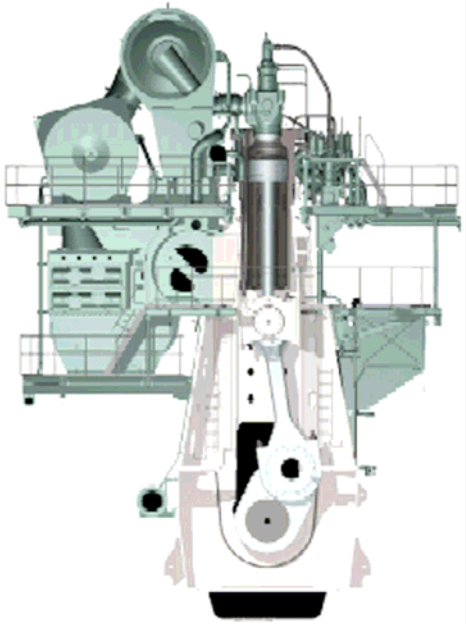


HUDONG HEAVY MACHINERY CO.,LTD.

Discussion on NOx Certification Obtainment and NOx Emission Survey on Board for Low Speed Diesel Engine

Zhou Weizhong

Oct.2008

Shanghai ,China

Abstract





- **MAN Diesel A/S and WCH's different processing modes of emission of NOx certification obtainment and emission of NOx survey on board.**

- **the advantages and disadvantages of these different processing modes**

Keywords: *Emission of NOx certification obtainment*
Survey on board
Low speed diesel engine

Ⅰ Introduction

《The Protocol of 1997 to Amend The International Convention for The Prevention of Pollution from Ship, 1973, as Modified by Protocol of 1978 Relating Thereto》

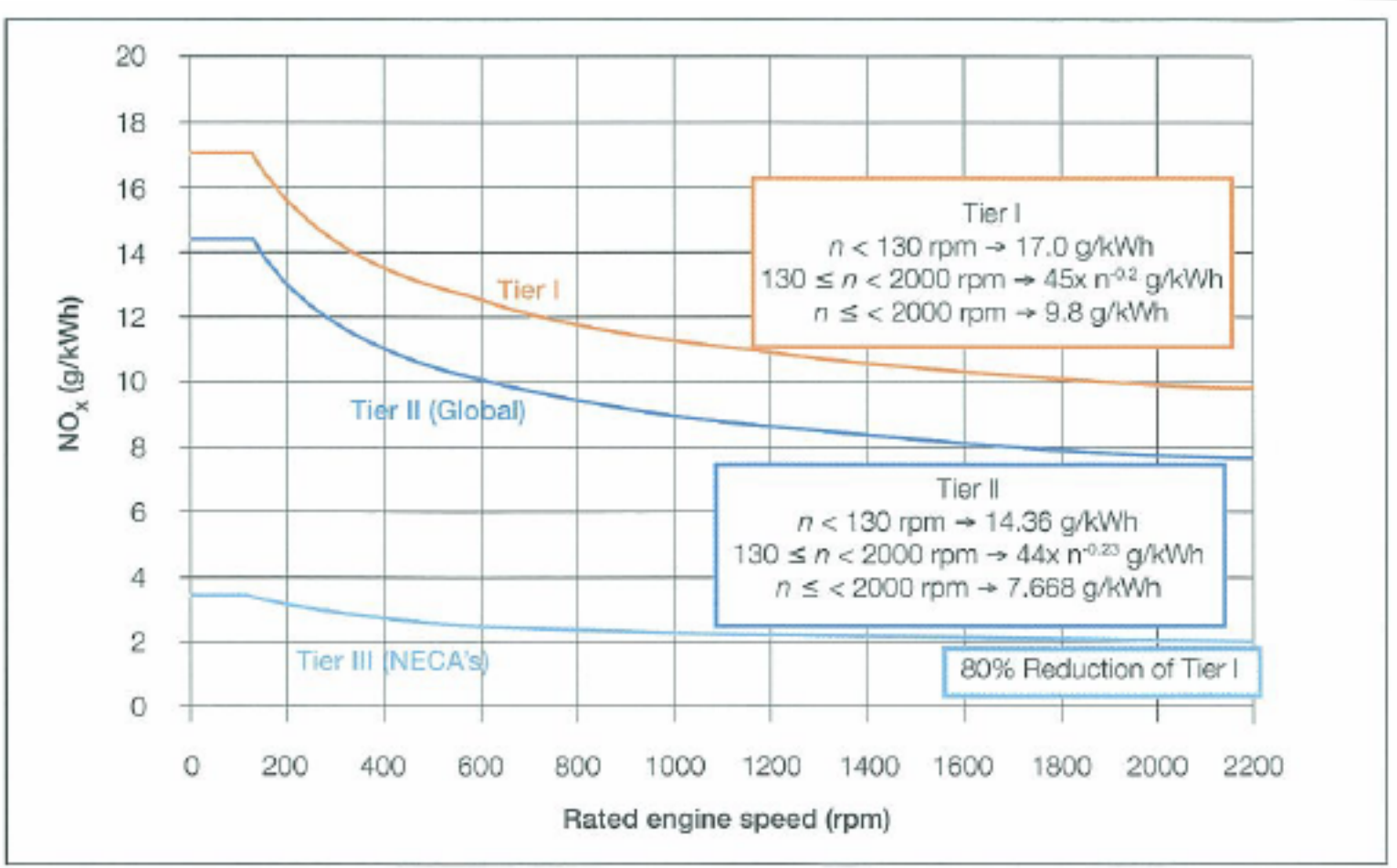
appended a new annex VI ——— Regulation for The Prevention of Air pollution from ship.

This regulation appended to the protocol in 1997.

I Introduction







Ⅰ Introduction





The conference of parties to the international convention in 1997 made consideration and adoption of conference resolution 1 to 8 and technical code on control of emission of NOx (nitrogen oxides) from marine diesel engine , including the mandatory of

《The Technical Code on Control of Emission of NOx (Nitrogen Oxides) from Marine Diesel Engines》

_____

relation to the new annex VI. and attached at the conference resolution No.2.

Introduction

MAN Diesel

WÄRTSILÄ

have taken corresponding measures to meet the requirements of IMO emission, especially the requirements of emission of NOx.

Introduction

the necessary documents (compiling format and essential elements of technical document) for obtaining emission certification have no concrete detail requirements, but only principle specifications.

The manufacturers could compile the technical document according to the format used by themselves.

There are much differences between two technical documents of MAN Diesel and WCH , both of them included theory and test achievements of their own.

II International Rule

chapter No.6.2.3.4.1

specified different factors which influence emission of NOx

——— In the related documents MP/CONF 3/35 from International Marine Organization

II International Rule





including

a) injecting timing
b) injecting nozzle
c) injecting fuel pump
d) fuel cam
e) injecting pressure of common rail system
f) combustion chamber
g) compressing ratio
h) type and structure of turbocharger
i) cooler, heater
j) valve timing
k) NOx restrained device “water spray”
l) NOx restrained device “fuel water emulsification”
m) NOx restrained device “exhaust gas recycle”
n) NOx restrained device “selective catalytic reduction” or
o) other parameters specified by authorities.

II International Rule





the actual technical documents for the engine could be less than these mentioned components and/or parameters of specified engine and special design.

Generally speaking

for present low speed diesel engine

the contents of **No. k**, **No. l**, **No. m** and **No. n** can be out of consideration.

III Basic ideas of the two technical documents





A)MAN Diesel A/S Company (MD)

MD found that ***three major factors***, which will influence emission of NOx by working process calculations and simulation system (TAPCODE) calculations and actual measurement analysis, mainly

- cylinder combustion pressure (P max)
- scavenging temperature (T scav)
- back pressure of diesel engine (P back)

III Basic ideas of the two technical documents





The concrete influenced values (Table No.1)

Power (%)	ΔNOx,P max (g NOx/kWh pr. bar)	ΔNOx,T scav (g NOx/kWh pr. deg.C)	ΔNOx,P turb.back (g NOx/kWh.pr. Mm WC)
100	0.1816	0.0224	0.0004
75	0.1760	0.0209	0.0006
50	0.1760	0.0209	0.0006
25	0.1760	0.0209	0.0006

III Basic ideas of the two technical documents





According to MD's research results, compressing pressure has also great influence on emission of NOx, however, the influence has no quantitative datum but qualitative relationship only.

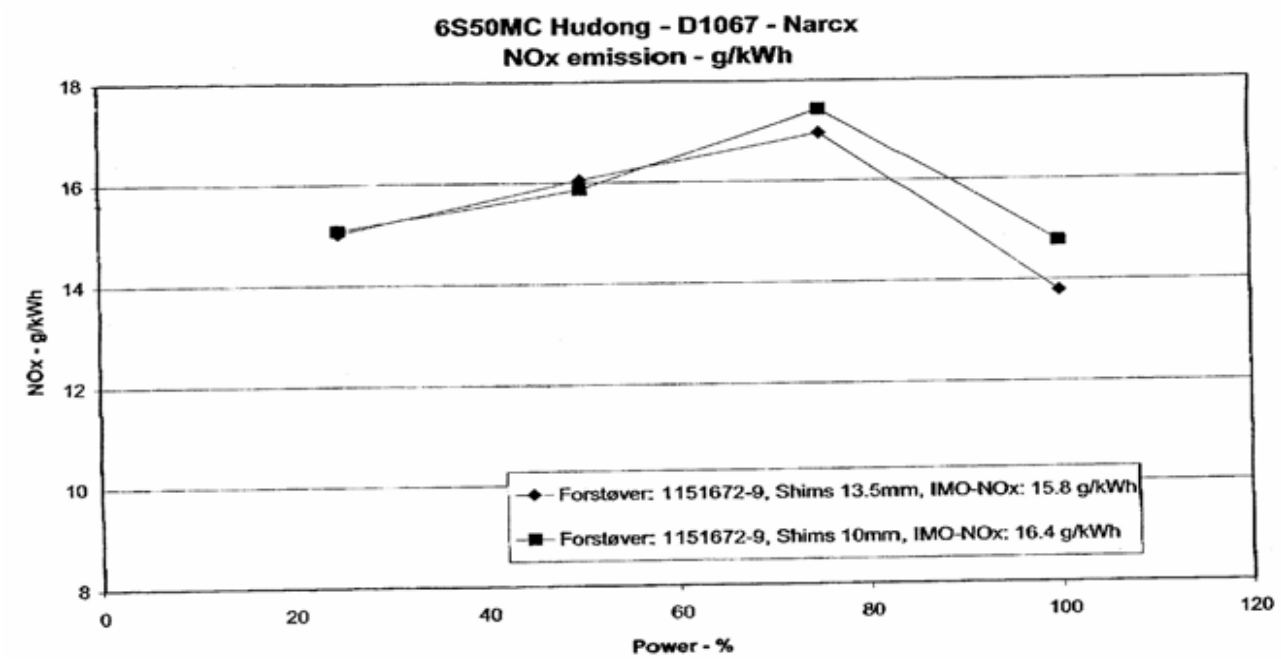


Figure No.1

along with the increasing thickness of adjusting shim and compressing pressure, emission of NOx would be decreased in a certain degree.

III Basic ideas of the two technical documents





to take engine 5L42 MC for example, MD specifies

The limit range of parameters (Table No.2)

Parameters	Reference values on ISO condition				Allowable tolerances			
Power（%）	100	75	50	25	100	75	50	25
Scavenge pressure（bar）	3.76	2.96	2.11	1.50	N/A			
Scavenge temperature（ºC）	41	34	29	34	+6	+3	+3	+3
Compressing pressure（bar）	131	101	75	51	-1	-1	-1	-1
Combustion pressure（bar）	146	120	91	60	+3	+3	+3	+3
Engine back pressure（mm WC）	300	225	150	75	Max. 450	Max. 340	Max. 225	Max. 115

Notes: a,. The pressure “bar” in the table refers as absolute pressure.

b, There is no tolerance request for N/A, but the best is adjust to this value.

III Basic ideas of the two technical documents





MD defines emission values by defining the actual performance. The step of calculating emission of NOx value are as follows:

First step:

To convert emission values into ISO status

$$\text{Corr NOx}\,(Ha, Ta, P\,amb) = \frac{1}{1 + C1\times(Ha-10.71) + C2\times(Ta-298.15) + C3\times(P\,amb-1000)}$$

- Ha: Air humidity (%)
- Ta: Ambient temperature (K °)
- P amb: Ambient pressure (m bar)

III Basic ideas of the two technical documents





ISO environmental condition correction coefficient

Engine Load（%）	C1	C2	C3
100	-0.00994	0.00144	-0.00007
75、50、25	-0.00505	0.00145	-0.00011

Ha could be calculated as follows:

Set:

$$Ha^{*}= \frac{6.220\times Ra\times Pa}{Pb-Pa\times Ra\times 10^{-2}} \qquad H\,sc = \frac{6.220\times P\,sc\times 100}{Pc-P\,sc}$$

- If: Ha* ≧ H sc
- Then Ha = H sc
- Otherwise Ha = Ha*

III Basic ideas of the two technical documents





Second step

According to quantitative relationship

to compare with

converted performance parameters

and

reference values (table No.2)

the emission of NOx values could be calculated by

comparison values ***and*** regular data in table No.1

This value could be regarded as emission of NOx value.

III Basic ideas of the two technical documents





During survey on board, MD designed a set of

software (Survey Code)

- input parameters of environmental conditions

(such as ambient temperature, humidity and pressure)

- the engine performance parameters

(such as combustion pressure, scavenging temperature and engine back pressure)

get the emission of NOx

III Basic ideas of the two technical documents





B)WÄRTSILÄ (WCH)

Get the emission of NOx only by

converting the actual emission into ISO condition

WCH specifies the range of set values of diesel engine timing, when surveying on board

first to inspect if the actual timing is within the range of set value

then to inspect if the components are satisfied the requirements of technical documents.

If the set value is within the range and the components are satisfied the requirements of technical documents, then survey on board is qualified.

Ⅳ Analyses





A)The mechanism to form of NOx

NOx is formed by the reaction of nitrogen and oxygen under the conditions at high temperature and high pressure.

Incomplete combustion

$$N_2+O_2 \text{ ========== } 2NO$$

Complete combustion

$$N_2+2O_2 \text{ ========== } 2NO_2$$

Ⅳ Analyses





The total amount of NOx is

mainly

a function of flame or combustion temperature

and

a function of the amount of organic nitrogen (if existed) which existed in the fuel

also

a function of the time that nitrogen and remaining oxygen exposed in high temperature during the combustion

Ⅳ Analyses





- the higher combustion temperature (such as peak pressure, high compressing ratio, high fuel supply ratio, etc.) is, the larger total amount of NOx formed

- Generally speaking, the amount of NOx formed within low speed diesel engine is much more than that formed within medium speed and high speed diesel engine.

Ⅳ Analyses





B) it is reasonable for MD to evaluate the emission condition by using cylinder parameters.

limit emission value of NOx

√ *Evaluate the cylinder parameters*

? *limit the timing*

Ⅳ Analyses





For example

grease stain heavily existed in scavenge box → the scavenging air temperature getting higher → the emission exceed the allowed value

→ no big difference can be found from the view of limitation range

Ⅳ Analyses

However, it is relatively difficult to apply the method of performance parameter of diesel engine to survey on board.

If the parameters recorded in the ship's log is completely believable:

Enter the parameters into survey code and get the result

Otherwise:

Make a sea trial voyage to calculate the corresponding emission according to measuring actual parameters.

Ⅴ Conclusion

Applying performance parameters for diesel engine to evaluate and calculate the emission is scientific and reasonable;

Applying timing relationship for diesel engine to inspect the emission is simple and practical.

Both of these two methods have their own advantages and disadvantages respectively.

Thanks a lot!