth. Due to high clean (fresh) water need application restrictions in arid areas. Space availability may be a restriction in existing plants."

Justification for c:

In below text some text from the Background paper (BP) is first highlighted which supported above table “generally applicable” statement are cited and responses are given to this text with a conclusion supporting above proposal modification.

EIPPCB assessment page 148 of BP document:

1. “ .. DSI is a well-known desulphurization technique ..”
2. “.. bag filter, other techniques may be used (i.e. ESP)) ..”
3. “ .. Plants 362, 363, 364 and 365 ..”one diesel reference referred to

Response :

1. DSI is novel/new in the diesel power plant (references mentioned in BP: no. 70 and 46 are boiler plants which have completely different exhaust gas properties .), a direct comparison to boiler plant experience with a abatement technique cannot be made. We are not aware of any other

diesel plant DSI reference. As has been noted e.g. with ESP, proper testing is needed before implementation of a technique used for years in the boiler sector in a diesel plant (see text in current LCP BREF 2006). Aging of the filters is to be taken into account and thus a sufficient long operation time is needed before a real judgment of a (novel) bag filter process can be judged /5/, /8/, /9/ in a diesel plant. Typical exchange time of a filter is 2 ..5 years (chapter 3.3.3.1.2 /10/), this should be the minimum operating period before any meaningful BAT conclusions can be drawn. See further discussion below about technical availability of the Maltese plant calculated on the obtained measurement data.

2. In case with ESP in place of the bag filter the corrosion risk is to be judged (chapter 3.3.3.2.9 /10/). Composition of the diesel flue gas is different than of the boiler flue gas and proper testing is needed before a judgment of the ESP suitability can be done. ESP usage in place of FGD (bag filter) might also change performance of the FGD /9/.
3. We are not aware of any other diesel engine plant applying the NaHCO3 FGD technique. The Maltese plant has still a very limited operational time and technical feasibility is low (see below discussion).

<u>EIPPCB assessment</u> page 150 of BP document:

“.. BAT AELS are based on well-performing plants ..”

<u>Response:</u>

Availability of the NaHCO3 FGD units in the Maltese plant is low: Plant operated on expensive gas oil 15.2 … 35.8 % of the total operating hours in year 2013 /5/. Aging of the bag filters is to be taken into account and thus a sufficient long operation time is needed before a real judgment of a novel bag filter process can be judged. Typical exchange time of a filter is 2 ..5 years (chapter 3.3.3.1.2 /10/), this should be the minimum operating period before any BAT conclusions can be drawn i.e. first after the exchange period the FGD performance can be judged in a meaningful way, still big challenges seem to be occur (low availability of FGD). Note also the gas conversion of the plant to start up /9/. We have understood that gas conversion work of the plant will start up in beginning of 2016. And be finished autumn 2016 (see below for more information).

<u>EIPPCB assessment</u> page 151 of PB document:

1.“ .. Bag filters with a high temperature resistance are available ..”

2. “Multicyclones may be used with high temperature flue-gases ..”

<u>Response</u>:

1. No reference for above statement is given so we took the freedom to search on internet, for information on this, we found source /11/, see below. In the Maltese NaHCO3 FGD diesel engine plant (362, 363, 364, 365) Goretex bag filters (max. 170 .. 180 degree C) are used /9/. In source /10/ chapter 3.3.3.1.2. table 3.10. some max temperatures are given (in line with source /11/ reported maximum temperatures) for some other fabric filter material largely used which are below a diesel flue gas temperature. As far as we know IGCC plants have used ceramic filters which can withstand high

temperatures /8/. These kind of filters have never been used in a diesel power plant as far as we are aware, challenges should be the different particulate spectra distribution which should probably affect the fly ash handling (diesel particulate is sticky and thus filter might easily clog). Diesel particulate contains some soot (hydrocarbons) which together with the high oxygen content (much higher than in a boiler or gasification plant flue gas) and temperature of the diesel flue gas would increase the firing risk significantly. The cracking risk, long term durability is also a big question mark of these filters.

In Current LCP BREF /18/ at page xi BAT is "*Availability*" defined as

'available' techniques are those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced

The statement:" …Bag filters with a high temperature resistance are available …" is not in line with above availability definition for a diesel plant when no operating plant with these filters is known.

2. It is common knowledge that cyclones are inefficient in case with diesel flue gas particulate. Diesel particulates are small in size and a cyclone will be very inefficient, a comparison to a oil fired boiler plant cannot be made . See also "dust" chapter below.

In the Maltese plant obtained data is mentioned the cyclic operation detrimental impact on the FGD. Note the Maltese plant operated in practice as a base load plant and anyway faced the challenges imposed by cyclic operation /5/. A diesel plant has a much bigger flue gas flow (see text below) than a boiler plant per produced MWhe thus the FGD reactor will be bigger than in a similar sized electric power producing boiler plant.

We want also to remind of paragraph 2.3.8 of the "*Commission Implementing Decision .. on collecting of data and drawing up of BAT reference document*" which in our opinion has not been followed. /5/.

➔ DSI not general applicable in a diesel power plant. Appropriate flue gas cooling is needed in order to protect bag filters. NO DSI experience in diesel plant with ESP or cyclone existing so far. DSI might suffer from cyclic operation of plant.

Justification for d:

In a diesel power plant there is a huge high quality (low chlorine) fresh water need, about 1.1 m3/MWhe (flue gas fed straight to FGD) → 100 MWe plant – about 110 m3/h water need, much bigger than for a boiler plant due to the difference in flue gas temperatures. Thus wet FGD cannot be judged according to the IPPC principle to be BAT especially for arid areas or in other areas with water shortages. BAT 33 (of BP) for liquid HFO boilers table 33 states for Wet FGD " *There may be technical and economic restrictions for applying the technique to combustion plants of < 300 MWt*h".
A diesel power plant has due to the high oxygen content in the flue gas compared to a liquid fired boiler plant an up to 2,3 .. 3 times bigger flue gas (depending on engine type) flow per produced MWhe, i.e. the FGD unit reactor is to be bigger in size and as a consequence

investment price is higher. In Chapter 6.1.10.3.2. /18/ is further given other aspects of the FGD in a diesel engine power plant.
Thus in regard of wet FGD, requirements for a diesel power plant shall not be set stricter than for a liquid boiler plant.

Table 10.21:

Current text of the LCP BREF PB Document:

Table 10.21: BAT-associated emission levels (BAT-AELs) for SO_2 ~~SO_X~~ emissions to air from the combustion of HFO and/or gas oil in reciprocating engines

~~Type of engine~~		~~Pollutant~~	~~Unit~~	~~Monitoring frequency~~	~~BAT-AEL~~	
					~~Yearly average~~	~~Daily average~~
~~All but emergency plants~~	~~Existing~~	~~SO_X~~	~~mg/Nm³~~	~~Continuous measurement (*)~~	~~100–200~~	~~ND~~
	~~New~~				~~< 100~~	~~< 110~~
~~(*) Only SO_2 is continuously measured, SO_3 is periodically measured (e.g. during calibration)~~						

Combustion plant total rated thermal input (MW_{th})	BAT-AELs for ~~SO_X~~ SO_2 (mg/Nm³)				~~Monitoring frequency~~
	Yearly average		Daily average or average over the sampling period		
	New plant~~s~~	Existing plant~~s~~ (²)	New plant~~s~~	Existing plant~~s~~	
All sizes ~~but emergency plants~~	~~<~~ 45–100	100–200	~~<~~ 60–110	~~ND~~ 105–235	~~Continuous measurement (¹)~~
~~(¹) Only SO_2 is continuously measured, SO_3 is periodically measured (e.g. during calibration).~~ (²) These BAT-AELs do not apply when plants operate in peak- or emergency-load modes.					

The associated monitoring is in BAT 3 ter.

Proposal for modification SO2:

- New/existing Peaking and emergency plants SO2 limit should be based on appropriate fuel choice.
- If SO3 fraction is included and SOx is regulated as sum of SO2 + SO3 the value should be raised 2 .. 7 % (depending on engine type) /12/.

New plant:
Daily average value: 300 MWth plant and area with fresh water supply amount not restricted : 60 … 200 mg/Nm3 (15 % O2) SO2. Other cases: 60 … 600 mg/Nm3 SO2 (15 % O2)

Existing Plant:
Daily average value: 200 … 600 mg/Nm3 (15 % O2) SO2

Justification SOx (SO2):

– New Plant:

Yearly:
Upper end is based on performance of Maltese plants (362, 363) and lower end with a wet FGD 90 % SO2 reduction if a 0.7 % S fuel is used.

Daily:
Seems to be based on the Maltese plant performance and lower range is set 30 % higher than yearly average lower span limit.

BAT conclusion is very optimistic when considering following: In the Maltese plant (no. 362, 363) a low sulphur HFO < 0.7 % S was used /9/. In order to reach the proposed SO2 limit of 100 mg/Nm3 (15 % O2) (= higher end limit proposed) an about 75 % reduction was needed in the FGD. This starts to be at the higher end of a dry FGD process in order to maintain reasonable reagent stochiometry /9/. In EUROMOT paper /5/ the "fault", "operational hours" and "GASOIL" data of the FGD units calculated from obtained field data can be found.

From this data the Technical Availability of the specific exhaust train can be judged. I.e. "Exhaust Gas Train (FGD on dust) 6A":

- Hours in emission data sheet: 8524 - 4 = 8520 hours
- "Fault hours": 129 (calc. from the EEB submitted Maltese "filtered" material in December 2014 to BATIS).
- No operation: 2067 hours
- "GASOIL" 983 h
- ➔ **Availability: 1 – 1112/(8520-2067) = 0.828 i.e. about 82.8 %**

Exhaust Train "6A" actually had one of the best technical availabilities in the plant, availabilities between the different ("6A", "6B", "6C", "6D") exhaust gas trains to be calculated. The different exhaust gas trains were **operated on gas oil** (typically 2 times more expensive than HFO) **mode 15.2 .. 35.8 % of the total operation time**.

The FGD is also reducing particulate, when technical availability is taking this function into account the availability will further drop (see discussion below).

Worldwide practive is that all of the set maximum levels should be achieved for at least 95 % of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours. i.e. the Maltese FGD units performance values shall does not be used when setting SO2/particulate (see below) BAT-limits for a oil fired reciprocating engine plant., BREF BAT shall conclusions shall be based on (preferable several) well-functioning plants which the Maltese plant (362, 363, 364 and 365) FGDs are NOT .

No average limits should (at least not yearly) be set in light of the low technical availability levels of the Maltese FGD plants.

A wet FGD operating on a maximum 3.5 wt-% S HFO with a 90 % SO2 reduction should fulfill SO2 limit of 200 mg/Nm3 (15 % O2). This should not be according to the

IPPPC approach (with a dry FGD) and the dry FGD process (especially in light of above shown availability figures and novelty) should be preferable changed to a wet FGD type (if sufficient good quality process water amount available). In case of FGD this (90 % removal of SO2 for a 3.5 wt-% S HFO) should be set as the upper and operation on a 0.1 % gas oil giving 60 mg/Nm3 (15 % O2) as the lower daily spans.

A wet FGD needs a huge amount of good (low chlorine, etc. **No operating diesel plant with sea water FGD exists to our knowledge**). quality fresh water about 1.1 m3/MWhe (flue gas fed straight to FGD) → 100 MWe plant – about 110 m3/h water need . Thus this is not according to the IPPC principle BAT especially for arid areas or other areas with water shortages. BAT 33 (of BP) for liquid HFO boilers table 33 states for Wet FGD " *There may be technical and economic restrictions for applying the technique to combustion plants of < 300 MWt*h". A diesel power plant has due to the high oxygen content in the flue gas compared to a liquid fired boiler plant an up to 2,3 .. 3 times bigger flue gas (depending on engine type) flow per produced MWhe, i.e. the FGD unit reactor is to be bigger in size and as a consequence investment price is higher- and more space required. In Chapter 6.1.10.3.2. /18/ is further given other aspects of the FGD in a diesel engine power plant. **Thus in regard of wet FGD, requirements for a diesel power plant shall not be set stricter than for a liquid boiler plant.**

If a wet FGD cannot be applied due to water shortage low sulfur oil shall be set to be BAT, depending on commercially available HFO brands: 1 wt-% S HFO gives an about 600 mg/Nm3 (15 % O2) and 0,5 wt-% S an about 300 mg/Nm3 (15 % O2) SO2 emission – as upper span limit.

– Existing Plant:

Yearly average reference technique for existing plants is said to be "fuel choice" (page 150 of BP).

Yearly average: We informed in spring 2013 / 7/ EIPPCB that obtained SO2 emission value from references 177, 178 burning 0.8 wt-% sulphur content HFO were erroneous and asked for a check. Actually Greece has in October 2013 updated emissions (in BATIS) for amongst all references 177, 178, 179, 180 and 181. For reference 177 is reported SO2 is 433 mg/Nm3 (15 % O2) and reference 178 a SO2 value of 441 mg/Nm3 (15 % O2), "the rule of thumb" in source /4/ gives for a 0.8 wt-% S HFO about 460 mg/Nm3 (15 % O2) SO2 . Given fuel specification values are often max values and reference 177 seems to be have operated on a 0.75 % S HFO and reference 178 on a an bout 0.77 % S HFO.

Daily average upper average value (based on yearly) is from no. 430 and limit is set to 235 mg/Nm3 (15 % O2).

We informed in spring 2013 / 7/ EIPPCB that obtained SO2 emission value from this plant was erroneous and asked for a check. Reported average value of 181 mg/Nm3 (15 % O2) is not in line with reported fuel < 0.91 % HFO. A 0.91 % HFO should lead to a 196*0.91*2.93 = about 520 mg/Nm3 (15 % O2) SO2 / 4/. Daily average lower value is from no. 362 (new Maltese plant) not a suitable reference, see discussion above should be raised to 200 mg/Nm3 (15 % O2) SO2.

If based on "fuel choice": upper BAT range should be based on a commercially available fuel e.g. in case of a 1.0 % S HFO → about 600 mg/Nm3 (15 % O2) and if a 0.5 wt-% S HFO → about 300 mg/Nm3 (15 % O2) SO2.

10.3.2.2 BAT 39 - Dust emissions

Current text of the LCP BREF PB Document: Table item c, d, e and f:

c.	Bag filter	See description in Section 10.8	~~Generally applicable to new plants~~ Not applicable to combustion plants operated in emergency-load mode ~~plants. Applicable to existing plants within the constraints given by space availability~~
d.	Electrostatic precipitator (ESP)	See description in Section 10.8	
e.	Multicyclones	See description in Section 10.8	Generally applicable
f.	Dry, semi-dry or wet FGD system	See descriptions in Section 10.8	Generally applicable when the technique is mainly used for SO_X, HCl and/or HF abatement

Proposal for modification:

c: Add in right hand column text: "Sufficient cooling of the flue gas needed for the protection of used bag filter material. A bag filter needs a protection agent in order to protect (from clogging) against the sticky particulate from oil burning. Plant to have a sufficient heat recovery need. Cyclic operation of the plant detrimental for the bags.. Space availability may be a restriction in existing plants ".
d: add: very limited experience exist in a liquid fired diesel plant, Space availability may be a restriction in existing plants ".

e: Remove multicyclones

f:combine semi dry FGD (filter) with "c". Delete wet FGD.

Justification:

c: see text in BAT 38 justification discussion

d: See a "challenge" text in 6.1.10.3.1 /18/.

e: Source /13/ table 3.4-2 shows a typical diesel engine particulate spectre.. "*Multicyclones are reported to achieve from 80 to 95 percent collection efficiency for 5 micrometer particles* .." /14/. Source /13/ indicates that only about 2 % of the diesel particulate mass is > 3 micrometer → multi cyclone impact is neligible.

f: Wet FGD has in light of above particulate spectre a (see above "e") very low dust removal efficiency and should be removed in this context.

Table 10.21:

<u>Current text of the LCP BREF PB Document:</u>

Table 10.22: BAT-associated emission levels (BAT-AELs) for dust emissions to air from the combustion of HFO and/or gas oil in reciprocating engines

~~Type of engine~~	~~Pollutant~~	~~Unit~~	~~BAT-AEL~~		~~Monitoring frequency~~
			~~Yearly average~~	~~Daily average~~	
~~New~~	~~Dust~~	~~mg/Nm³~~	~~1–5~~	~~6–12~~	~~Continuous measurement~~
~~Existing, all but emergency mode~~			~~1–10~~	~~ND~~	

Combustion plant total rated thermal input (MW_{th})	BAT-AELs for dust (mg/Nm^3)				~~Monitoring frequency~~
	Yearly average		Daily average or average over the sampling period		
	New plants	Existing plants~~, all but emergency plants~~ ([1])	New plants	Existing plants~~, all but emergency plants~~	
All sizes ~~but emergency plants~~	~~1~~–5 2–7	~~1–10~~ 2–20	6–~~12~~15	~~ND~~ 6–40	~~Continuous measurement~~

([1]) These BAT-AELs do not apply when plants operate in peak- or emergency-load modes.

The associated monitoring is in BAT 3 ter.

<u>Proposal for modification Dust:</u>

For peak or emergency plants no particulate limits

New plant: Dust daily average:

1. < 30 mg/Nm3 (15 % O2) for > 300 MWth plant (if ESP used) at 85 .. 100 % MCR engine load
2. < 40 mg/Nm3 (15 % O2) for others at 85 .. 100 % MCR engine load, if 0.5wt-% S HFO
3. Otherwise: < 50 mg/Nm3 (15 % O2) for others at 85 .. 100 % MCR engine load

Existing Plant: Daily average: 50 .. 75 mg/Nm3 (15 % O2) at 85 .. 100 % MCR engine load

<u>Justification Dust</u>:

– New Plant:

BP current text:
Yearly BAT-AELs is based solely on the Maltese plant (units 362, 363, 364 and 365). Ditto for daily average limits.

The filtered data statistics gives a very skewed picture of the performance of this plant .

In EUROMOT report (submitted to BATIS /5/ it is shown in graph 1 that frequently dust emissions exceeded the in table used average e.g. 7 mg/Nm3 (15 % O2) depending on exhaust gas train about 1400 .. 3200 h during the reference year.

In EUROMOT paper /5/ the "fault" and "operational hours" of the FGD units calculated from year 2013 obtained field data can be found. In Annex 1 is stated if set frame conditions for Dust (> 20 mg/Nm3) was not met "Fault" was marked for "Dust" in filtered data sheet. We noticed that "Fault"s for dust and SO2 measurements sometimes occurred at different times in the excel sheet, but GASOIL mark occurred simultaneously for both. Thus below calculation is "optimistic" for the FGD performance when **only** the "fault" caused by particulate (dust) is considered. "GASOIL": FGD was probably bypassed due to (repair, etc.) work on the unit. From this data the technical availability of the specific exhaust train can be judged. I.e. "Exhaust Gas Train (FGD on dust) 6A", in case of particulate frame =< 20 mg/Nm3 (15 % O2):

- o Hours in emission data sheet: 8524 -4 = 8520 hours
- o "Fault hours": 98 h (calc. from the EEB submitted Maltese "filtered" material in December 2014 to BATIS).
- o No operation: 2067 hours
- o "GASOIL" 983 h
- ➔ **Technical Availability: 1 – 1081/(8520-2067) = 0.8325 i.e. about 83.2 %**

With a stricter set particulate frame (than =< 20 mg/Nm3):

- o **=< 15 mg/Nm3 (15 % O2)**, "fault" hours increase with 150 h and technical availability drops to about **81 %**
- o **=< 10 mg/Nm3** (**15 % O2)**,,, "fault" hours increase with 534 h and technical availability drops to about **75 %**
- o **=< 7 mg/Nm3** (**15 % O2)**, "fault" hours increase with 1069 h and technical availability drops to <u>about **66.7 %**</u>

Availabilities for all the FGD units (362, 363, 364 and 365) to be inserted into the table. This gives an overall view of the functionality of the FGD units.

Worldwide practice is that all of the set maximum levels should be achieved for at least 95 % of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

I.e. the Maltese FGD units performance values shall thus not be used when setting particulate BAT-limits for a oil fired reciprocating engine plant., BREF BAT shall conclusions shall be based on (preferable several) well-functioning plants which the Maltese plant (362, 363, 364 and 365) FGDs are NOT

In the Maltese material is also stated "*Minor dust problem continued to occur ´due to filter bag leaking ..*" , a very limited amount of measured hours on high dust (particulate) emissions is reported so switch to "gasoil" operation seems to have been fast in disturbance cases.

In the Maltese material it is also mentioned that the plant will be converted to a gas plant (more info /19/: **work will begin in January 2016 and the estimated completion time is October 2016. Four of the existing diesel engines will be converted to SG type gas engines and the rest four ones into DF type gas**

engines) and thus there is a big risk that **the plant will never reach the needed minimum operational hours before meaningful BAT conclusions could be drawn.** It should thus be incorrect to base BAT conclusions for the whole liquid fired diesel engine plant sector based on a plant with a novel abatement technique which will very soon stop operating on HFO.

Emission limits shall not be based on a single technology which cannot be universally used (if no big local heat recovery need or combined cycle installation) in the whole HFO diesel engine plant field due to the temperature restrictions of the used bag filters.

As stated in LCP BREF 2006 /18/ diesel flue gas properties are different compared to the oil boiler flue gas, long term ESP field tests have shown that a particulate limit of 30 mg/Nm3 (15 % O2) is reachable. In document /8/ we proposed a dust (particulate) limit for big diesel plants > 300 MWth, who has the workforce/expertise to sort out the complicated handling/disposal of the erased dust and can operate ("explosion risks, etc.")/maintain the plant in a proper way. We do not understand the set limit of quantification of 2 mg/Nm3 used, in light of the technical availability of used reference plant this should be taken out. In the light of present status of missing well functioning dust secondary abatement technique we propose following: reduce current dust limit of HFO in BREF 2006 of 50 mg/Nm3 (15 % O2) to 40 mg/Nm3 (15 % O2) which can be fulfilled with a low ash, max. if a 0.5 wt-% S HFO commercially available, otherwise maintain limit 50 mg/Nm3 (15 % O2) at engine loads 85 .. 100 % MCR. Only daily average limits to be given.

We want also to remind of paragraph 2.3.8 of the "*Commission Implementing Decision .. on collecting of data and drawing up of BAT reference document*" which in our opinion has not been followed. /4/. **No general discussion in the TWG has been done in order to judge if this novel plant (362, 3623, 364, 365) if suitable as a BAT AEL reference plant or not**. EUROMOT analyses /4/ indicates not.The Maltese FGD **is not in our opinion fulfilling the BAT** criterias set on page Xi /18/.

– Existing Plant / BP current text:

Yearly average: Upper span limit < 20 mg/Nm3 (15 % O2) is said to be based on references 180 and 428-10. Reported values from no 180 and 428-10 are typical gas oil values, not with reported HFO brand 0.8 % S respectively 0.95 % S HFO fuels.

We have in an e-mail /7/ to EIPPCB in May 17th 2013 pointed this out that these measured dust are erroneous (too too low). See paper "Dust Emission to air" /4/, here it was shown that above values are too low. Actually Greece has in October 2013 updated emissions (in BATIS) for amongst all references 177, 178, 179, 180 and 181. For reference 180 is reported a particulate value of 84.4 (>> 20 mg/Nm3) mg/Nm3 (15 % O2) with the 0.8 wt-% S HFO.),

BATIS: Reference 427-3 operating on a 1.01 % S HFO reported 56 mg/Nm3 (15 % O2) CEMS-measured dust and no. 428-7 operating on a 0.95 % S HFO 76 mg/Nm3 (15 % O2) dust CEMS.

Take out lower span limit of 2 mg/Nm3, no meaning.

Daily average value:

Upper end said to be "*based on variations reported by plants fitted with bag filter applied to reference plant taken for setting yearly BAT-AEL*". Only cases reported with bag filter uis the Maltese ones (362, 363, 364, 365) which availability is not high (see above text) . As stated above bag filters are not applicable on all installations either due to temperature restriction and lack of space and shown low availability in the Maltese plant.

➔ Dust limit to be based on fuel choice. With a max. 0.5.. 1.0 wt-% S and low ash HFO a particulate level of 75 mg/Nm3 (15 % O2) should be targeted for in a well maintained plant at engine loads 85 .. 100 % MCR. Only daily average limits to be given

Sources besides BATIS:

/1/ EPPSA/Eurelectric "Report of the Task-Force Energy Efficiency Large Combustion Plant BREF TWG"; submitted to BATIS December 2014

/2/ EUROMOT Comments on "Report of the Task-Force Energy Efficiency -Large Combustion Plant BREF TWG"; submitted to BATIS January 2015 (also available at http://www.euromot.eu/download/54da4bfeb49bf328fd49c7b8)

/3/ Euromot: "BAT Associated Energy Efficiency Levels" report submitted to BATIS September 2014 (also available at http://www.euromot.eu/download/5453c772de27a3a6fea5ce05) .

/4/ Euromot feedback on LCP BREF Data Collection 2011 – 2012 submitted to BATIS 08.05-15.

/5/ Comments on Maltese Plant Data Submitted by EEB (European Environmental Bureau) on 3 December 2014. Submitted to BATIS February 2015 also available at (http://www.euromot.eu/download/54da4c2cb49b86c3cbe73ca9) .

/6/ "Euromot Position for the Gothenburgh Protocol", submitted April 2012 to BATIS, also available at http://www.euromot.eu/download/54383790de278fdcb4d094c7

/7/ Euromot e-mail on 17th of May 2013 from P. Zepf to T.Lecomte at EIPPCB.

/8/ Euromot Position : Draft D1 Large Combustion Plants BREF- BAT AELS for HFO fired Engines submitted to BATIS September2013 (also available at http://www.euromot.eu/download/54383683de278fdcb4d093b1)

/9/ "Euromot Response to CEFIC Comments as of 17 July 2014", submitted to BATIS December 2014, (available also at http://www.euromot.eu/download/5478c1c83efeb631842bcb77)

/10/ LCP BREF D1

/11/" Industrial Baghouse Filters: Filter Bags and Cartridges " at link http://www.gore.com/en_xx/products/filtration/baghouse/filterbags/industrial-baghouse-filters-products.html

/12/ https://www.google.fi/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=10&ved=0CFYQFjAJ&url=https%3A%2F%2Fcleanshippingcurrents.eu%2Fojs%2Findex.php%2FCSCurr%2Farticle%2Fdownload%2F6%2F9&ei=XCNHVbq1NLGf7gaJqIH4CA&usg=AFQjCNEU6JS9_FpVHzoSK0QNUZRXCvbLUg see page 13.

/13/ US EPA AP-42 at http://www.epa.gov/ttn/chief/ap42/ch03/final/c03s04.pdf

/14/ http://www.epa.gov/ttncatc1/dir1/fcyclon.pdf

/15/ Euromot: Large Combustion Plant BREF D1 (Draft) – BAT AELs for Gas Engines, submitted September 2013 to BATis, also available at http://www.euromot.eu/download/54383688de278fdcb4d093b6

/16/ Danish gas Center report at http://www.dgc.eu/sites/default/files/filarkiv/documents/R0703_formaldehyd_reduction.pdf .

/17/ Euromot e-mail on 25th of March 2013 from J.Boij to T.Lecomte at EIPPCB.

/18/ LCP BREF 2006

/19/ http://www.lngworldnews.com/wartsila-to-convert-maltese-power-station-to-run-on-gas/

We remain available for further clarifications and in-depth discussions of our positions.

EUROMOT – 2015-05-20

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