第 42/2017 號行政長官公告

國際海事組織海上環境保護委員會於二零零八年十月十日在第五十八屆會議上，透過第MEPC.177（58）號決議通過了《船用柴油發動機氮氧化物排放控制技術規則》（《氮氧化物技術規則》）的修正案，該修正案於二零一零年七月一日在國際法律秩序上生效，包括對中華人民共和國及澳門特別行政區生效；

此外，上述委員會於二零一二年三月二日在第六十三屆會議上，透過第MEPC.217（63）號決議通過了《修正〈經1978年議定書修訂的1973年國際防止船舶造成污染公約〉的1997年議定書》附則的修正案，該修正案於二零一三年八月一日在國際法律秩序上生效，包括對中華人民共和國及澳門特別行政區生效；

基於此，行政長官根據第3/1999號法律《法規的公佈與格式》第六條第一款的規定，命令公佈國際海事組織海上環境保護委員會下列決議的中文及英文正式文本：

——二零零八年十月十日通過的、包含《船用柴油發動機氮氧化物排放控制技術規則》（《2008年氮氧化物技術規則》）修正案的第MEPC.177（58）號決議；

——二零一二年三月二日通過的、包含《修正〈經1978年議定書修訂的1973年國際防止船舶造成污染公約〉的1997年議定書》附則修正案（《防污公約》附則VI和《2008年氮氧化物技術規則》的修正案）的第MEPC.217（63）號決議。

《修正〈經1978年議定書修訂的1973年國際防止船舶造成污染公約〉的1997年議定書》（《防污公約》1997年議定書）涵蓋了包含《氮氧化物技術規則》的《防污公約》附則VI。該議定書公佈於二零一六年十一月二十三日第四十七期《澳門特別行政區公報》第二組副刊。

二零一七年七月二十四日發佈。

行政長官 崔世安

Aviso do Chefe do Executivo n.º 42/2017

Considerando que, em 10 de Outubro de 2008, na sua 58.ª sessão, o Comité para a Protecção do Meio Marinho da Organização Marítima Internacional, através da resolução MEPC.177(58), adoptou emendas ao Código Técnico sobre o Controlo de Emissões de Óxidos de Azoto Provenientes de Motores Diesel Marítimos (Código Técnico NO_x), e que tais emendas entraram em vigor na ordem jurídica internacional, incluindo a República Popular da China e a sua Região Administrativa Especial de Macau, em 1 de Julho de 2010;

Considerando igualmente que, em 2 de Março de 2012, na sua 63.ª sessão, o mesmo Comité, através da resolução MEPC.217(63), adoptou emendas ao Anexo do Protocolo de 1997 que altera a Convenção Internacional para a Prevenção da Poluição por Navios, 1973, tal como modificada pelo Protocolo de 1978 a ela relativo, e que tais emendas entraram em vigor na ordem jurídica internacional, incluindo a República Popular da China e a sua Região Administrativa Especial de Macau, em 1 de Agosto de 2013;

O Chefe do Executivo manda publicar, nos termos do n.º 1 do artigo 6.º da Lei n.º 3/1999 (Publicação e formulário dos diplomas) os textos autênticos em línguas chinesa e inglesa das seguintes resoluções do Comité para a Protecção do Meio Marinho da Organização Marítima Internacional:

— Resolução MEPC.177(58), adoptada em 10 de Outubro de 2008, que contém emendas ao Código Técnico sobre o Controlo de Emissões de Óxidos de Azoto Provenientes de Motores Diesel Marítimos (Código Técnico NO_x 2008);

— Resolução MEPC.217(63), adoptada em 2 de Março de 2012, que contém emendas ao Anexo do Protocolo de 1997 que altera a Convenção Internacional para a Prevenção da Poluição por Navios, 1973, tal como modificada pelo Protocolo de 1978 a ela relativo (emendas ao Anexo VI da MARPOL e ao Código Técnico NO_x 2008);

O Protocolo de 1997 que altera a Convenção Internacional para a Prevenção da Poluição por Navios, 1973, tal como modificada pelo Protocolo de 1978 a ela relativo (MARPOL PROT 1997), o qual incorpora o Anexo VI da MARPOL que, por sua vez, integra o Código Técnico NO_x, encontra-se publicado no Suplemento do *Boletim Oficial da Região Administrativa Especial de Macau* n.º 47, II Série, de 23 de Novembro de 2016.

Promulgado em 24 de Julho de 2017.

O Chefe do Executivo, *Chui Sai On*.

第 MEPC.177（58）號決議

2008 年 10 月 10 日通過

船用柴油發動機氮氧化物排放控制技術規則修正案

（2008 年氮氧化物技術規則）

海上環境保護委員會，

憶及《國際海事組織公約》關於防止和控制海洋污染國際公約賦予海上環境保護委員會（本委員會）的職能之第 38（a）條，

注意到《1973 年國際防止船舶造成污染公約》（以下簡稱“1973 年公約”）第 16 條和《〈1973 年國際防止船舶造成污染公約〉1978 年議定書》（以下簡稱“1978 年議定書”）第 VI 條，以及修訂《經 1978 年議定書修訂的〈1973 年國際防止船舶造成污染公約〉》的 1997 年議定書（以下簡稱“1997 年議定書”）第 4 條，共同規定了 1997 年議定書的修正程序並賦予本組織的適當機構審議和通過經 1978 年議定書和 1997 年議定書修正的 1973 年公約修正案之職能，

還注意到 1997 年議定書將標題為《防止船舶造成大氣污染規則》的附則 VI（以下簡稱“附則 VI”）增加到了 1973 年公約中，

進一步注意到《防污公約》附則 VI 第 13 條使《船用柴油發動機氮氧化物排放控制技術規則》（氮氧化物技術規則）在該附則下具有強制性，

審議了《氮氧化物技術規則》修正草案，

1. 根據 1973 年公約第 16（2）（d）條，**通過**《氮氧化物技術規則》的修正案，正文列於本決議附件中；

2. **決定**，根據 1973 年公約第 16（2）（f）（iii）條，本修正案將於 2010 年 1 月 1 日視為獲接受，除非在此日期之前，有不少於三分之一的當事國或合計商船噸位不少於世界商船隊總噸位 50%的當事國正式向本組織提出反對本修正案；

3. **提請**各當事國注意，根據 1973 年公約第 16（2）（g）（ii）條，該修正案在根據上述第 2 段獲接受後，將於 2010 年 7 月 1 日生效；

4. **要求**秘書長，依照 1973 年公約第 16（2）（e）條，將本決議和載於附件中的修正案案文的核正無誤副本分發給經 1978 年議定書和 1997 年議定書修訂的 1973 年公約的所有當事國；

5. **進一步要求**秘書長將本決議及其附件的副本分發給經 1978 年議定書和 1997 年議定書修正的 1973 年公約非當事國的所有本組織會員；

6. **邀請**《防污公約》附則 VI 各當事國和其他成員國政府提請船舶所有人、船舶經營人、造船廠、船用柴油發動機製造商和其他感興趣組織注意本《氮氧化物技術規則》修正案。

2008年氮氧化物技術規則

船用柴油發動機氮氧化物排放控制技術規則

目 錄

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附錄

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附錄 II － 船用柴油發動機檢驗和發證流程圖

附錄 III － 確定船用柴油發動機排放氣體成分的分析儀的技術規範

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－ 第 1 節－母型機試驗報告

－ 第 2 節－要列入技術檔案中的母型機試驗數據

附錄 VI － 廢氣質量流量計算（碳平衡法）

附錄 VII － 發動機參數檢查方法的檢查清單

附錄 VIII － 直接測量和監測法的實施

引 言

2008 年氮氧化物技術規則

1997 年 9 月 26 日，《經 1978 年議定書修訂的〈1973 年國際防止船舶造成污染公約〉》（MARPOL73/78）當事國大會以大會決議 2 通過了《船用柴油發動機氮氧化物排放控制技術規則》（《氮氧化物技術規則》）。《防污公約》附則 VI－《防止船舶造成空氣污染規則》於 2005 年 5 月 19 日生效後，該附則第 13 條所適用的所有船用柴油發動機均須符合本規則的規定。2005 年 7 月，環保會第 53 屆會議同意對《防污公約》附則 VI 和《氮氧化物技術規則》進行修訂。2008 年 10 月，環保會第 58 屆會議完成了審議，本版本的《氮氧化物技術規則》（以下簡稱本規則）就是該過程的結果。

作為一般性的背景信息，在燃燒過程中形成氮氧化物的前體是氮和氧。這些成分一起構成柴油發動機吸入空氣的 99%。在燃燒過程中氧氣將被消耗，多餘氧氣的數量是柴油發動機運轉的空氣/燃料比的函數。氮在燃燒過程中大多未起反應；但有很小一部分將被氧化形成多種形式的氮氧化物。可形成的氮氧化物（NO_X）包括一氧化氮（NO）和二氧化氮（NO_2），其數量主要是火焰或燃燒溫度的函數，以及存在於燃料中有機氮（如果存在）數量的函數，氮氧化物的形成還是氮和多餘氧氣在柴油發動機燃燒過程中暴露在高溫下的時間的函數。換句話說，燃燒溫度越高（如高峰值壓力、高壓縮比、高供油比率等），形成的氮氧化物數量就越大。通常低速柴油發動機所形成的氮氧化物量比高速機要大。氮氧化物能引起酸化，形成對流層臭氧，營養富集等不良環境影響，並加劇了對全球健康的不利影響。

本規則旨在為船用柴油發動機的試驗、檢驗和發證定出強制性程序，以使柴油發動機製造廠、船舶所有人和主管機關能夠確保所有適用的船用柴油發動機符合附則VI第13條規定的相關氮氧化物排放限值。在認識到難於精確確定船用柴油發動機實際加權平均氮氧化物排放量的情況下，制定了一系列簡單實用的要求，其中對確保符合氮氧化物排放允許值的措施做出了定義。

鼓勵各主管機關在能夠於適當控制條件下進行精確試驗的試驗台上，對船用推進系統和輔助柴油發動機的排放性能進行評估。本規則的一個重要特點就是在這個初始階段確保符合附則VI第13條。之後的船上試驗，其範圍和精確度將不可避免地受到限制，其目的應為推理或推斷排放性能和證實柴油發動機的安裝、操作和維護遵循了製造廠的技術規範，以及任何調整或改裝未降低製造廠初次試驗和發證時確定的排放性能。

縮寫、下標和符號

下列表 1、2、3 和 4 概述了本規則，包括附錄 III 中的分析儀器的技術規範、附錄 IV 中的分析儀器的校準要求、第 5 章和附錄 VI 中的氣體質量流量計算公式中所用的縮寫、下標和符號以及第 6 章有關船上核實檢驗數據所用的符號。

.1 表 1：代表本規則中所述的柴油發動機氣體排放以及校準和量程氣體中的化學成分的符號；

.2 表 2：用於本規則附錄 III 中規定的柴油發動機氣體排放測量的分析儀的縮寫；

.3 表 3：用於本規則第 5 章、第 6 章、附錄 IV 和附錄 VI 中的術語和變量的符號及下標；及

.4 表 4：用於本規則第 5 章、第 6 章和附錄 VI 中的燃料成分符號。

表 1

化學成分的符號和縮寫

符號	定義
CH_4	甲烷
C_3H_8	丙烷
CO	一氧化碳
CO_2	二氧化碳
HC	碳氫化合物
H_2O	水
NO	一氧化氮
NO_2	二氧化氮
NO_x	氮氧化物
O_2	氧

表 2

柴油發動機氣體排放測量分析儀的縮寫

（參閱本規則附錄 III）

CLD	化學熒光探測器
ECS	電化傳感器
HCLD	加熱式化學熒光探測器
HFID	加熱式火焰離子探測器
NDIR	非彌散紅外分析儀
PMD	順磁探測器
ZRDO	二氧化鋯傳感器

表 3

術語和變量的符號及下標

（參閱本規則第 5 章、第 6 章、附錄 IV 和附錄 VI）

符號	術語	單位
A/F_{st}	空氣與燃料的理論配比值	1
c_x	廢氣濃度（成分的後綴命名，d＝乾或 w＝濕）	ppm %（V/V）
E_{CO2}	NO_X 分析儀的 CO_2 抑制	%
E_{H2O}	NO_X 分析儀的水抑制	%
E_{NOx}	NO_X 轉換器的效率	%
E_{O2}	氧分析儀修正係數	1
λ	過量空氣係數kg乾空氣/（kg燃料・A/Fst）	1
f_a	試驗條件參數	1
f_c	碳係數	1
f_{fd}	乾基廢氣流量計算的燃料特定係數	1
f_{fw}	濕基廢氣流量計算的燃料特定係數	1
H_a	吸入空氣的絕對濕度，（g 水/kg 乾空氣）	g/kg
H_{SC}	增壓空氣濕度	g/kg
i	代表個別模式的下標	1
k_{hd}	柴油發動機 NO_X 的濕度修正係數	1
k_{wa}	吸入空氣的乾對濕修正係數	1
k_{wr}	原始廢氣的乾對濕修正係數	1
n_d	發動機轉速	min^{-1}
n_{turb}	渦輪增壓器轉速	min^{-1}
$\%O_2I$	HC 分析儀氧干擾百分比	%
p_a	在測量 p_b 和 R_a 的同一位置測量的吸入空氣溫度確定的	kPa

符號	術語	單位
	發動機吸入空氣飽和蒸氣壓力	
p_b	總大氣壓力	kPa
p_C	增壓空氣壓力	kPa
p_r	分析系統冷卻槽之後的水汽壓力	kPa
p_s	乾燥大氣壓力，由以下公式確定： $p_s = p_b - R_a \cdot p_a/100$	kPa
p_{SC}	增壓空氣的飽和蒸氣壓力	kPa
P	未修正的制動功率	kW
P_{aux}	僅為試驗而安裝但 ISO 14396 不要求的輔機吸收的的總標稱功率	kW
P_m	試驗條件下柴油發動機試驗轉速下的最大實測功率或標稱功率	kW
q_{mad}	乾基吸入空氣質量流量	kg/h
q_{maw}	濕基吸入空氣質量流量	kg/h
q_{mew}	濕基廢氣質量流量	kg/h
q_{mf}	燃料質量流量	kg/h
q_{mgas}	個別氣體排放質量流量	g/h
R_a	吸入空氣的相對濕度	%
r_h	碳氫化合物響應係數	1
ρ	密度	kg/m³
s	燃料齒條位置	
T_a	發動機進口處確定的吸入空氣溫度	K
T_{caclin}	增壓空氣冷卻器，冷卻劑進口溫度	℃
$T_{caclout}$	增壓空氣冷卻器，冷卻劑出口溫度	℃
T_{Exh}	廢氣溫度	℃
T_{Fuel}	燃油溫度	℃
T_{Sea}	海水溫度	℃
T_{SC}	增壓空氣溫度	K
T_{SCRef}	增壓空氣參照溫度	K
u	廢氣成分和廢氣密度比率	1
W_F	加權因數	1

表 4

燃料成分的符號

符號	定義	
w_{ALF}	燃料的氫含量	%m/m
w_{BET}	燃料的碳含量	%m/m
w_{GAM}	燃料的硫含量	%m/m
w_{DEL}	燃料的氮含量	%m/m
w_{EPS}	燃料的氧含量	%m/m
α	摩爾比率（H/C）	1

第 1 章
總　則

1.1 目的

1.1.1 本《船用柴油發動機氮氧化物排放控制技術規則》，以下稱本規則的目的為定出船用柴油發動機的試驗、檢驗和發證要求，以確保其符合附則 VI 第 13 條的氮氧化物（NO_x）排放限值。本規則中所引用的規則條款均指附則 VI。

1.2 適用範圍

1.2.1 本規則適用於所有已安裝或設計並擬安裝在附則 VI 和第 13 條適用的任何船上的輸出功率大於 130 kW 的船用柴油發動機。就第 5 條關於檢驗和發證要求而言，本規則僅涉及柴油發動機符合 NO_x 排放限值的適用要求。

1.2.2 就本規則的適用而言，各主管機關有權委託經授權的組織代行本規則要求的主管機關的全部職能*。在任何情況下，主管機關對檢驗和發證負全部責任。

1.2.3 就本規則而言，如能證明柴油發動機在初次發證、年度、中間和換證檢驗和其他要求的檢驗時其 NO_x 加權排放在限值之內，則該柴油發動機須被認為符合第 13 條的適用 NO_x 排放限值。

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* 參見第 A.739(18)號決議通過的《代表主管機關的組織的授權指南》和第 A.789(19)號決議通過的《被認可組織代表主管機關執行檢驗和發證職責的規範》。

1.3 定義

1.3.1 *氮氧化物（NO_X）排放*係指氮氧化物總排放量，按二氧化氮加權排放總量計算，並以本規則所規定的相關試驗循環和測量方法確定。

1.3.2 船用柴油發動機的*實質性改裝*係指：

.1 對於 2000 年 1 月 1 日或以後建造的船上所安裝的發動機而言，*實質性改裝*係指：可能造成發動機超出列於第 13 條規定的適用排放限值的任何發動機改裝。用技術檔案中規定的部件進行不改變排放性能的發動機構件常規更換，不論是一部分還是多部分部件更換，均不視為“實質性改裝”。

.2 對於 2000 年 1 月 1 日以前建造的船上所安裝的發動機而言，*實質性改裝*係指增加了 6.3 所述的簡單測試方法確定的發動機現有排放特性，使其超出 6.3.11 規定的允許值的任何改裝。這些改變包括，但不限於，其運作或技術參數（例如：改變凸輪軸、燃油噴射系統、空氣系統、燃燒室構造，或發動機定時校準）的改變。就本附則第 13.2 條的適用而言，符合第 13.7.1.1 條的經證明的認可方法的安裝，及符合第 13.7.1.2 條的發證，不被視為實質性改裝。

1.3.3 *構件*係指影響氮氧化物排放功能的互換性部件，由其設計/部件號標識。

1.3.4 *設定*係指對影響發動機氮氧化物排放性能的可調整部分的調整。

1.3.5 *操作值*係指發動機日誌中所載與氮氧化物排放性能有關的柴油發動機數據，如氣缸峰值壓力、排氣溫度等。這些數據均為載荷控制。

1.3.6 *EIAPP 證書*係指與氮氧化物排放相關的發動機國際防止空氣污染證書。

1.3.7 *IAPP 證書*係指國際防止空氣污染證書。

1.3.8 *主管機關*的含義與《73 防污公約》第 2 章第（5）款相同。

1.3.9 *船上氮氧化物核實程序*係指由發動機證書申請方制訂並經主管機關認可，在所要求的初次發證檢驗或換證、年度或中間檢驗時，在船上使用的可包括設備要求的程序，以證實符合本規則的任何要求。

1.3.10 *船用柴油發動機*係指第 13 條適用的，以液體或雙燃料運行的任何往復式內燃機，包括加壓器/混合系統（如適用）。

如果發動機擬通常以氣體模式運轉，即主要燃料為氣體及少量的液體引燃燃料，僅此運轉模式須滿足第 13 條的要求。如果發生故障造成氣體供應受限而使用純液體燃料運轉，須對駛往下個港口進行故障修理的航次予以免除。

1.3.11 *額定功率*係指第 13 條和本規則適用的船用柴油發動機的銘牌及技術檔案中載明的最大持續額定輸出功率。

1.3.12 *額定轉速*係指船用柴油發動機銘牌及技術檔案中載明的在額定功率輸出時的每分鐘的曲軸轉數。

1.3.13 *制動功率*係指，發動機僅設有在試驗台上運轉所必需的標準輔助設備時，在曲軸或其等效處測量的實測功率。

1.3.14 *船上狀態*係指發動機：

.1 安裝在船上並與其驅動的實際設備相連接；及

.2 處於執行該設備功能的運行狀態。

1.3.15 *技術檔案*係指符合本規則第 2.4 條，含有包括發動機構件和設定值在內的，會影響發動機氮氧化物排放的所有參數細節的記錄。

1.3.16 *發動機參數記錄簿*係指與《發動機參數檢查法》共用、記錄包括構件和發動機的設定值等可能影響發動機氮氧化物排放的所有參數變化的文件。

1.3.17 *認可方法*係指應用於特定發動機或一系列發動機、確保其符合第 13.7 條所述的適用氮氧化物限值的方法。

1.3.18 *現有發動機*係指第 13.7 條所適用的的發動機。

1.3.19 *認可方法檔案*係指描述認可方法及其檢驗方式的文件。

第 2 章
檢驗和發證

2.1 通則

2.1.1 凡 1.2 中規定的船用柴油發動機，除本規則另有規定外，均須接受下列檢驗：

.1 前期發證檢驗，此檢驗須保證所設計和裝備的發動機符合第 13 條規定的氮氧化物排放限值。如經檢驗合格，主管機關須簽發發動機國際防止空氣污染（EIAPP）證書。

.2 初次發證檢驗，此檢驗須在發動機安裝上船後但尚未投入使用之前進行。該檢驗須保證安裝上船的發動機包括前期發證後的任何改裝和/或調整（如適用）符合第 13 條規定的氮氧化物排放限值。該檢驗，作為船舶初次檢驗的一部分，完成後可向船舶初次簽發《國際防止空氣污染（IAPP）證書》或對船舶有效 IAPP 證書予以修正以反映出安裝了新發動機。

.3 換證、年度和中間檢驗，此類檢驗須為第 5 條要求的船舶檢驗的一部分，以確保發動機繼續完全符合本規則的要求。

.4 發動機初次發證檢驗，此種檢驗須在每次對發動機進行了第 13 條定義的重大改裝後在船上進行，以確保發動機符合第 13 條的適用氮氧化物排放限值。在此之後，如適用，將簽發 EIAPP 證書和修正 IAPP 證書。

2.1.2 為符合 2.1.1 中規定的各種檢驗和發證要求，本規則包含了下列供發動機製造廠、造船廠或船舶所有人酌情選用的測量、計算、試驗或核實發動機氮氧化物排放的方法：

.1 符合第 5 章要求的前期發證檢驗試驗台試驗；

.2 符合第 5 章全部試驗台要求的對未經前期發證的發動機在船上進行的前期發證檢驗和初次發證檢驗的合併試驗；

.3 按照 6.2 規定，使用技術檔案規定的構件數據、發動機設定值和發動機性能數據，在初次、換證、年度和中間檢驗時確認前期發證的發動機或自最近一次檢驗後對氮氧化物關鍵構件、設定值和操作值進行過改裝或調整的發動機，符合要求的船上發動機參數檢查方法；

.4 需要時，按照 6.3 規定，在換證、年度和中間檢驗時確認符合要求或初次發證檢驗時確認已獲前期發證的柴油發動機符合要求的船上簡化測量法；或

.5 按照 6.4 的規定，僅在換證、年度和中間檢驗時確認符合要求的船上直接測量和監測法。

2.2 發動機前期發證程序

2.2.1 除 2.2.2 和 2.2.4 允許者外，每台船用柴油發動機（單發動機）在船上安裝前須：

.1 予以調整，以符合適用的氮氧化物排放限值；

.2 根據本規則第 5 章規定的程序在試驗台上對氮氧化物排放進行測量；

.3 由主管機關進行前期發證，以簽發 EIAPP 證書為證。

2.2.2 依據主管機關的認可，對系列化生產的發動機的前期發證可採用發動機族或組的概念（見第 4 章）。在此情況下，僅要求對發動機組或發動機族的母型機進行 2.2.1.2 中規定的試驗。

2.2.3 獲得發動機前期發證的方法是讓主管機關：

.1 證實試驗台上進行的發動機試驗；

.2 核實所有經過試驗的發動機，包括在發動機族或發動機組內交付的發動機（如適用），符合適用的氮氧化物限值；及

.3 如適用，核實所選母型機可代表該發動機族或發動機組。

2.2.4 有些柴油發動機因其尺寸、構造和交貨計劃，不能在試驗台上進行前期發證測試。在此情況下，發動機製造廠、船舶所有人和造船廠須向主管機關申請進行船上試驗（見 2.1.2.2）。申請者必須向主管機關證明該船上試驗完全滿足本規則第 5 章規定的試驗台程序的所有要求。這種檢驗僅對單機或由母型機所代表的發動機組可以接受，但對發動機族的發證不得接受。如果初次檢驗在船上進行，且無任何有效的前期發證試驗，則無論如何不允許有任何可能的測量偏差。對於在船上進行發證試驗以取得 EIAPP 證書的發動機，須採用與在試驗台上進行前期發證試驗相同的程序。

2.2.5 *氮氧化物減少裝置*

.1 如在 EIAPP 證書中包括氮氧化物減少裝置，該裝置須被認為是發動機的一個構件並且其存在須記錄於到發動機技術檔案中。前期發證試驗時，須對裝有氮氧化物減少裝置的發動機進行試驗。

.2 如果因前期發證試驗時未能滿足所要求的排放值而安裝氮氧化物減少裝置，為使該組合獲得 EIAPP 證書，對發動機包括所安裝的減少裝置須重新試驗以表明符合適用的氮氧化物排放限值。但在此情況下，該組合可按 6.3 所述的簡化測量方法重新試驗。在任何情況下均不得給予 6.3.11 中給出的容許偏差。

.3 如果按 2.2.5.2 使用簡化測量方法核實氮氧化物減少裝置的有效性，該試驗報告須作為前期發證試驗報告的附件，表明發動機本身不能滿足所要求的排放值。兩份報告均須提交主管機關，兩次試驗的 2.4.1.5 中詳述的試驗報告數據，均須包括在發動機技術檔案中。

.4 根據 2.2.5.2 作為符合要求證實程序一部分而使用的簡化測量方法僅對發動機和氮氧化物減少裝置組合的有效性證實可以接受，對發動機族或發動機組發證則不可接受。

.5 在 2.2.5.1 和 2.2.5.2 所述的兩種情況下，該氮氧化物減少裝置連同設備運行時獲得的排放值和主管機關要求的其他記錄須一同包括在 EIAPP 證書中。發動機的技術

檔案也須包括該裝置的船上氮氧化物核實程序，以確保該設備正確運行。

.6 儘管有 2.2.5.3 和 2.2.5.4 的規定，主管機關可依據本組織有待制訂的導則對氮氧化物減少裝置予以批准。

2.2.6 如因構件設計改變需要確立新的發動機族或發動機組但無可用母型機，發動機製造廠可向主管機關申請使用對適用試驗循環的各特定模式作出修改後的以前獲取的母型機試驗數據，以得到氮氧化物排放值的相應變化。在此情況下，用於確定修改排放數據的發動機須按 4.4.6.1、4.4.6.2 和 4.4.6.3 的要求對應於以前使用的母型機。如果多於一個構件需要改變，由此變化引起的複合效果由單獨一套試驗結果予以證實。

2.2.7 對於發動機族或發動機組內發動機的前期發證，須按照主管機關制定的程序，為母型機和在該發證下生產的每一台成員發動機簽發 EIAPP 證書，以伴隨發動機安裝於該主管機關管轄下的船舶上的整個使用期。

2.2.8 *發動機製造國主管機關簽發證書*

.1 如果船上將安裝的發動機在該船舶主管機關的國家之外製造，則船舶主管機關可要求發動機生產國的主管機關檢驗該發動機。如果能滿意地認定第 13 條的適用要求已按照本規則得到滿足，發動機製造國的主管機關須簽發或授權簽發 EIAPP 證書。

.2 證書副本和檢驗報告副本各 1 份須儘快送交提出要求的主管機關。

.3 如此簽發的證書須含有1份聲明，說明此證書係應主管機關要求而簽發。

2.2.9 本規則附錄II中的相關流程圖，提供了有關本規則第2章所述船用柴油發動機前期檢驗和發證指南。如有不一致，以第2章文本為準。

2.2.10 EIAPP證書的格式範本作為附錄I附於本規則之後。

2.3 發動機的發證程序

2.3.1 對於製造廠的原技術規範未做調整或改裝的發動機，有效的EIAPP證書應足以證明其符合適用的氮氧化物排放限值。

2.3.2 發動機安裝於船上後，須確定其經過何種程度的會影響氮氧化物排放的進一步改裝和/或調整。因此在發動機安裝於船上之後但簽發IAPP證書之前，須檢驗其改裝情況並且採用船上氮氧化物核實程序及2.1.2中所述方法之一予以核准。

2.3.3 有些發動機在前期發證後，需要做最後的性能調整或改裝。在此情況下，可以使用發動機組的概念以保證發動機仍符合適用限值。

2.3.4 凡安裝於船上的船用柴油發動機須備有1份技術檔案。該技術檔案須由發動機發證申請方提供並經主管機關認可，並要求伴隨發動機的整個船上使用期。技術檔案須包括2.4.1中所述資料。

2.3.5 如安裝並需要氮氧化物減少裝置以符合氮氧化物排放限值，便於核實符合第13條要求的可選手段之一是符合6.4的直接測

量和監測方法。但是，根據所用裝置的技術可能性，經主管機關認可，也可以監測其他相關參數。

2.3.6 如為符合氮氧化物要求而引進一種附加物質如氨、尿素、蒸氣、水、燃料添加劑等，則須提供監測此物質消耗的方法。技術檔案須提供足夠的資料以便能夠使用一種便捷方法證明該附加物質的消耗與達到符合適用的氮氧化物限值的目的相一致。

2.3.7 在使用符合 6.2 的發動機參數檢查方法核實符合性時，如前期發證後對發動機進行了任何調整或改裝，則 1 份該調整或改裝的完整記錄須記載在發動機參數記錄簿上。

2.3.8 如所有安裝於船上的發動機經核查仍保持在技術檔案記錄的參數、構件和可調整特徵之內，則須認為發動機在第 13 條規定的適用氮氧化物限值內運行。在此情況下，如本附則其他所有適用要求均獲滿足，則應為該船舶簽發 IAPP 證書。

2.3.9 如果任何調整或改裝超出技術檔案規定的認可限值，只有通過下列方法之一核實氮氧化物總體排放性能處於規定的限值之內，方可簽發 IAPP 證書：符合 6.3 的簡化船上測量；或參照表明該調整或改裝未超出適用氮氧化物排放限值的有關發動機組認可的試驗台試驗。在初次發動機檢驗之後的檢驗中，可選用經主管機關認可的符合 6.4 的直接測量和監測方法。

2.3.10 對於已獲得 EIAPP 證書的發動機，主管機關可根據本規則自行決定省略或減少所有船上檢驗部分。但是，對於發動機族或發動機組（如適用）中的至少 1 個氣缸和/或 1 台發動機必須完成全部船上檢驗，並且僅在所有其他氣缸和/或發動機預期與被檢驗的發動機和/

或氣缸運作相同時方可省略。對已裝構件檢查，主管機關可對船上的備件進行該部分檢驗作為替代，但是該備件應能代表已裝構件。

2.3.11 本規則附錄 II 的流程圖，提供了本規則第 2 章所述船用柴油發動機初次、換證、年度和中間檢驗時的檢驗和發證指南。如有不一致，以第 2 章文本為準。

2.4 技術檔案和船上氮氧化物核實程序

2.4.1 為使主管機關能夠進行 2.1 中所述發動機檢驗，2.3.4 所要求的技術檔案須最低限度包括下列資料：

.1 列明影響氮氧化物排放的構件、設定值和操作值，包括任何氮氧化物減少裝置或系統；

.2 列明發動機構件的可允許調整或替代的整個範圍；

.3 有關發動機性能包括其額定轉速和額定功率的全部記錄；

.4 根據第 6 章規定，在船上核實檢驗中的證明符合氮氧化物排放限值的船上氮氧化物核實程序體系；

.5 本規則附錄 V 第 2 節所述母型機相關試驗數據副本 1 份；

.6 如適用，對屬於發動機組或族的 1 台發動機的劃定和限定；

.7 按照規範在發動機上使用時將使發動機繼續符合適用的氮氧化物排放限值的備件/部件的規範；以及

.8 EIAPP 證書（如適用）。

2.4.2 作為一般原則，船上氮氧化物核實程序須能使驗船師易於判定發動機是否仍符合第 13 條的適用要求。同時，不得過於繁複以致不當延誤船舶或需要對某一特定發動機的特性有深入的了解或需要船上所沒有的專門測量裝置。

2.4.3 船上氮氧化物核實程序須為下列方法之一：

.1 符合 6.2 的發動機參數檢查方法以核定發動機構件、設定值和操作值沒有偏離發動機技術檔案的規定；

.2 符合 6.3 的簡化測量方法；或

.3 符合 6.4 的直接測量和監測方法。

2.4.4 當考慮何種船上氮氧化物核實程序應包括在發動機技術檔案中以在所要求的船上核實檢驗（發動機的初次船上檢驗除外）中核實發動機是否符合氮氧化物排放限值時，6.1 中所列 3 種船上氮氧化物核實程序的任何一種均適用。但是，與所用方法相關的程序要經主管機關認可。如方法與原經認可的技術檔案中規定的核實程序方法不同，該方法程序須增為技術檔案的修正案或者添為技術檔案所述程序的替代方法。此後船舶所有人可選擇使用技術檔案中經認可的何種方法證明符合要求。

2.4.5 除經主管機關認可的發動機製造廠規定並包括在技術檔案中用於發動機初次發證的方法外，船舶所有人須可以選擇符合 6.4 的氮氧化物排放直接測量法。該測量數據可以為涵蓋發動機運作全程與發動機的其他操作數據一同定期抽樣記錄的形式，或者為連續監測和數據儲存的結果。數據必須是現時的（最近 30 天之內）並且必須使

用本規則中列舉的試驗程序獲取。這些監測記錄須在船上保存 3 個月以備當事國按第 10 條進行核查。須按照船上操作手冊中經認可的程序，對數據根據環境條件和燃料規格進行校正，並對測量設備是否校準和運作正確進行檢查。如裝有影響氮氧化物排放的廢氣後處理裝置，測量點必須位於該裝置的下游。

第 3 章

氮氧化物排放標準

3.1 船用柴油發動機氮氧化物最大允許排放限值

3.1.1 氮氧化物最大允許排放限值按其適用於第 13 條第 3、4、5.1.1 和 7.4 段中給出。根據本規則中的程序測量和計算出的氮氧化物加權排放總量（修正至小數點後第一位）須等於或小於對應於發動機額定轉速的適用計算值。

3.1.2 當發動機按照 5.3 使用試驗燃油運轉時，氮氧化物排放總量（以二氧化氮加權排放總量計）須採用本規則規定的試驗循環和測量方法確定。

3.1.3 按第 13 條第 3、4 或 5.1.1 段中所適用的公式計算出的發動機廢氣排放限值和實際計算出的發動機廢氣排放值（修正至小數點後第一位）須在發動機的 EIAPP 證書中予以標明。如果發動機是發動機族或發動機組的成員發動機，須將相關母型機的排放值與該發動機族或發動機組的適用限值進行比較。此限值須為按第 13 條第 3、4 或 5.1.1 段，以該發動機族或發動機組應涵蓋的最高發動機轉速為基礎的該發動機族或發動機組的限值，（不考慮該發動機 EIAPP 證書標明的母型機額定轉速或該特定發動機的額定轉速）。

3.1.4 如發動機按第 13 條第 5.1.1 段予以驗證，則在各模式點的具體排放量不得超過適用的氮氧化物排放限值的 50%，但下列除外：

.1 3.2.5 規定的 D2 試驗循環的 10%模式點。

.2 3.2.6 規定的 C1 試驗循環的 10%模式點。

.3 3.2.6 規定的 C1 試驗循環的空轉模式點。

3.2 所應用的試驗循環和加權因數

3.2.1 對每一台發動機或發動機組或發動機族的母型機，須使用 3.2.2 至 3.2.6 中規定的一個或多個相關試驗循環核實是否符合第 13 條規定中適用的氮氧化物排放限值。

3.2.2 用於船舶主推進包括柴油電力驅動的恆速船用柴油發動機，須按照表 1 應用 E2 試驗循環。

3.2.3 與可控螺距螺旋槳相連的發動機，無論其組合曲線如何，須按照表 1 應用 E2 試驗循環。

表 *1*

應用於“恆速主推進”的試驗循環

（包括柴油-電力驅動和所有可控螺距螺旋槳裝置）

試驗循環類型 E2	轉速	100%	100%	100%	100%*
	功率	100%	75%	50%	25%
	加權因數	0.2	0.5	0.15	0.15

3.2.4 按推進器原理運轉的主、輔發動機，須按照表 2 應用 E3 試驗循環。

表 *2*

應用於“按推進器原理運轉的主、輔發動機”的試驗循環

試驗循環類型 E3	轉速	100%	91%	80%	63%
	功率	100%	75%	50%	25%
	加權因數	0.2	0.5	0.15	0.15

3.2.5 恆速輔發動機，須按照表 3 應用 D2 試驗循環。

表 3

應用於“恆速輔發動機”的試驗循環

試驗循環類型 D2	轉速	100%	100%	100%	100%	100%
	功率	100%	75%	50%	25%	10%
	加權因數	0.05	0.25	0.3	0.3	0.1

3.2.6 上述未包括的變速、變載荷輔發動機，須按照表 4 應用 C1 試驗循環。

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* 在一些特殊情況下，包括擬應用 E2 的大缸徑發動機，由於其振動質量和構造，發動機在標定轉速下低載荷運轉有損壞重要部件的風險。在此情況下，發動機製造廠須向主管機關提出申請，對表 1 中試驗循環的 25%功率模式點，就發動機轉速作出修改。但是，調整後的 25%功率時的發動機轉速須儘可能接近發動機製造廠建議的和主管機關認可的額定發動機轉速。試驗循環的適用加權因數須保持不變。

表 4

應用於“變速、變載荷輔發動機”的試驗循環

試驗循環類型 C1	轉速	額定				中間			空轉
	扭矩	100%	75%	50%	10%	100%	75%	50%	0%
	加權因數	0.15	0.15	0.15	0.1	0.1	0.1	0.1	0.15

3.2.7 試驗循環 C1 中給出的扭矩值是代表着在一給定的試驗模式下，在給定轉速下，所要求的扭矩和最大可能扭矩之比的百分比。

3.2.8 試驗循環 C1 的中間轉速須由製造廠申報，並考慮到下列要求：

.1 對於設計在一定轉速範圍中在滿負荷扭矩曲線上運行的發動機，所申報的最大扭矩轉速，如果出現於額定轉速的 60%至 75%之間，須為中間轉速。

.2 如所申報的最大扭矩轉速小於額定轉速的 60%，則中間轉速須為額定轉速的 60%。

.3 如所申報的最大扭矩轉速大於額定轉速的 75%，則中間轉速須為額定轉速的 75%。

.4 對於未設計成在穩定狀態下在一定轉速範圍中在滿負荷扭矩曲線上運行的發動機，中間轉速將典型地處於最大額定轉速的 60%至 70%之間。

3.2.9 如果發動機製造廠請求對已經按照 3.2.2 至 3.2.6 中規定的不同試驗循環核准過的發動機應用新的試驗循環，則也許不需要因新的應用對發動機再完成全部發證過程。在此情況下，發動機製造廠可以將第一次發證試驗的具體模式下的測量結果，使用新的試驗循環的相應加權因數，用以計算新的試驗循環應用的加權排放總量，通過此重新計算證明符合排放限值。

第 4 章

系列化生產的發動機認可：發動機族和發動機組的概念

4.1 通則

4.1.1 為避免對每台發動機進行證明其符合氮氧化物的排放限值的發證測試，可採用兩種認可的概念之一，即發動機族或發動機組概念。

4.1.2 發動機族概念可用於任何系列化生產的發動機，通過其設計已證明具有類似的氮氧化物排放特性，按原樣使用，及，在船上安裝中，毋需進行任何會對氮氧化物的排放造成不利影響的調整或改裝。

4.1.3 發動機組概念可用於具有相似用途的小系列生產的發動機，在船上安裝或使用過程中需做輕微調整和改裝。

4.1.4 發動機製造廠最初可自行決定發動機是否要屬於發動機族或發動機組的概念。通常，應用的類型須基於在試驗台試驗後，對發動機是否將要，及在多大程度上進行改裝。

4.2 文件

4.2.1 所有發證文件必須完整並酌情由經正式授權的當局適當地蓋章。該文件還須包括所有條款和條件，包括備件的更換，以確保發動機保持符合適用的氮氧化物排放限值。

4.2.2 對發動機族或發動機組中的發動機，發動機參數檢查方法所要求的文件規定於 6.2.2 中。

4.3 發動機族概念的運用

4.3.1 發動機族概念在保證發動機族中的所有發動機均符合認可要求的同時，提供了減少須交付認可試驗的發動機數量的可能性。在發動機族的概念中，以 1 台母型機代表具有相似排放特點和設計的發動機。

4.3.2 系列生產並且不打算進行改裝的發動機可以納入發動機族概念。

4.3.3 母型機的選擇程序須為所選擇的發動機具有對氮氧化物排放水平產生最不利影響的特點。該發動機通常在該發動機族的所有發動機中具有最高的氮氧化物排放水平。

4.3.4 製造廠根據試驗和技術判斷，須提議哪些發動機屬於發動機族，哪些發動機產生最高的氮氧化物排放，以及應選出哪個發動機進行發證試驗。

4.3.5 主管機關須對發動機族中的母型機選擇進行發證認可審查，並須可以選擇一台不同的發動機進行認可檢驗或產品合格試驗以確信發動機族中的所有發動機符合適用的氮氧化物排放限值。

4.3.6 發動機族概念允許通過可調整零件對發動機進行微量調整。備有可調整零件的船用柴油發動機必須符合對在實際可及範圍內的任何調整的全部要求。如果某一零件為永久性封焊的或其他在通常情況下不可及的零件，則不能視為可調整零件。主管機關可要求將可調整零件調整到發證或在用試驗的可調整範圍內的任何規格以確定是否符合要求。

4.3.7 在對發動機族給予認可之前，主管機關須採取必要措施核實已作出適當安排以確保對產品合格的有效控制。這可包括，但不限於：

.1 氮氧化物關鍵部件或建議作為發動機族的標識號與這些部件的圖紙編號（及修改狀況，如適用）之間的關係；

.2 主管機關在檢驗時核實用於生產氮氧化物關鍵部件的圖紙與為界定該發動機族而確立的圖紙是否一致的方法；

.3 圖紙修正控制措施。如製造廠提議對界定一發動機族的氮氧化物關鍵部件圖紙的修改可在發動機的服務期限內進行時，則產品合格保證體系需展示修改將，或將不影響氮氧化物排放時，要採用的程序。這些程序須包括圖紙編號的分配、對氮氧化物關鍵部件的標識標誌的影響以及向負責原發動機族認可的主管機關提供經修改的圖紙的規定。如這些修改可能影響氮氧化物的排放，則評估或核實母型機性能須採用的方法連同與通知主管機關有關的要採取的後續行動須一起予以說明，及，如必要，在這些改裝投入服務前，申報新的母型機；

.4 業已實施的確保提供給經認證的發動機的任何氮氧化物關鍵部件的備件將與經認可的技術檔案中所列明的一致，因而將按界定該發動機族的圖紙生產的程序；或

.5 經主管機關認可的等效措施。

4.3.8 *發動機族選擇指南*

4.3.8.1 發動機族須由該發動機族中所有發動機共同的基本特性予以界定。某些情況下參數間會有相互作用；這些影響也必須得到考慮，以確保僅具有相似排放特性的發動機方可包括在一個發動機族

中，例如，在某些發動機上，由於所用的增壓空氣或燃料系統，氣缸數量可成為相關參數，但對其他設計，廢氣排放特性可能與氣缸數或構形無關。

4.3.8.2 發動機製造廠負責從其不同型號的發動機中選出可包括在一個發動機族中的發動機。下列基本特性而非規格須是一個發動機族中的所有發動機所共有的：

.1 燃燒循環

— 二衝程循環
— 四衝程循環

.2 冷卻介質

— 空氣
— 水
— 油

.3 單個氣缸排量

— 在總差異範圍 15%之內

.4 氣缸數量及氣缸構形

— 僅在某些情況下適用，例如與廢氣清潔裝置相聯時

.5 空氣抽吸方法

— 自然抽吸
— 增壓

.6 燃料類型

— 蒸餾/殘餘燃油

— 雙燃料

.7 燃燒室

— 開式燃燒室

— 分開燃燒室

.8 閥和開孔，構形、尺寸和數量

— 氣缸頭

— 氣缸壁

.9 燃料系統類型

— 泵線噴射器

— 串聯

— 分配器

— 單一元件

— 單元噴射器

— 氣體閥

.10 其他特性

— 廢氣再循環

— 水/乳液噴射

— 空氣噴射

— 增壓冷卻系統

— 廢氣後處理

— 還原催化劑

— 氧化催化劑

— 熱反應器

— 顆粒捕捉器。

4.3.8.3 如果發動機包含其他被認為能影響氮氧化物廢氣排放的特徵，則這些特徵必須在選擇包括在發動機族中的發動機時予以認定和考慮。

4.3.9 *發動機族的母型機選擇指南*

4.3.9.1 用於氮氧化物測量的母型機選擇方法須經主管機關同意並認可。該方法須基於所選擇的發動機具有根據經驗已知會產生以克每千瓦小時（g/kWh）表示的最高氮氧化物排放量的發動機特徵和特性。這需要對發動機族中的發動機有詳盡的了解。在某些情況下，主管機關會斷定，對另外一台發動機進行實驗能更好地體現該發動機族的最差氮氧化物排放率。因此，主管機關可以根據該發動機族的發動機中表明具有最高氮氧化物排放水平的特徵，選擇另一台發動機進行試驗。如果在發動機族的發動機範圍中包含其他可能被認為影響氮氧化物排放的可變特徵，這些特徵也必須在母型機選擇中予以認定和考慮。

4.3.9.2 母型機須具有所適用試驗循環的最高排放值。

4.3.10 *發動機族的發證*

4.3.10.1 證書須包括一份由發動機製造廠制定和保管並經主管機關批准的清單，該清單中列有同一發動機族中的所有發動機及其規格，其操作條件限制和可允許的發動機調整細節和限度。

4.3.10.2 根據本規則須為發動機族的一成員發動機簽發一張前期證書或 EIAPP 證書，證明母型機符合第 13 條中規定的適用氮氧化物限

值。如果成員發動機的前期發證需要測量性能值，須按照本規則附錄 IV 中 1.3 的要求校準測量用設備。

4.3.10.3 如果在本規則規定的最惡劣條件下對發動機族的母型機進行試驗和氣體排放測量並證實符合 3.1 中給出的適用的最大允許排放限值，和試驗及氮氧化物測量結果須記錄在簽發給該特定母型機及該發動機族的所有成員機的 EIAPP 證書中。

4.3.10.4 如果兩個或以上主管機關同意接受彼此的 EIAPP 證書，則由其中一個主管機關發證的整個發動機族須得到與原發證主管機關簽定協議的其他主管機關的接受，協議中另有規定者除外。按該協議簽發的證書須被視為該發動機族證書所包括的所有發動機均符合特定氮氧化物排放要求的初步證據。如經證實所安裝的發動機未經改裝並且其調整在發動機族證書所允許的限度之內，則不需要對符合第 13 條規定做進一步證實。

4.3.10.5 如果發動機族的母型機根據本規則允許之外的其他標準或不同試驗循環予以認證，則製造廠必須向主管機關證明適當試驗循環下的氮氧化物加權平均排放在本規則和第 13 條的有關限值內，之後主管機關方可簽發 EIAPP 證書。

4.4 發動機組概念的應用

4.4.1 發動機組的發動機通常需要調整或改裝以適合船上運作條件，但這些調整或改裝不得導致氮氧化物排放超過第 13 條的適用限值。

4.4.2 發動機組概念還提供了減少對生產或使用中的發動機的改裝進行認可試驗的可能性。

4.4.3 發動機組概念通常可適用於具有 4.4.6 規定的相同設計特徵的任何發動機型，但在試驗台測試後允許單機改裝或調整。發動機組內的發動機範圍和母型機的選擇須經主管機關同意和認可。

4.4.4 如發動機製造廠或其他方要求應用發動機組概念，主管機關須考慮給予發證認可。如果發動機所有人無論有無發動機製造廠的技術支持，決定對其擁有船隊中許多相似發動機進行改裝，發動機所有人可以申請發動機組證書。發動機組可基於測試台上一台作為試驗發動機的母型機。典型應用為相似運作條件下相似柴油發動機的相似改裝。如除發動機製造廠之外的其他方申請發動機證書，發動機證書的申請方承擔本規則其他部分給出的發動機製造廠的責任。

4.4.5 在對系列化生產的發動機給予初始發動機組認可前，主管機關須採取必要措施核實已做出適當安排以確保對產品合格的有效控制。4.3.7 中的要求在細節上做出必要修正後，適用於本節。對於在簽發 EIAPP 證書後，為船上發動機改裝而建立的發動機組，此要求可能沒有必要。

4.4.6 *發動機組選擇指南*

4.4.6.1 除 4.3.8 中為發動機族定義的參數之外，發動機組可按基本特性和規格界定。

4.4.6.2 發動機組中的發動機須共有的參數和規格如下：

.1 缸內徑和衝程尺寸；

.2 增壓和排氣系統的方法和設計特點：

— 恆壓；

— 脈衝系統；

.3 增壓空氣冷卻系統方法：

— 有/無增壓空氣冷卻器；

.4 影響氮氧化物排放的燃燒室設計特點；

.5 可確定影響氮氧化物排放的基本特徵的燃料噴射系統、活塞和噴射凸輪的設計特點；及

.6 額定轉速下的額定功率。發動機功率（kW/氣缸）和/或額定轉速的允許範圍由製造廠申報並經主管機關認可。

4.4.6.3 如果 4.4.6.2 所要求的標準並非預期發動機組內所有發動機所共有，則一般可認為那些發動機不屬同一個發動機組。但是，如那些標準中僅一項不是預期發動機組中所有發動機所共有，則發動機組可予接受。

4.4.7 *發動機組中可允許的調整或改裝指南*

4.4.7.1 經有關當事國同意及主管機關認可，在發動機組的前期發證或最後試驗台測量之後，符合發動機組概念的輕微調整和改裝可以允許，如果：

.1 對與排放有關的發動機參數和/或發動機船上氮氧化物核實程序的規定和/或發動機製造廠提供的數據的檢查證實經調整或改裝的發動機符合適用的氮氧化物排放限值。發動機試驗台上氮氧化物排放結果可作為核查發動機組中發動機的船上調整或改裝的一種選擇而加以接受；或

.2 船上測量證實經調整或改裝的發動機符合適用的氮氧化物排放限值。

4.4.7.2 發動機組內可以允許的調整和改裝實例（但不限於這些實例）如下：

.1 針對船上條件：

— 為補償燃料性質差異對噴射定時的調整，

— 為最大氣缸壓力對噴射定時的調整，

— 對氣缸間燃料輸送差異的調整。

.2 針對性能，對下列部件進行的改裝：

— 渦輪增壓器，

— 噴射泵部件，

— 柱塞規格，

— 輸送閥規格，

— 噴嘴，

— 凸輪輪廓，

— 進氣和/或排氣閥，

— 噴射凸輪，

— 燃燒室。

4.4.7.3 上述試驗台試驗後的改裝實例涉及到發動機整個使用壽命中的部件或發動機性能的重大改進。這是發動機組概念存在的主要原因之一。主管機關在收到申請之後，可將對一台發動機（可能是試驗發動機）進行的表明該改裝對氮氧化物排放水平造成的影響驗證試驗

結果，接受為該發動機組內的所有發動機的試驗結果，而不要求對發動機組的每台成員發動機進行發證測量。

4.4.8 *發動機組的母型機選擇指南*

4.4.8.1 母型機的選擇須符合 4.3.9 中的適用標準。並非總能以與大批量生產發動機（發動機族）相同的方式從小批量生產的發動機中選出母型機。第一台訂購的發動機可被登記為母型機。此外在前期發證試驗中，如果母型機未調整至發動機製造廠定義的發動機組的參照或最大允許運作條件（可包括但不限於：最大燃燒壓力、壓縮壓力、排氣背壓、增壓空氣溫度），所測定的氮氧化物排放值須根據其他代表性發動機的排放敏感度測試修正至所定義的參照和最大允許條件。經修正的參照條件下的加權平均氮氧化物排放值須在 EIAPP 證書附件的 1.9.6 中標明。在任何情況下參照條件公差的影響不得導致排放值超過第 13 條要求的適用的氮氧化物排放限值。用於選擇代表發動機組的母型機的方法、參照值和應用的公差須經主管機關同意和認可。

4.4.9 *發動機組的發證*

4.4.9.1 4.3.10 中的要求，在細節上作出必要修正後，適用於本節。

第 5 章

試驗台氮氧化物排放的測量程序

5.1 通則

5.1.1 此程序須應用於船用柴油發動機的每一次初始認可試驗而不論其試驗地點（2.1.2.1 和 2.1.2.2 所述試驗方法）。

5.1.2 本章規定了確定氮氧化物廢氣排放加權平均值所需往復式內燃機在穩定狀態下的氣體排放測量和計算方法。

5.1.3 由於確定排放值需要進行一組多元單項測量而並非僅獲得單一測量值，所以許多下述程序為實驗室方法的詳細闡述。因此，所獲結果不僅取決於發動機和試驗方法並同樣地取決於測量程序。

5.1.4 本章包括作為試驗台測量程序的試驗和測量方法、試驗運行和試驗報告。

5.1.5 原則上，在排放試驗過程中，發動機須以與其船上應用相同的方式配備輔助設備。

5.1.6 對於本規則範圍內的許多發動機類型，發動機運行時會安裝的輔助設備在製造和發證時可能不會得知。因此，所標示的排放基於 1.3.13 所定義的制動功率。

5.1.7 當不適合在 5.2.3 規定的條件下試驗發動機時，例如，如果發動機和傳動裝置構成一個整體單元，發動機僅可在裝妥其他輔助設備後進行試驗。在這種情況下，功率計的設置須按照 5.2.3 和 5.9 確定。輔助設備損耗須不超過最大實測功率的 5%。超過 5%的損耗須在試驗前經有關主管機關認可。

5.1.8 所有容量和容積流量率須與 273K（0℃）和 101.3kPa 相關。

5.1.9 除另有規定外，本章要求的所有測量結果、試驗數據或計算須按照 5.10 記錄在發動機試驗報告中。

5.1.10 本規則中提到的“增壓空氣”一詞同樣適用於掃氣。

5.2 試驗條件

5.2.1 *發動機族認可的試驗條件參數和試驗有效性*

5.2.1.1 須測量發動機吸入空氣的絕對溫度 T_a（以 K 表示），須根據以下公式測量或計算乾燥大氣壓力 p_s，以 kPa 表示：

$$p_s = p_b - 0.01 \cdot R_a \cdot p_a$$

p_a 按公式（10）確定

5.2.1.2 對於自然進氣和機械增壓發動機，f_a 參數須根據以下公式確定：

$$f_a = \left(\frac{99}{p_s}\right) \cdot \left(\frac{T_a}{298}\right)^{0.7} \quad (1)$$

5.2.1.3 對於有或無吸入空氣冷卻的渦輪增壓發動機，f_a 參數須根據以下公式確定：

$$f_a = \left(\frac{99}{p_s}\right)^{0.7} \cdot \left(\frac{T_a}{298}\right)^{1.5} \quad (2)$$

5.2.1.4 對於承認發動機族認可有效的試驗，參數 f_a 須為：

$$0.93 \le f_a \le 1.07 \quad (3)$$

5.2.2 *具有增壓空氣冷卻的發動機*

5.2.2.1 冷卻介質溫度和增壓空氣溫度須予以記錄。

5.2.2.2 所有發動機按照擬定的船上安裝配置後，必須能夠在25℃環境海水溫度下於第13條的適用氮氧化物排放限值內運轉。此參照溫度，須根據下列適用於具體安裝的增壓空氣冷卻安排加以考慮：

.1 發動機增壓空氣冷卻器直接海水冷卻。須證實增壓空氣冷卻器冷卻劑的進口溫度為25℃時符合適用的氮氧化物限值。

.2 發動機增壓空氣冷卻器中間淡水冷卻。須證實增壓空氣冷卻系統在與25℃的環境海水溫度相對應的冷卻劑進口設計溫度下運行時，符合適用的氮氧化物限值。

註：以上（.1）中所述直接海水冷卻系統的母型機試驗證明符合要求，不能證明本節所要求的在使用中間淡水冷卻安排所必有的更高增壓空氣溫度機制下符合要求。

.3 對於安裝的增壓空氣冷卻器不含直接或間接海水冷卻，如散熱器冷卻的淡水系統、氣/氣增壓空氣冷卻器，須證實發動機和增壓空氣冷卻系統在25℃空氣溫度下按製造廠的規定運行時，符合適用的氮氧化物限值。

5.2.2.3 是否符合第13條規定的適用的氮氧化物排放限值，須使用製造廠所規定和證明的增壓空氣參照溫度（T_{SCRef}）通過試驗或，適用時，計算加以證實。

5.2.3 *功率*

5.2.3.1 具體排放量測量的基礎是 1.3.11 和 1.3.13 定義的未經修正的制動功率。發動機須與發動機運行所需的輔助設備（例如：風扇、水泵等）一同提交。如在測試台上無法或不適宜安裝輔助設備，則其功耗須加以確定並從測定的發動機功率中扣除。

5.2.3.2 發動機上可能安裝的非運行必需的輔助設備可在試驗時拆除。另參閱 5.1.5 和 5.1.6。

5.2.3.3 如果輔助設備未拆除，其試驗轉速下的功耗須加以確定，以計算功率計的設定值，但輔助設備與發動機構成單一整體的發動機除外（例如：空氣冷卻發動機的冷卻風扇）。

5.2.4 *發動機空氣進氣系統*

5.2.4.1 須使用發動機空氣進氣系統或試驗車間系統，所呈現的空氣進氣限制為乾淨空氣濾清器在額定功率和滿載荷的轉速時，製造廠規定的最大值的±300Pa 以內。

5.2.4.2 如果發動機配有一體化空氣進氣系統，則須在試驗時使用。

5.2.5 *發動機排氣系統*

5.2.5.1 須使用發動機排氣系統或試驗車間系統，所呈現的背壓為在額定功率和滿載荷的轉速時，製造廠規定的最大值的±650Pa 以內。排氣系統須符合 5.9.3 中的廢氣取樣要求。

5.2.5.2 如果發動機配有一體化排氣系統，則須在試驗時使用。

5.2.5.3 如果發動機配有廢氣後處理裝置，其排氣管直徑須與包含廢氣後處理裝置的展開部分開端進口上游至少 4 倍於管直徑之處所使用的管直徑相同。從排氣總管法蘭或渦輪增壓器出口至廢氣後處理裝

置的距離須與船上構形相同，或位於製造廠的距離規格之內。排氣背壓或限制須遵循上述同一標準並可使用閥門調定。

5.2.5.4 如試驗台的裝置妨礙按照要求調整排氣背壓，對氮氧化物排放的影響應由該製造廠予以證明，並在主管機關認可後，對排放值相應地做出必要修正。

5.2.6 *冷卻系統*

5.2.6.1 須使用具有足夠容量的發動機冷卻系統以維持製造廠規定的發動機正常運作溫度。

5.3 試驗燃油

5.3.1 燃油特性會影響發動機廢氣排放；特別是，一些燃油結合氮在燃燒中會轉換成氮氧化物。因此，試驗所用燃油的特性須予以確定並記錄。如使用參照燃油，則須提供該燃油的參照號碼或規格及分析。

5.3.2 試驗用燃油的選擇取決於試驗的目的。如果沒有適合的參照燃油，建議使用 ISO 8217：2005 規定的具有適合該發動機類型的性質的 DM 級蒸餾船用燃料。如果沒有 DM 級船用燃料，須使用與 ISO 8217：2005 相符的 RM 級殘油燃油。對燃油的所有構成成分須進行必要的分析，以明確其規格及確定其 DM 或 RM 級別。母型機試驗時使用的燃油須在試驗中取樣。

5.3.3 燃油溫度須符合製造廠的建議。燃油溫度須在燃料噴射泵進口處或按照製造廠的規定測量，並且溫度和測量點須予以記錄。

5.3.4 以液體燃料為引燃燃料的雙燃料發動機須使用最大液體和氣體燃料比進行試驗。燃料的液體部分須符合 5.3.1、5.3.2 和 5.3.3。

5.4 測量設備和測量數據

5.4.1 交付試驗的發動機所排放的氣體成分須按本規則附錄 III 所述方法測量，該附錄闡述了氣體排放的建議分析系統。

5.4.2 其他系統或分析儀，如果能得出與 5.4.1 中所提到的設備等效的結果，經主管機關認可，可被接受。為確立等效，經使用公認國家或國際標準驗證合格的建議替代系統或分析儀，用於測量柴油發動機的廢氣排放濃度時，就 5.4.1 所援引的要求而言，能得出等效結果。

5.4.3 對於引入新系統，等效的確定須基於 ISO 5725-1 和 ISO 5725-2 或其他類似的公認標準中闡述的重複性和再現性的計算。

5.4.4 本規則不包含流量、壓力和溫度測量設備的詳細資料，而僅在本規則附錄 IV 的 1.3.1 中給出了此類設備進行排放試驗所需精度要求。

5.4.5 *功率計規格*

5.4.5.1 須採用具有適當性能可完成 3.2 所述的適合的試驗循環的發動機功率計。

5.4.5.2 扭矩和轉速測量儀器須使軸功率測量精度在給定範圍之內。可能需要附加計算。

5.4.5.3 測量設備的精度須不超過本規則附錄 IV 的 1.3.1 中給出的允許偏差。

5.5 廢氣流量測定

5.5.1 廢氣流量須採用 5.5.2，5.5.3 或 5.5.4 中規定的方法之一予以測定。

5.5.2 *直接測量方法*

5.5.2.1 該方法通過流量嘴或等效的測量系統直接測量廢氣流量，並且須符合公認的國際標準。

註： 直接氣體流量測量是一項困難的任務。須採取預防措施避免將會導致排放值錯誤的測量錯誤。

5.5.3 *空氣和燃料測量方法*

5.5.3.1 採用空氣和燃料測量方法確定廢氣排放流量的方法須根據公認的國際標準進行。

5.5.3.2 該方法對空氣流量和燃料流量進行測量。須使用具有本規則附錄 IV 中 1.3.1 所定義的精確度的空氣流量表和燃料流量表。

5.5.3.3 廢氣流量須作如下計算：

$$q_{\mathrm{mew}} = q_{\mathrm{maw}} + q_{\mathrm{mf}} \quad (4)$$

5.5.3.4 空氣流量表須符合本規則附錄 IV 的精確度規範，CO_2 分析儀須滿足本規則附錄 III 的技術規範，且整個系統須符合本規則附錄 IV 的廢氣流量的精確度規範。

5.5.4 *燃料流量和碳平衡法*

5.5.4.1 該方法採用本規則附錄 VI 規定的碳平衡法根據燃料消耗、燃料成分和廢氣濃度進行廢氣質量流量計算。

5.6 發動機相關參數和其他基本參數測試儀的允許偏差

5.6.1 所有測量儀的校準，包括本規則附錄 IV 中詳述的測量儀和為了確定發動機的氮氧化物排放性能，例如測量汽缸峰值或增壓空氣

壓力而額外需要的測量儀的校準，須符合主管機關認可的標準和本規則附錄 IV 的 1.3.1 中列出的要求。

5.7 確定氣體成分的分析儀

5.7.1 確定氣體成分的分析儀須滿足本規則附錄 III 的規定。

5.8 分析儀的校準

5.8.1 用於發動機氣體排放測量的分析儀須按照本規則附錄 IV 的要求校準。

5.9 試驗運行

5.9.1 *通則*

5.9.1.1 對建議取樣和分析系統的詳細描述包含在 5.9.2 至 5.9.4 和本規則附錄 III 中。由於不同的結構可產生相同的結果，所以不要求完全一致。可使用附加構件，如儀器、閥、螺線管、泵和開關提供補充資料及協調構件系統的功能。如主管機關同意，對維持某些系統的精確性所不需要的其他構件可以排除，只要該排除基於良好的技術判斷。

5.9.1.2 進氣限制（自然進氣發動機）或增壓空氣壓力（渦輪增壓發動機）和廢氣背壓的處理須分別符合 5.2.4 和 5.2.5 的要求。

5.9.1.3 對於增壓發動機，進氣限制條件須以乾淨空氣進氣濾清器，及增壓系統在母型機試驗結果所代表，為該發動機族或發動機組申報或確立的範圍內運作為條件。

5.9.2 *主要廢氣成分：CO、CO_2、HC、NO_x 和 O_2*

5.9.2.1 確定原始廢氣中氣體排放的分析系統須以使用 5.4 中規定的分析儀為基礎。

5.9.2.2 對於原始廢氣所有成分的試樣可以使用一隻取樣管或用兩隻位置緊靠在一起並內部分至不同分析儀的取樣管採集。必須當心不要在分析系統的任何部位發生廢氣成分（包括水和硫酸）凝結。

5.9.2.3 這些分析儀的規格和校準須分別符合本規則附錄 III 和 IV。

5.9.3 *氣體排放物的取樣*

5.9.3.1 氣體排放物取樣管須安裝在發動機、渦輪增壓器或最後一個後處理裝置（取最下游者）的出口之後至少 10 倍於排氣管直徑之處，但同時至少在廢氣系統出口上游 0.5m 或 3 倍於排氣管直徑（取大者）之處。對於位置無法滿足上述規格的短廢氣系統，取樣管的替代位置須由主管機關認可。

5.9.3.2 碳氫化合物取樣管處的廢氣溫度須至少為 190℃，與碳氫化合物取樣管分離的其他氣體測量取樣管處須至少為 70℃。

5.9.3.3 對於帶有多路支管廢氣管的多氣缸發動機，取樣管進口須位於足夠下游之處，以確保試樣能代表從所有氣缸排出的平均廢氣排放。對於帶有不同支管組的多氣缸發動機，允許分別從每組廢氣管處取樣並計算平均廢氣排量。另外，允許從一組中取樣以代表平均廢氣排量，條件是能向主管機關證明其他組的排放是相同的。經主管機關認可，已表明和上述方法相關聯的其他方法可以採用。廢氣排放計算，須採用總廢氣質量排量。

5.9.3.4 廢氣取樣系統須按本規則附錄 IV 的第 4 節進行泄漏試驗。

5.9.3.5　如果廢氣成分受到任何廢氣後處理系統的影響，則廢氣試樣必須在該設備的下游取得。

5.9.3.6　取樣管入口位置須能避免吸入廢氣系統中為冷卻、調節或降低噪音而注入的水。

5.9.4　*分析儀的檢查*

5.9.4.1　排放分析儀須按本規則附錄 IV 的第 6 節置零及設定量程。

5.9.5　*試驗循環*

5.9.5.1　發動機須按照 3.2 定義的試驗循環進行試驗，這考慮到發動機應用的不同。

5.9.6　*試驗順序*

5.9.6.1　完成 5.9.1 至 5.9.5 的程序後，須開始試驗順序。發動機須按照 3.2 定義的適用試驗循環以任何順序進行每一種模式的運行。

5.9.6.2　在實驗循環的每一種模式的初轉換期之後，除低速空轉時須在製造廠申報的公差之內，指定轉速須維持在額定轉速的±1%或 ±3min^{-1}（取大者）之間。指定扭矩須加以維持，使整個測量期間的平均扭矩在發動機額定轉速下的額定扭矩的±2%之間。

5.9.7　*分析儀響應*

5.9.7.1　當穩定時，在試驗和所有零位和量程響應檢查過程中分析儀的輸出須使用數據採集系統或條圖記錄器進行記錄。分析廢氣時的記錄時間須不小於 10 分鐘，每次零位和量程響應檢查時須不小於 3 分鐘。數據採集系統須使用每分鐘至少三次的取樣頻率。所測定的 CO、HC 和 NO_X 濃度須使用 ppm 或等效方式記錄並至少精確到最接近整數

位。所測定的 CO_2 和 O_2 濃度須使用%或等效方式記錄並精確到不少於小數點後兩位。

5.9.8 *發動機狀況*

5.9.8.1 各模式點下發動機的轉速、負荷及其他重要參數須在發動機穩定之後測量。廢氣流量須予以測量或計算並記錄。

5.9.9 *分析儀複查*

5.9.9.1 排放試驗後，須使用零位氣體和測量前使用的相同量程氣體對分析儀的零位和量程響應進行複查。如果滿足以下條件，則須認定試驗合格：

.1 試驗前、後零位氣體響應差異低於初始量程氣體濃度的 2%；及

.2 在試驗前、後量程氣體響應差異低於初始量程氣體濃度的 2%。

5.9.9.2 對按 5.9.7 記錄的分析儀響應不得進行零位和量程漂移校正。

5.10 試驗報告

5.10.1 對建立發動機族或發動機組而測試的每台單機或母型機，發動機製造廠須為其準備一份試驗報告，內容須包括能全面確定發動機性能和進行氣體排放計算的必要數據，包括本規則附錄 V 第 1 節規定的數據。試驗報告的正本須由製造廠存檔保管，一份經核准的真實副本須由主管機關存檔保管。

5.11 氣體排放數據評估

5.11.1 對於氣體排放評估，須對每種模式的至少最後 60s 記錄的數據作平均，每種模式中 CO、CO_2、HC、NO_X 和 O_2 的濃度須根據平均記錄數據和相應零位和量程檢查數據確定。CO_2 和 O_2 的平均結果須精確到不少於小數點後兩位（以%表示），CO、HC 和 NO_X 須至少精確到最接近整數位（以 ppm 表示）。

5.12 氣體排放計算

5.12.1 試驗報告的最後結果須按下列 5.12.2 至 5.12.6 中的步驟確定。

5.12.2 *廢氣流量的確定*

5.12.2.1 每種模式的廢氣流量率（q_{mew}）須按照 5.5.2 至 5.5.4 中所述的方法之一確定。

5.12.3 *乾/濕修正*

5.12.3.1 如排放未按濕度基礎測量，則須根據下列公式將所測濃度轉換成濕度基礎：

$$C_{\mathrm{w}} = K_{\mathrm{w}} \cdot C_{\mathrm{d}} \qquad (5)$$

5.12.3.2 對於原始廢氣：

.1 完全燃燒，按 5.5.2 的直接測量方法或 5.5.3 的空氣和燃料測量方法確定廢氣流量時，須使用下列公式：

$$K_{\mathrm{WR1}} = \left(1 - \frac{1.2442 \cdot H_a + 111.19 \cdot W_{\mathrm{ALF}} \cdot \frac{q_{\mathrm{mf}}}{q_{\mathrm{mad}}}}{7773.4 + 1.2442 \cdot H_a + \frac{q_{\mathrm{mf}}}{q_{\mathrm{mad}}} \cdot f_{\mathrm{fw}} \cdot 1000}\right) \cdot 1.008 \qquad (6)$$

或

$$k_{wT1} = \left(1 - \frac{1.2442 \cdot H_a + 111.19 \cdot w_{ALF} \cdot \frac{q_{mf}}{q_{mad}}}{773.4 + 1.2442 \cdot H_a + \frac{q_{mf}}{q_{mad}} \cdot f_{fw} \cdot 1000}\right) \Big/ \left(1 - \frac{p_r}{p_b}\right) \quad (7)$$

式中

$$f_{fw} = 0.055594 \cdot w_{ALF} + 0.0080021 \cdot w_{DEL} + 0.0070046 \cdot w_{EPS} \quad (8)$$

H_a 係指以 g（水）/kg（乾空氣）表示的吸入空氣的絕對濕度

註： 可通過相對濕度測量、露點測量、蒸氣壓力測量或乾/濕球測量，運用普遍接受的公式，計算出 H_a。

$$H_a = 6.22 \cdot p_a \cdot R_a / (p_b - 0.01 \cdot R_a \cdot p_a) \quad (9)$$

式中：

p_a＝吸入空氣的飽和蒸氣壓力，kPa

$$p_a = (4.856884 + 0.2660089 \cdot t_a + 0.01688919 \cdot t_a^2 - 7.477123 \cdot 10^{-5} \cdot t_a^3 + 8.10525 \cdot 10^{-6} \cdot t_a^4 - 3.115221 \cdot 10^{-8} \cdot t_a^5) \cdot (101.32/760) \quad (10)$$

式中：

t_a＝ 吸入空氣溫度，℃；$t_a = T_a - 273.15$

p_b＝ 總大氣壓力，kPa

p_r＝ 分析系統冷卻槽後的水汽壓力，kPa

p_r＝ 0.76kPa，冷卻槽溫度 3℃

.2 不完全燃燒，在一個或多個模式點 CO 大於 100ppm 或 HC 大於 100ppmC，按 5.5.2 的直接測量方法或 5.5.3 的

空氣和燃料測量方法及任何情況下使用 5.5.4 的碳平衡法確定廢氣流量時，須使用下列公式：

註：（11）和（13）中 CO 和 CO2 濃度的單位是%。

$$k_{\mathrm{wT2}}=\frac{1}{1+a\cdot 0.005\cdot(c_{\mathrm{co2d}}+c_{\mathrm{cod}})-0.01\cdot c_{\mathrm{H2d}}+k_{\mathrm{w2}}-\frac{p_{\mathrm{r}}}{p_{\mathrm{b}}}} \qquad (11)$$

式中：

$$a=11.9164\cdot\frac{w_{\mathrm{ALF}}}{w_{\mathrm{BET}}} \qquad (12)$$

$$c_{\mathrm{H2d}}=\frac{0.5\cdot a\cdot c_{\mathrm{COd}}\cdot(c_{\mathrm{COd}}+c_{\mathrm{CO2d}})}{c_{\mathrm{COd}}+3\cdot c_{\mathrm{CO2d}}} \qquad (13)$$

$$k_{\mathrm{w2}}=\frac{1.608\cdot H_{\mathrm{a}}}{1000+(1.608\cdot H_{\mathrm{a}})} \qquad (14)$$

5.12.3.3 對於吸入空氣：

$$k_{\mathrm{wa}}=1-k_{\mathrm{w2}} \qquad (15)$$

5.12.4 *氮氧化物濕度和溫度修正*

5.12.4.1 由於氮氧化物的排放取決於環境空氣狀況，所以氮氧化物濃度須使用 5.12.4.5 或 5.12.4.6 中的適用系數進行環境空氣溫度和濕度修正。

5.12.4.2 除參照溫度 25℃下 10.71g/kg 外，不得使用其他濕度參照值。

5.12.4.3 其他修正公式如證明正確、有效，並經主管機關認可，可以使用。

5.12.4.4 增壓空氣中注入水或蒸氣（空氣加濕）被視作排放控制手段，因此濕度修正中不做考慮。增壓冷卻器中凝結的水會改變增壓空氣的濕度，因此濕度修正中須作考慮。

5.12.4.5 壓燃式發動機：

$$k_{hd} = \frac{1}{1-0.0182\cdot(H_a-10.71)+0.0045\cdot(T_a-298)} \quad (16)$$

式中：

T_a= 空氣濾清器進口的空氣溫度，K

H_a= 空氣濾清器進口的吸入空氣濕度，克水（g）/每千克乾空氣（kg）

5.12.4.6 具有中間空氣冷卻器的壓燃式發動機須使用下列替代公式：

$$k_{hd} = \frac{1}{1-0.012\cdot(H_a-10.71)-0.00275\cdot(T_a-298)+0.00285\cdot(T_{SC}-T_{SCRef})} \quad (17)$$

式中：

T_{SC} 係指增壓空氣溫度；

T_{SCRef} 係指 5.2.2 規定的對應於海水溫度 25℃的每個模式點的增壓空氣溫度。

T_{SCRef} 須由製造廠規定。

為考慮增壓空氣的濕度，須增加下列因素：

H_{SC}= 增壓空氣濕度，克水（g）/每千克乾空氣（kg），其中：

H_{SC}= 6.22·p_{SC}·100/（p_C-p_{SC}）

式中：

p_{SC}= 增壓空氣的飽和蒸氣壓力，kPa

p_C= 增壓空氣壓力，kPa

但是，如果 $H_a \geq H_{SC}$，須使用 H_{SC} 替代公式（17）中的 H_a。

5.12.5 *排放質量流量的計算*

5.12.5.1 每種模式原始廢氣中各成分的排放質量流量須使用按 5.11.1 獲取的測量濃度、表 5 中的適用 u_{gas} 值和 5.5 中的廢氣質量流量按照 5.12.5.2 計算出。

表 5

原始廢氣的系數 u_{gas} 和燃料特定參數

氣體		NO_X	CO	HC	CO_2	O_2
ρ_{gas}	kg/m^3	2.053	1.250	*	1.9636	1.4277
	ρ_e**	系數 u_{gas}***				
燃油	1.2943	0.001586	0.000966	0.000479	0.001517	0.001103

* 取決於燃料

** ρ_e 為廢氣的正常密度。

*** λ=2 時，濕空氣，273K，101.3kPa

表 5 中的 u 值基於理想的氣體特性。

5.12.5.2 須使用以下公式：

$$q_{mgas} = u_{gas} \cdot c_{gas} \cdot q_{mew} \cdot k_{hd} \text{(對} NO_X \text{)} \quad (18)$$

$$q_{mgas} = u_{gas} \cdot c_{gas} \cdot q_{mew} \cdot k_{hd} \text{(對其他氣體)} \quad (18a)$$

式中：

q_{mgas}=個別氣體排放質量流量，g/h

u_{gas}=廢氣成分密度和廢氣密度比率，見表 5

c_{gas}=原始廢氣中各成分的濃度，ppm，濕基

q_{mew}=廢氣質量流量，kg/h，濕基

k_{hd}=NO_X 濕度修正系數

註： 對於 CO_2 和 O_2 測量，濃度通常以%報告。應用公式 18a 時，濃度須以 ppm 表示。1.0%=10000ppm。

5.12.5.3 對於氮氧化物的計算，須使用按 5.12.4 確定的濕度修正系數 k_{hd}。

5.12.5.4 測量的濃度如不是以濕度基礎測量，須按 5.12.3 轉換成濕度基礎。

5.12.6 *具體排放量計算*

5.12.6.1 所有單獨成分的排量須按照下列公式計算

$$\mathrm{gas}_x = \frac{\sum_{i=1}^{i=n}\left(q_{\mathrm{mgasi}} \cdot W_{\mathrm{Fi}}\right)}{\sum_{i=1}^{i=n}\left(p_{\mathrm{i}} \cdot W_{\mathrm{Fi}}\right)} \qquad (19)$$

式中：

$$p = p_{\mathrm{m}} + p_{\mathrm{aux}} \qquad (20)$$

和

q_{mgas} 係指個別氣體排放質量流量

P_{m} 係指單獨模式的測定功率

P_{aux} 係指單獨模式的安裝到發動機上的輔助設備功率。

5.12.6.2 上述計算中使用的加權因數和模式數目（n）須符合 3.2 的規定。

5.12.6.3 按公式（19）得出的發動機平均加權氮氧化物排放值須和第 13 條中適用排放限值相比較，以確定發動機是否符合要求。

第 6 章

船上驗證符合氮氧化物排放限值的程序

6.1 通則

6.1.1 獲得前期證書的發動機安裝到船上後，每台船用柴油發動機須按照 2.1.1.2 到 2.1.1.4 的規定，進行船上核實檢驗以驗證該發動機繼續符合第 13 條規定的適用氮氧化物排放限值。這種符合驗證須用下列方法之一確定：

.1 按照 6.2 規定的發動機參數檢查法驗證發動機的構件，設定值和操作值未偏離發動機技術檔案中的技術規範；

.2 符合 6.3 的簡化測量法；或

.3 符合 6.4 的直接測量和監測法。

6.2 發動機參數檢查方法

6.2.1 *一般要求*

6.2.1.1 滿足下述條件的發動機適合發動機參數檢查法：

.1 業已得到試驗台前期證書（EIAPP 證書）的發動機及按照 2.2.4 進行初次發證檢驗後得到證書（EIAPP 證書）的發動機；及

.2 上次檢驗後，指定的構件和可調特性業經改裝或調整的發動機。

6.2.1.2 當柴油發動機設計成在適用的氮氧化物排放限值內運轉時，很可能在其船上使用壽命內氮氧化物的排放限值不會改變。但是

對發動機的調整或改裝就可能使適用的氮氧化物排放限值被突破。因此，須採用發動機的參數檢查方法驗證發動機是否仍在適用的氮氧化物排放限值之內運轉。

6.2.1.3 發動機構件的檢查，包括設定值和發動機操作值的檢查旨在提供一種推斷發動機排放性能的簡易手段，以驗證未經或業經微小調整或改裝的發動機仍符合適用的氮氧化物排放限值。如果需對一些操作值進行測定，所用測量設備的校準須符合本規則附錄 IV 的要求。

6.2.1.4 上述檢查旨在提供一種方便方法，確定發動機按照製造廠的技術規範進行正確調整，並處於與主管機關證明與第 13 條中的適用的規定相符的初次發證相一致的調整狀態。

6.2.1.5 如果使用電子發動機控制系統，須對照原設定值予以評估以確保適當參數運行於建造時設定的限值之內。

6.2.1.6 為了評估是否符合第 13 條，並非總需要測量氮氧化物排放量以了解未配備後處理裝置的發動機是否符合適用的氮氧化物排放限值。只要了解發動機現狀和初次發證時特定的構件、校準或參數調整的狀況一致就可能足夠。如果發動機參數檢查方法的結果顯示該發動機符合適用的氮氧化物排放限值，可對該發動機重新發證而毋需氮氧化物直接測量。

6.2.1.7 對於配備氮氧化物減少裝置的發動機，作為參數檢查的組成部分，有必要對該裝置的運轉進行檢查。

6.2.2 *發動機參數檢查方法的文件*

6.2.2.1 每台船用柴油發動機均須備有 2.3.4 要求的技術檔案，列明影響廢氣排放的發動機構件、設定值或操作值，並須經核查以確保符合要求。

6.2.2.2 發動機的技術檔案須包括與氮氧化物排放性能相關，在發動機前期發證或船上發證時（取先者）指定的發動機構件、可調特性及參數的所有適用的資料。

6.2.2.3 根據特定的發動機的具體設計，各種影響氮氧化物排放的船上改裝和調整是可能而且常見的。這包括下列發動機參數：

.1 噴射定時；

.2 噴嘴；

.3 噴油泵；

.4 燃油凸輪；

.5 共軌系統的噴油壓力；

.6 燃燒室；

.7 壓縮比；

.8 渦輪增壓器類型和構造；

.9 增壓空氣冷卻器，增壓空氣預熱器；

.10 閥定時；

.11 氮氧化物抑制設備“水噴射”；

.12 氮氧化物抑制設備“乳化的燃料”（燃料水乳化液）；

.13 氮氧化物抑制設備“廢氣再循環”；

.14 氮氧化物抑制設備“選擇性催化還原”；或

.15 主管機關規定的其他參數。

6.2.2.4 根據發動機發證申請方的建議和主管機關的認可，依據特定的發動機和具體的設計，發動機的實際技術檔案可以包含少於第6.2.2.3節所論述的構件和/或參數。

6.2.2.5 對某些參數存在不同的檢驗可能性。經主管機關認可及在發動機發證申請方的支持下，船舶所有人可以選擇適合的方法。本規則附錄VII給出的發動機參數檢查法檢查清單中所列的任何一種或一組方法均足以證明符合要求。

6.2.2.6 包含在發動機技術檔案中的有關發動機構件改裝的技術文件，須包括改裝的細節及其對氮氧化物排放的影響，並須在進行改裝時提供。從該發動機組概念適用範圍內的晚期發動機獲得的試驗台數據，可以接受。

6.2.2.7 船舶如配有需接受發動機參數檢查法檢查的船用柴油發動機，其船舶所有人或船舶負責人須在船上保存下列有關船上氮氧化物核實程序的文件：

.1 記錄關於發動機構件和設定值的所有變化，包括相同部件更換或認可範圍內的調整的發動機參數記錄簿；

.2 發動機發證申請方提交並經主管機關認可的發動機指定構件和設定值參數清單和/或發動機載控操作值文件；及

.3 對任何發動機指定構件進行了改裝時，發動機構件改裝技術文件。

6.2.2.8 任何影響特定發動機參數的改變，包括調整、發動機部件的更換和改裝，其說明須在發動機參數記錄簿上按時間順序予以記錄。

上述說明須輔以用以評估發動機氮氧化物排放量的任何其他有用數據。

6.2.3 *發動機參數檢查方法的程序*

6.2.3.1 發動機參數檢查方法須用下列 2 個程序進行：

.1 除其他檢查外，須對發動機參數進行文件檢查，包括發動機參數記錄簿檢查以並驗證發動機參數在發動機技術檔案規定的許可範圍之內；及

.2 如必要，除進行文件檢查外，須對發動機構件及可調特性進行實際檢查。然後須參照文件檢查的結果，驗證發動機可調特性在發動機技術檔案所規定的許可範圍內。

6.2.3.2 驗船師須能夠選擇對 1 個或所有被列明的構件、設定值或操作值進行檢查以確保未經或業經微小調整或改裝的發動機符合適用的氮氧化物排放限值並確保按照 2.4.1.7 的規定，僅使用了符合經核准的規格的構件。如果調整和/或改裝參照技術檔案中的技術規範，則須為發動機發證申請方建議並經主管機關認可的範圍之內。

6.3 簡化測量方法

6.3.1 *一般要求*

6.3.1.1 本節規定的下列簡化試驗和測量程序僅適用於需要時在船上進行的確認試驗、及換證檢驗、年度檢驗和中間檢驗。各首次試驗台上發動機試驗均須按照第 5 章規定的程序進行。由於船舶在冷/熱和乾/濕氣候下航行，而這會造成氮氧化物排放變化，因此按照 5.12.4 對環境空氣濕度和溫度進行修正至關重要。

6.3.1.2 為了使船上確認試驗和船上換證檢驗、年度檢驗和中間檢驗獲得有意義的結果，作為最低的要求，須按照適當試驗循環對氮氧化物和二氧化碳的氣體排放濃度予以測量。計算中所使用的加權因數（W_F）和模式數目（n）須符合 3.2。

6.3.1.3 須測量發動機扭矩和轉速。但為簡化程序，為船上核實而測量發動機有關參數的儀器，其容許偏差（見 6.3.7）不同於在試驗台試驗方法中所允許的容許偏差。如直接測量扭矩有困難，可採用經發動機發證申請方推薦並經主管機關認可的任何其他方法估算制動功率。

6.3.1.4 在實際情況下，發動機一旦裝於船上，經常不再可能測量燃油消耗。為簡化船上程序，發動機前期發證試驗台試驗的燃油消耗測量結果可以接受。在這種情況下，特別是對於殘餘燃油（根據 ISO 8217：2005 的 RM 級燃油）的運轉，須對相應的估算誤差進行估算。因為計算中所用的燃油流量（q_{mf}）必須與試驗中抽取的燃油試樣所確定的燃油成分相關聯，所以須對試驗台試驗測定的 q_{mf} 就試驗台和試驗燃油之間的任何淨熱值差異進行修正。此誤差對最終排放造成的影響須加以計算，並與排放測量的結果一同報告。

6.3.1.5 除另有規定外，所有本章要求的測量結果、試驗數據或計算，均須按照 5.10 的要求記錄於在發動機試驗報告中。

6.3.2 *須測量和記錄的發動機參數*

6.3.2.1 表 6 列出了在船上核實程序中須予以測量和記錄的發動機參數。

表 6

須測量和記錄的發動機參數

符號	參數	量綱
H_a	絕對濕度（發動機吸入空氣水分質量與乾燥空氣質量之比）	g/kg
$n_{d,i}$	發動機轉速（循環中第i次模式時）	min^{-1}
$n_{turb,i}$	渦輪增壓器轉速（如適用）（循環中第i次模式時）	min^{-1}
p_b	總大氣壓力（在ISO 3046-1，1995中：p_x=P_x=現場環境總壓力）	kPa
$p_{C,i}$	增壓空氣冷卻器後的增壓空氣壓力（循環中第i次模式時）	kPa
P_i	制動功率（循環中第i次模式時）	kW
$q_{mf,i}$	燃油流量（循環中第i次模式時）	kg/h
s_i	燃料齒條位置（每個氣缸，如適用）（循環中第i次模式時）	
T_a	空氣入口處吸入空氣溫度（在ISO 3046-1，1995中：T_x=TT_x=現場環境熱力空氣溫度）	K
$T_{SC,i}$	增壓空氣冷卻器後的增壓空氣溫度（如適用）（循環中第i次模式時）	K
T_{caclin}	增壓空氣冷卻器，冷卻劑進口溫度	℃
$T_{caclout}$	增壓空氣冷卻器，冷卻劑出口溫度	℃
$T_{Exh,i}$	取樣點的廢氣溫度（循環中第i次模式時）	℃
T_{Fuel}	發動機前的燃油溫度	℃
T_{Sea}	海水溫度	℃

6.3.3 *制動功率*

6.3.3.1 船上氮氧化物試驗中，獲得所要求數據的能力問題特別地與制動功率相關。雖然對直連齒輪箱的情況在第 5 章（5.1.7）中給予了考慮，但是，正如在船上所能看到的，發動機在許多應用中的佈置，由於沒有明確的主軸因而無法進行扭矩測量（如通過專門安裝的應變

儀獲得扭矩測量值）。在這裏主要是發電機，但發動機還可能與泵，液壓裝置，壓縮機等連接。

6.3.3.2 驅動 6.3.3.1 中所列機器的發動機，在安裝到船上與功率消耗裝置永久連接之前的建造階段，一般均已用水力測功器進行過試驗。對發電機來說，採用電壓和電流測量及製造廠申報的發電機效率，應不成問題。對按推進器原理運轉的設備來講，可採用已知的轉速功率曲線以及有保證的從自由端或利用例如凸輪軸轉速的速比，測量發動機轉速的能力。

6.3.4 *試驗燃油*

6.3.4.1 一般來說，所有排放測量均須在發動機使用 ISO 8217：2005，DM 級船用柴油運轉時進行。

6.3.4.2 為了避免造成船舶所有人不能接受的負擔，根據發動機發證申請方的建議和主管機關的認可，確認試驗測量或重新檢驗測量可允許發動機使用 ISO 8217：2005，RM 級殘餘燃油運行。在這種情況下，燃油結合氮和燃油的點火性能可能會對發動機的氮氧化物排放有影響。

6.3.5 *氣體排放的取樣*

6.3.5.1 5.9.3 所述的一般要求亦須適用於船上測量。

6.3.5.2 所有發動機的船上安裝，須使得這些試驗可以安全地進行並且對發動機有最少的干擾。船上須提供廢氣取樣的合適佈置和獲得所要求的數據的能力。所有發動機的排氣管均須設置一個易於接近的標準取樣點。取樣點接頭法蘭的實例在本規則附錄 VIII 第 5 節中給出。

6.3.6 *測量設備和須測量的數據*

6.3.6.1 氣體污染物的排放須採用第 5 章所述方法予以測量。

6.3.7 *發動機有關參數和其他重要參數測量儀器的允許偏差*

6.3.7.1 本規則附錄 IV 的第 1.3 節中的表 3 和 4 列出了船上驗證程序過程中用於測量發動機有關參數和其他重參數的儀器的允許偏差。

6.3.8 *氣體成分的確定*

6.3.8.1 須採用第 5 章所述分析測量設備和方法。

6.3.9 *試驗循環*

6.3.9.1 船上所用的試驗循環須與 3.2 所規定的適用試驗循環相符。

6.3.9.2 發動機在船上並非總有可能按照 3.2 所規定的試驗循環運行，但基於發動機製造廠的建議並經主管機關認可的試驗程序須儘可能接近 3.2 所確定的程序。因此，這種情況下的測定值可能無法與試驗台試驗結果直接比較，因為測定值在很大程度上取決於試驗循環。

6.3.9.3 如果船上測量點的數目與試驗台試驗測量點數目不同，考慮到 6.4.6 的規定，測量點和加權因數須符合發動機發證申請方的建議並經主管機關認可。

6.3.10 *氣體排放計算*

6.3.10.1 考慮到簡化測量程序的特殊要求，須採用第 5 章規定的計算程序。

6.3.11 *容許偏差*

6.3.11.1 由於船上應用本章簡化測量程序時可能出現偏差，可接受適用限值 10%的容許偏差，但僅適用於確認試驗、換證檢驗、年度檢驗和中間檢驗。

6.3.11.2 發動機氮氧化物排放可隨燃油點火性能和燃油結合氮而改變。如沒有燃燒過程中點火性能影響氮氧化物形成的充分資料且燃油結合氮轉換率也取決於發動機的效率，對於以 RM 級燃油（ISO 8217：2005）進行的船上試驗運轉，可以允許 10%的容許偏差，但船上進行的前期發證試驗沒有容許偏差。對於所使用的燃油，須對其碳、氫、氮、硫的成分，以及在 ISO 8217：2005 的範圍內，對任何其他成分進行分析以明確其規格。

6.3.11.3 對船上簡化測量及使用 ISO 8217：2005 標準的 RM 級殘餘燃油所准許的總容許偏差不得超過適用限值的 15%。

6.4 直接測量和監測方法

6.4.1 *一般要求*

6.4.1.1 換證、年度和中間檢驗時，船上核實可使用下述直接測量和監測程序。

6.4.1.2 與廢氣的處理和接近、測量設備以及鋼瓶裝純氣體和校準氣體的儲存和使用相關的安全問題須予以適當注意。取樣位置和通道腳手架須能確保監測安全並且不干擾發動機。

6.4.2 *排放種類測量*

6.4.2.1 船上氮氧化物測量須至少包括氮氧化物（$NO+NO_2$）氣體排放濃度的測量。

6.4.2.2 如廢氣質量流量按照本規則附錄 VI 的碳平衡法確定，須同時測量二氧化碳。另外也可測量一氧化碳、碳氫化合物和氧。

6.4.3 *發動機性能測量*

6.4.3.1 表 7 列出了船上氮氧化物監測時在每個模式點須測量或計算和記錄的發動機性能參數。

表 7

須測量和記錄的發動機參數

符號	參數	量綱
n_d	發動機轉速	min^{-1}
p_C	接收器增壓空氣壓力	kPa
P	制動功率（如同以下規定）	kW
P_{aux}	輔機功率（如相關）	kW
T_{sc}	接收器增壓空氣溫度（如適用）	K
T_{caclin}	增壓空氣冷卻器冷卻劑進口溫度（如適用）	℃
$T_{caclout}$	增壓空氣冷卻器冷卻劑出口溫度（如適用）	℃
T_{Sea}	海水溫度（如適用）	℃
q_{mf}	燃油流量（如同以下規定）	kg/h

6.4.3.2 界定發動機操作條件所需的其他發動機設定值，如廢氣門、增壓空氣旁通、渦輪增壓器的狀態，須予以確定和記錄。

6.4.3.3 氮氧化物減少裝置的設定值和操作條件須予以確定和記錄。

6.4.3.4 如果直接測量功率有困難，可使用主管機關認可的任何其他方法估算未經修正的制動功率。確定制動功率的可行方法包括，但不限於：

.1 與 6.3.3 相符的間接測量；或

.2 從諾模圖估算。

6.4.3.5 燃油流量（實際消耗率）須按下列方式確定：

.1 直接測量；或

.2 於 6.3.1.4 相符的試驗台數據。

6.4.4 *環境條件測量*

6.4.4.1 表 8 列出了船上氮氧化物監測時在每個模式點須測量或計算和記錄的環境條件參數。

表 8

須測量和記錄的環境條件參數

符號	參數	量綱
H_a	絕對濕度（發動機吸入空氣水分質量與乾燥空氣質量之比）	g/kg
p_b	總大氣壓力（在 ISO 3046-1，1995 中：p_x=P_x=現場環境總壓力）	kPa
T_a	空氣入口溫度（在 ISO 3046-1，1995 中：T_x=TT_x=現場環境熱力空氣溫度）	K

6.4.5 發動機性能和環境條件監測設備

6.4.5.1 發動機性能和環境條件監測設備須依照製造廠的建議安裝和維護，以使本規則附錄 IV 中 1.3 節和表 3 和表 4 中有關允許偏差的要求得到滿足。

6.4.6 *試驗循環*

6.4.6.1 發動機在船上並非總有可能按照規定的試驗循環運行，但經主管機關認可的試驗程序須儘可能接近 3.2 規定的程序。因此，這種

情況下的測定值可能不能與試驗台試驗結果直接比較，因為測定值在很大程度上取決於試驗循環。

6.4.6.2 在 E3 試驗循環下，如實際螺旋槳曲線與 E3 曲線不同，所用載荷點須使用該循環相關模式給出的發動機轉速或相應的平均有效壓力（MEP）或平均指示壓力（MIP）予以設定。

6.4.6.3 如果船上測量點的數目與試驗台測量點數目不同，則測量點數目和相關的經修改的加權因數須由主管機關認可。

6.4.6.4 對於 6.4.6.3，如果應用 E2、E3 或 D2 試驗循環，則須使用 3.2 中規定的組合標定加權因數大於 0.5 的最少量的載荷點。

6.4.6.5 對於 6.4.6.3，如果應用 C1 試驗循環，則對每個額定、過渡和空轉部分須至少使用一個載荷點。如果船上測量點的數目與試驗台測量點數目不同，則每個載荷點的標定加權因數須按比例增加以總和取整（1.0）。

6.4.6.6 關於 6.4.6.3 的應用，有關載荷點的選擇和經修改的加權因數指南見本規則附錄 VIII 第 6 節。

6.4.6.7 為證明符合要求而使用的實際載荷點須在模式點額定功率±5%之內，但如果是 100%載荷，範圍須是+0-10%。例如，75%載荷點的可接受範圍須為額定功率的 70%-80%。

6.4.6.8 在每個選定的載荷點（空轉除外），並在最初轉換期之後（如適用），發動機功率須以 10 分鐘的間隔期在 5%偏差係數（%C.O.V.）內的載荷設定點予以保持。此偏差係數的計算實例見本規則附錄 VIII 第 7 節。

6.4.6.9 關於 C1 試驗循環，空轉轉速限度須申報，並經主管機關認可。

6.4.7 *試驗條件參數*

6.4.7.1 5.2.1 規定的試驗條件參數不適用於船上氮氧化物監測。任何現行環境條件下的數據均可接受。

6.4.8 *分析儀使用性能*

6.4.8.1 分析設備須按製造廠的建議操作。

6.4.8.2 測量前須檢查零位和量程值，必要時須對分析儀進行調整。

6.4.8.3 測量後須核實分析儀的零位和量程值在 5.9.9 的許可範圍內。

6.4.9 *排放計算數據*

6.4.9.1 在試驗過程和所有響應檢查（零位和量程）過程中分析儀的輸出須予以記錄。該數據須記錄在 1 台條圖記錄器或其他型式的數據記錄裝置上。數據記錄精度須符合 5.9.7.1 的要求。

6.4.9.2 對於氣體排放評估，須對每個載荷點的 10 分鐘穩定取樣間隔的至少 1Hz 圖形讀數作平均。NO_X 和 CO_2（如要求）和 CO、HC 及 O_2（可選）的平均濃度須根據平均圖形讀數和相應的校準數據確定。

6.4.9.3 上述的 10 分鐘期內，須至少記錄排放濃度、發動機性能和環境條件數據。

6.4.10 *廢氣流量*

6.4.10.1 廢氣流量須按下列方式確定：

.1 按照 5.5.2 或 5.5.3；或

.2 按照 5.5.4 和本規則附錄 VI，不測量類設為零，c_{CO2d} 設為 0.03%。

6.4.11 *燃油成分*

6.4.11.1 為了計算濕氣體質量流量 q_{mf}，燃油成分須按下列方式之一確定：

.1 分析得出的燃油成分，碳、氫、氮和氧（可採用默認氧值）；或

.2 表 9 的默認值。

表 9

默認燃油參數

	碳	氫	氮	氧
	w_{BET}	w_{ALF}	w_{DEL}	w_{EPS}
蒸餾燃油（ISO 8217：2005，DM 級）	86.2%	13.6%	0.0%	0.0%
殘餘燃油（ISO 8217：2005，RM 級）	86.1%	10.9%	0.4%	0.0%

6.4.12 *乾/濕修正*

6.4.12.1 如果排放未按濕度基礎測量，則須根據下列方式將氣體排放濃度轉換成濕度基礎：

.1 水成分的直接測量；或

.2 根據 5.12.3 計算的乾/濕修正。

6.4.13 *氮氧化物濕度和溫度修正*

6.4.13.1 氮氧化物濕度和溫度修正須符合 5.12.4。須標明參照增壓空氣溫度（T_{SCRef}）並經主管機關認可。T_{SCRef} 值須以 25℃海水溫度為參照，在 T_{SCRef} 值的應用中須按實際海水溫度留出餘量。

6.4.14 *排放流量和具體排放量的計算*

6.4.14.1 排放流量和具體排放量的計算須符合 5.12.5 和 5.12.6。

6.4.15 *限值和容許公差*

6.4.15.1 在應用 6.4.6.3 時，經主管機關認可，對獲取的排放值須作如下修正：

$$\text{經修正的 } gas_x = gas_x \cdot 0.9 \quad (21)$$

6.4.15.2 須酌情使用排放值 gas_x 或經修正的 gas_x 和第 13 條規定的的氮氧化物排放限值以及 6.3.11.1、6.3.11.2 和 6.3.11.3 的容許偏差值進行比較以核實發動機繼續符合第 13 條的要求。

6.4.16 *證明符合要求的數據*

6.4.16.1 在換證檢驗、年度檢驗和中間檢驗時或按 1.3.2 做了實質性改裝後，需要求證明符合要求。根據 2.4.5，數據必須是現時的；即 30 天內的。數據須在船上保存至少三個月。這些時間段須被看作是船舶在營運的時期。30 天內的數據可在一次試驗序列中從全部所要求的載荷點收集，或者當發動機載荷與 6.4.6 的要求相符的兩個或更多的不同時機獲取。

6.4.17 *認可格式*

6.4.17.1 直接測量和監測方法須記錄在船上監測手冊中。船上監測手冊須提交主管機關認可。船上監測手冊的認可參照須填入 EIAPP 證書附件第 3 節。如該方法在首次簽發 EIAPP 證書後獲得認可，即在前期發證檢驗之後，主管機關可簽發新的 EIAPP 證書，並對附件第 3 節中的細節作出適當修正。

6.4.18 *設備和方法的檢驗*

6.4.18.1 對直接測量和監測方法的檢驗須考慮但不限於：

.1 通過所要求的測量而獲得和產生的數據；以及

.2 獲取數據的方式，考慮到 6.4.14 要求的船上監測手冊中提供的資料。

第 7 章

現有發動機的發證

7.1 如現有發動機須符合第 13.7 條，負責獲得排放證書的實體須向認可主管機關申請發證。

7.2 如果對認可方法的認可申請中包括排放測量和計算，則須符合第 5 章的要求。

7.3 從一台發動機獲取的排放和性能數據可表明能適用於一系列發動機。

7.4 為符合第 13.7 條所採取的經認可的方法須包括該經認可的方法之檔案副本，且要求該副本須伴隨發動機的整個船上使用期限。

7.5 發動機船上核實程序的描述須包括在經認可的方法之檔案中。

7.6 經認可的方法安裝後，須按照經認可的方法之檔案進行檢驗。如檢驗證實符合要求，主管機關須對船舶的 IAPP 證書做出相應修改。

附錄 I

EIAPP 證書格式

（*參閱《2008 年氮氧化物技術規則》2.2.10*）

發動機國際防止空氣污染證書

本證書係根據經 2008 年 MEPC.176（58）號決議修正的修訂《經 1978 年議定書修訂的〈1973 年國際防止船舶造成污染公約〉》的 1997 年議定書（以下簡稱本公約）的規定，

經……………………………………………………………國政府授權，

（*國家全稱*）

由……………………………………………………………………簽發。

（*經按本公約規定授權的適任組織或個人全稱*）

發動機製造廠	**型號**	**序號**	**試驗循環**	**額定功率（kW）和轉速（rpm）**	**發動機認可號**

茲證明：

1 上述船用柴油發動機已按照本公約附則 VI 定為強制性的《2008 年船用柴油發動機氮氧化物排放控制技術規則》的要求進行了前期發證檢驗；及

2 前期發證檢驗表明，在其船上安裝和/或運行之前，該發動機，其構件、可調特性及技術檔案完全符合本公約附則 VI 第 13 條的適用規定。

在本政府管轄下的船舶上安裝，並按照本公約附則 VI 第 5 條的規定接受檢驗的發動機使用期內，本證書有效。

簽發於：

…………………………………………………………………………………………

（*簽發證書地點*）

（年/月/日）：……………… ……………………………………

（*簽發日期*） （*經正式授權的發證官員簽字*）

（*主管當局蓋章或鋼印*）

發動機國際防止空氣污染證書（EIAPP 證書）附頁

結構、技術檔案及核實方法記錄

註：

1 本記錄及其附件須永久附於 EIAPP 證書之後。EIAPP 證書須伴隨該柴油發動機整個使用壽命並須一直保存在船上。

2 本記錄須至少為英文、法文或西班牙文。如果還使用了發證國的官方文字，在出現爭議或不一致時，以發證國的官方文字為準。

3 除另有明文規定外，本記錄所述各條係指本公約附則 VI 的各條，發動機的技術檔案和核實方法的要求係指《2008 年氮氧化物技術規則》中的強制性要求。

1 發動機資料

1.1 製造廠名稱和地址……………………………………………………

1.2 發動機製造地點……………………………………………………

1.3 發動機製造日期……………………………………………………

1.4 前期發證檢驗地點…………………………………………………

1.5 前期發證檢驗日期…………………………………………………

1.6 發動機類型及型號…………………………………………………

1.7 發動機序號…………………………………………………………

1.8 如適用，該發動機是一台：母型機 或下列發動機族 或發動機組 的成員機 …………………………

1.9 單機或發動機族/發動機組的詳細資料：……………………………

1.9.1 認可參考………………………………………………………………

1.9.2 額定功率（kW）及額定轉速（rpm）值或範圍……………………

1.9.3 試驗循環………………………………………………………………

1.9.4 母型機試驗燃油規格………………………………………………

1.9.5 適用的氮氧化物排放限值（g/kWh），第 13.3、13.4 或 13.5 條（不適用者刪除）………………………………………………………

1.9.6 母型機排放值（g/kWh）……………………………………………

2 技術檔案資料

按照《2008 年氮氧化物技術規則》第 2 章的要求，技術檔案是 EIAPP 證書的重要組成部分且必須一直伴隨發動機的整個使用壽命並一直保存在船上。

2.1 技術檔案標識號/認可號……………………………………………

2.2 技術檔案認可日期…………………………………………………

3 船上氮氧化物核實程序技術規範

《2008 年氮氧化物技術規則》第 6 章所要求的船上氮氧化物核實程序技術規範是 EIAPP 證書的重要組成部分且必須一直伴隨發動機的整個使用壽命並一直保存在船上。

3.1 發動機參數檢查法：

3.1.1 標識號/認可號……………………………………………………

3.1.2 認可日期…………………………………………………………

3.2 直接測量和監測法：

3.2.1 標識號/認可號……………………………………………………

3.2.2 認可日期…………………………………………………………

作為替代，可使用符合《2008 年氮氧化物技術規則》的 6.3 的簡化測量方法。

簽發於：

………………………………………………………………………………………………

（簽發證書地點）

（年/月/日）：……………… ……………………………………

（簽發日期） *（正式授權發證官員簽字）*

（主管當局蓋章或鋼印）

附錄 II

船用柴油發動機檢驗和發證流程圖

（參閱《2008 年氮氧化物技術規則》2.2.9 和 2.3.11）

本附錄的圖 1、圖 2 和圖 3 給出了本規則第 2 章闡述的符合船用柴油發動機檢驗和發證的指南：

圖 1： 製造廠設施中前期發證檢驗

圖 2： 船上初次檢驗

圖 3： 船上換證、年度或中間檢驗

註：這些流程圖並未顯示第 13.7 條要求的現有發動機發證標準。

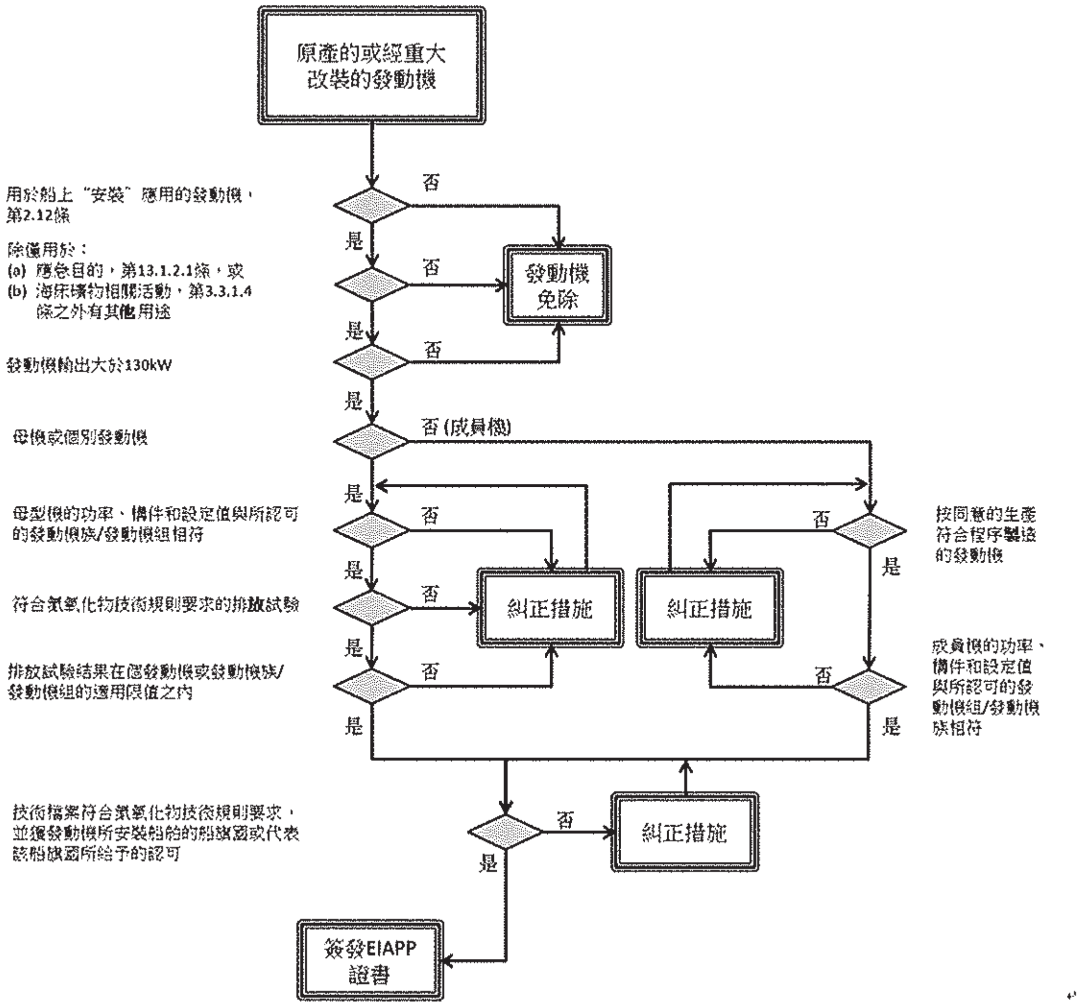
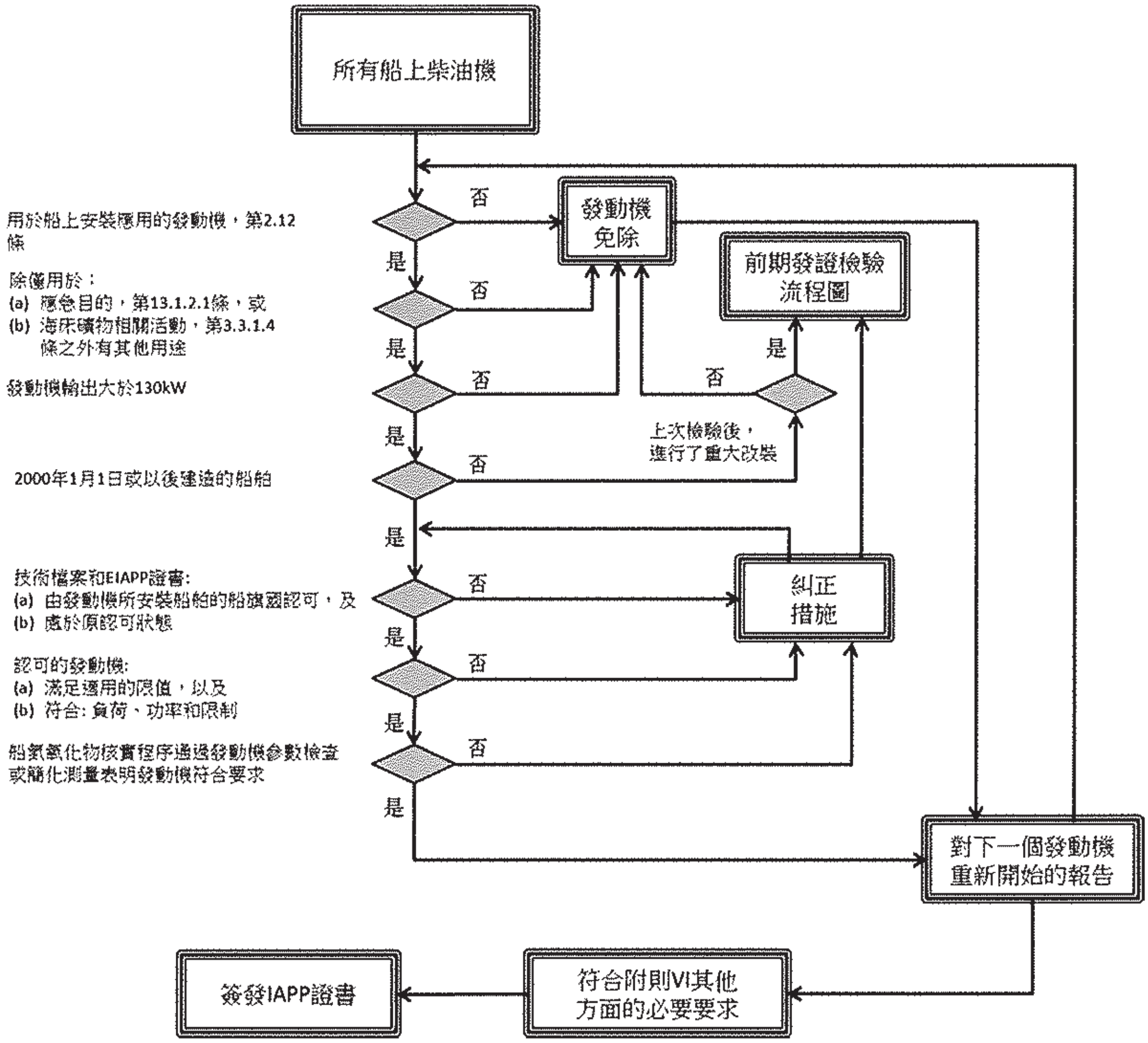


圖 1-製造廠設施中前期發證檢驗



所有船上柴油機
用於船上安裝應用的發動機，第2.12條
除僅用於：
(a) 應急目的，第13.1.2.1條，或
(b) 海床礦物相關活動，第3.3.1.4條之外有其他用途
發動機輸出大於130kW
2000年1月1日或以後建造的船舶
技術檔案和EIAPP證書:
(a) 由發動機所安裝船舶的船旗國認可，及
(b) 處於原認可狀態
認可的發動機:
(a) 滿足適用的限值，以及
(b) 符合: 負荷、功率和限制
船氮氧化物核實程序通過發動機參數檢查或簡化測量表明發動機符合要求
是
否
發動機免除
前期發證檢驗流程圖
上次檢驗後，進行了重大改裝
糾正措施
對下一個發動機重新開始的報告
符合附則VI其他方面的必要要求
簽發IAPP證書

圖 2-船上初次檢驗

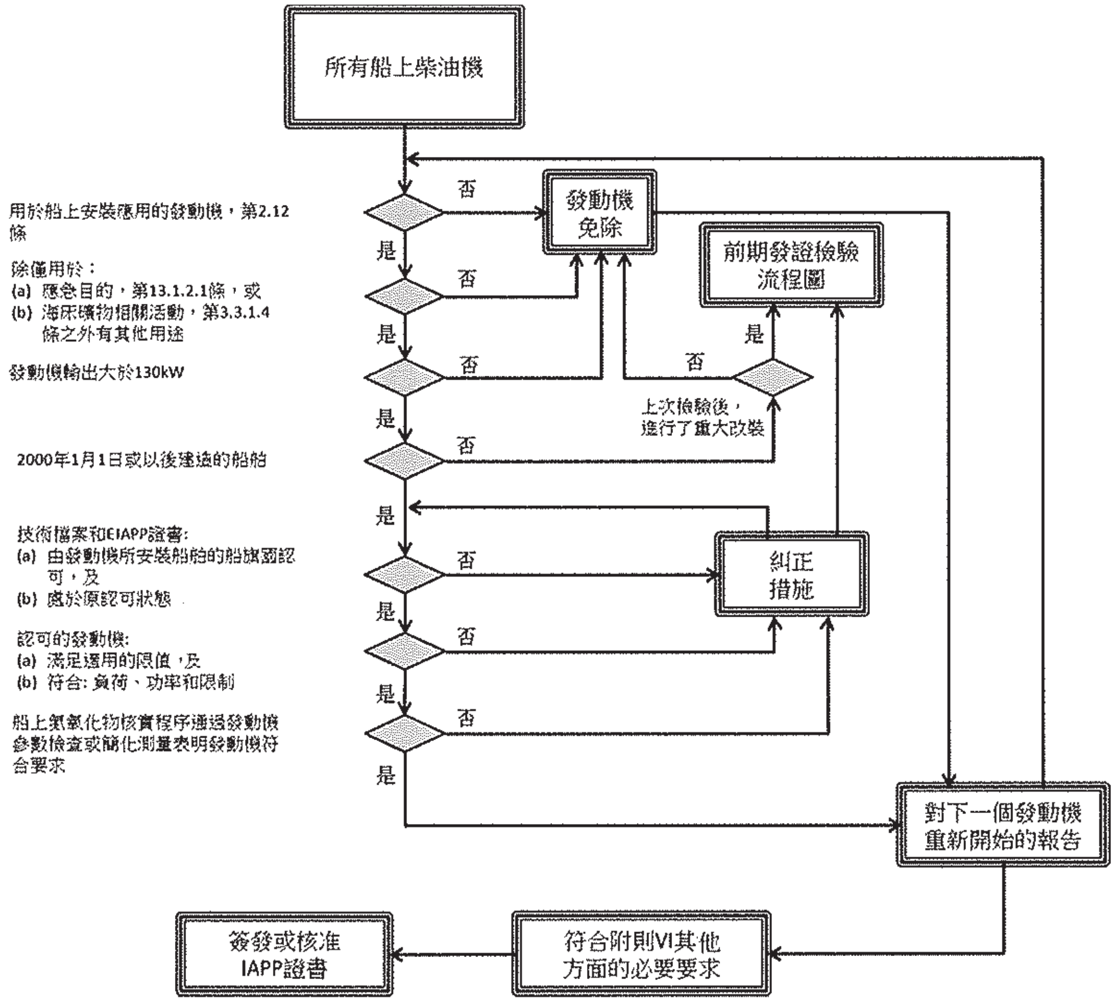


圖 3-船上換證、年度或中間檢驗

附錄 III

用於確定船用柴油發動機排放氣體成分的分析儀技術規範

（參閱《2008 年氮氧化物技術規則》第 5 章）

1 通則

1.1 用於確定 CO、CO_2、NO_X、HC 和 O_2 濃度的廢氣分析系統中所包括的構成部分見圖 1。取樣氣道上的所有構件須維持各系統的規定溫度。

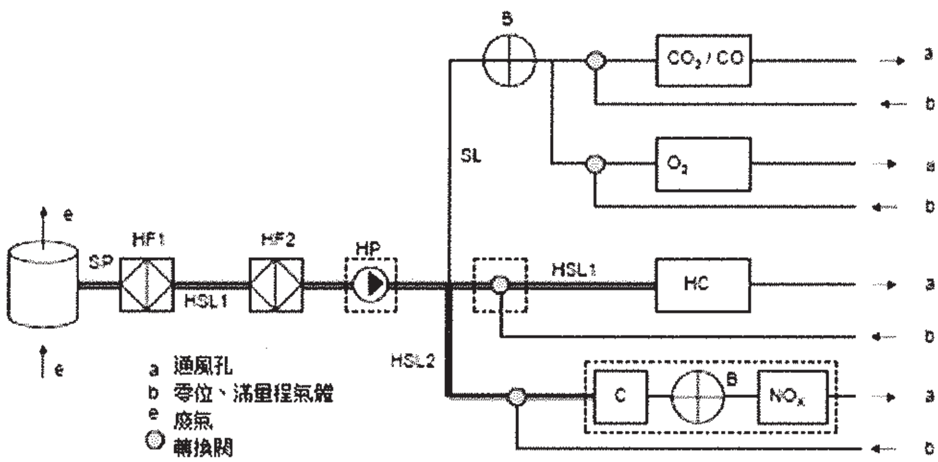


圖 1-廢氣分析系統的佈置

1.2 廢氣分析系統須包括下列部件。根據本規則第 5 章，經主管機關認可的等效佈置和部件可以接受。

.1 SP－原始廢氣取樣管

一末端封閉的不鏽鋼多孔直管。內直徑須不大於取樣管路的內直徑。管壁厚度不應大於 1 毫米。在 3 個不同徑

向平面內須至少有 3 個孔，其大小能夠對大致相同流量進行取樣。

原始廢氣所有成分的試樣可以使用 1 隻取樣管或用 2 隻位置極為接近並內部分至不同分析儀的取樣管採集。

註：如果廢氣脈動或發動機震動可能影響取樣管，經主管機關認可，壁厚可增大。

.2 HSL1－加熱取樣管路

取樣管路通過單一取樣管向分離點和 HC 分析儀提供氣體試樣。取樣管路須由不鏽鋼或聚四氟乙烯（PTFE）製成，其內直徑至少為 4 毫米，至多為 13.5 毫米。

取樣管處的廢氣溫度須不低於 190℃。取樣點至分析儀的廢氣溫度須使用加熱過濾器和管壁溫度為 190℃±10℃的加熱傳輸管路予以維持。

如果取樣管處的廢氣溫度高於 190℃，管壁溫度須維持在 180℃以上。

在加熱的過濾器和 HC 分析儀之前須維持 190℃±10℃的氣體溫度。

.3 HSL2－加熱氮氧化物取樣管路

取樣管路須由不鏽鋼或 PTFE 製成，如使用冷卻裝置 B，至轉換器 C 前，如不使用冷卻裝置 B，至分析儀前，管壁溫度須維持在 55℃至 200℃度。

.4 HF1－加熱預過濾器（可選）

所要求的溫度與 HSL1 相同。

.5 HF2－加熱過濾器

過濾器須在分析儀之前從氣體試樣中濾出任何固體顆粒。溫度須與 HSL1 的溫度相同。過濾器須按需更換。

.6 HP－加熱取樣泵（可選）

泵須加熱至 HSL1 的溫度。

.7 SL－CO、CO_2 和 O_2 取樣管路

管路須由 PTFE 或不鏽鋼製成，可加熱或不加熱。

.8 CO_2/CO－二氧化碳和一氧化碳分析儀

無彌散紅外（NDIR）吸收。可為不同的分析儀，或單個分析儀裝置中整合兩項功能。

.9 HC－碳氫化合物分析儀

加熱式火焰離子探測器（HFID）。溫度須保持在 180℃至 200℃。

.10 NO_X－氮氧化物分析儀

化學熒光探測器（CLD）或加熱式化學熒光探測器（HCLD）。如使用 HCLD，溫度須保持在 55℃至 200℃。

註：在所示佈置中氮氧化物以乾基測量。氮氧化物也可以濕基測量，在此情況下分析儀須為 HCLD 型式。

.11 C－轉換器

在 CLD 或 HCLD 中進行分析之前，須使用轉換器將 NO_2 催化還原成 NO。

.12 O_2－氧分析儀

順磁探測器（PMD）、二氧化鋯傳感器（ZRDO）或電化傳感器（ECS）。

註：在所示佈置中 O_2 以乾基測量。O_2 也可以濕基測量，在此情況下分析儀須為 ZRDO 型式。

.13 B－冷卻裝置

冷卻和冷凝廢氣試樣中的水分。冷卻器的溫度須通過冰或製冷機維持在 0℃至 4℃。如果水分通過冷凝去除，須在脫水器內或下游監測氣體試樣的溫度或露點。氣體試樣的溫度或露點不得超過 7℃。

1.3 分析儀須具有與所測廢氣成分濃度所需精度相稱的測量範圍（見 1.6 和本規則 5.9.7.1）。建議分析儀的操作須使所測量的濃度落在滿刻度的 15%和 100%之間，滿刻度係指所用的測量範圍。

1.4 如果滿刻度是 155ppm（或 ppmC）或更少，或如果使用在滿刻度的 15%以下具有足夠的精確度和清晰度讀數系統（計算機，數據記錄器），在滿刻度 15%以下的濃度也可以接受。在這種情況下須進行補充校準以確保校準曲線精確度。

1.5 設備的電磁兼容性（EMC）須能將附加誤差減至最低限度。

1.6 精確度

1.6.1 定義

ISO 5725-1：1994/Cor1：1998，測試方法與結果的精確度（正確度與精密度）－第 1 部分：基本原理與定義，技術勘誤 1。

ISO 5725-2：1994，測試方法與結果的精確度（正確度與精密度）－第 2 部分：測定標準測試方法的重複性和可再現性的基本方法。

1.6.2 分析儀與標定校準點的偏差不得超過整個測量範圍（零位除外）讀數的±2%，或者滿刻度的±0.3%（取大者）。精確度須按本規則附錄 IV 第 5 節的校準要求確定。

1.7 精密度

精密度，定義為對校準或量程氣體的 10 次重複響應的標準偏差的 2.5 倍，對於每個用於 100ppm（或 ppm C）以上的範圍，須不超過滿刻度濃度的±1%或對於每個用於 100ppm（或 ppm C）以下的範圍，須不超過±2%。

1.8 噪聲

分析儀對零位和校準或量程氣體在任一 10 秒期間內的峰間響應，不得超過所有所用範圍滿刻度的 2%。

1.9 零位漂移

零位響應的定義為 30 秒間隔期內對零位氣體的平均響應（包括噪聲）。1 小時期間內的零位響應漂移須小於所用最低範圍滿刻度的 2%。

1.10 量程漂移

量程響應的定義為在 30 秒間隔期內對量程氣體的平均響應（包括噪聲）。在最低使用範圍 1 小時期間內的量程響應漂移須小於所用最低範圍滿刻度的 2%。

2 氣體乾燥

廢氣可乾測或濕測。如使用，須使用對測量氣體成分影響最小的氣體乾燥裝置。用化學乾燥劑從試樣中除去水分的方法是不能接受的。

3 分析儀

3.1 至 3.5 節闡述了應使用的測量原則。待測量的氣體須用下列儀器予以分析。對非線性分析儀，允許使用線性化電路。

3.1 一氧化碳（CO）分析

一氧化碳分析儀須為無彌散紅外（NDIR）吸收型。

3.2 二氧化碳（CO_2）分析

二氧化碳分析儀須為無彌散紅外（NDIR）吸收型。

3.3 碳氫化合物（HC）分析

碳氫化合物分析儀須為加熱式火焰離子探測器（HFID）型，並對探測器、閥門、管路和相關部件加熱使氣體溫度維持在 190℃±10℃。

3.4 氮氧化物（NO_X）分析

如果為乾基測量，氮氧化物分析儀須為化學熒光探測器（CLD）或配有 NO_2/NO 轉換器的加熱式化學熒光探測器（HCLD）。

如果為濕基測量，須採用保持在 55℃以上的配有轉換器的 HCLD，但要水淬檢查合格(見本規則附錄 IV 第 9.2.2 節)。對於 CLD 和 HCLD，乾測時至轉換器和濕測時至分析儀的氣道管壁溫度須維持在 55℃至 200℃。

3.5 氧（O_2）分析

氧分析儀須為順磁性探測器（PMD），二氧化鋯型（ZRDO）或電化傳感器型（ECS）。

附錄 IV

分析和測量儀器的校準

（參閱《2008 年氮氧化物技術規則》第 5 和 6 章）

1 引言

1.1 用以測量發動機參數的每一台分析儀須按照本附錄的要求儘可能經常地進行校準。

1.2 除另有明文規定外，所有本附錄所要求的測量結果、試驗數據或計算須按本規則 5.10 節的規定記錄在發動機試驗報告中。

1.3 *測量儀器的精確度*

1.3.1 所有測量儀器的校準須符合表 1、2、3 和 4 中列出的要求且須符合主管機關認可的標準。主管機關可要求附加的發動機測量，所使用的附加測量儀器須符合適當的偏差標準和校準有效期限。

1.3.2 儀器須作如下校準：

.1 時間間隔不得大於表 1、2、3 和 4 規定的間隔期；或

.2 符合替代的校準程序和有效期限，但相關提議須在試驗前提交主管機關並獲認可。

註： 表 1、2、3 和 4 中給出的偏差係指最終記錄值，包括數據獲取系統在內。

表 *1*

試驗台上發動機相關參數測量

儀器的允許偏差和校準有效期

編號	測量儀器	允許偏差	校準有效期（月）
1	發動機轉速	讀數的±2%或發動機最大值的±1%（取大者）	3
2	扭矩	讀數的±2%或發動機最大值的±1%（取大者）	3
3	功率 （直接測量）	讀數的±2%或發動機最大值的±1%（取大者）	3
4	燃料消耗	發動機最大值的±2%	6
5	空氣消耗	讀數的±2%或發動機最大值的±1%（取大者）	6
6	廢氣流量	讀數的±2.5%或發動機最大值的±1.5%（取大者）	6

表 2

試驗台上其他重要參數測量

儀器的允許偏差和校準間隔期

編號	測量儀器	允許偏差	校準有效期（月）
1	溫度≤327℃	±2℃絕對值	3
2	溫度＞327℃	讀數的±1%	3
3	廢氣壓力	±0.2kPa 絕對值	3
4	增壓空氣壓力	±0.3kPa 絕對值	3
5	大氣壓力	±0.1kPa 絕對值	3
6	其他壓力≤1000kPa	±20kPa 絕對值	3
7	其他壓力＞1000kPa	讀數的±2%	3
8	相對濕度	±3%絕對值	1

表 3

已獲前期發證的發動機船上發動機

相關參數測量儀器的允許偏差和校準有效期

編號	測量儀器	允許偏差	校準有效期（月）
1	發動機轉速	發動機最大值的±2%	12
2	扭矩	發動機最大值的±5%	12
3	功率（直接測量）	發動機最大值的±5%	12
4	燃料消耗	發動機最大值的±4%	12
5	空氣消耗	發動機最大值的±5%	12
6	廢氣流量	發動機最大值的±5%	12

表 4

已獲前期發證的發動機船上其他重要

參數測量儀器的允許偏差和校準有效期

編號	測量儀器	允許偏差	校準有效期（月）
1	溫度≤327℃	±2℃絕對值	12
2	溫度＞327℃	±15℃絕對值	12
3	廢氣壓力	發動機最大值的±5%	12
4	增壓空氣壓力	發動機最大值的±5%	12
5	大氣壓力	讀數的±0.5%	12
6	其他壓力	讀數的±5%	12
7	相對濕度	±3%絕對值	6

2 校準氣體和零位與量程檢查氣體

須遵守所有校準氣體和零位與量程檢查氣體的安全儲存期限。生產廠聲明的校準氣體和零位與量程檢查氣體的有效期須予以記錄。

2.1 *純氣體（包括零位檢查氣體）*

2.1.1 所要求的氣體純度根據下列污染限度確定。須具有下列氣體：

.1 純化氮（污染：≤l ppm C，≤l ppm CO，≤400 ppm CO_2，≤0.1 ppm NO）；

.2 純化氧（純度＞容積 99.5%的氧含量）；

.3 氫氦混和氣（40±2%氫，其餘為氦），（污染：≤l ppm C，≤400 ppm CO_2）；以及

.4 純化合成空氣（污染：≤l ppm C，≤1 ppm CO，≤400 ppm CO_2，≤0.1 ppm NO，（氧含量在容積 18-21%之間）。

2.2 *校準和量程氣體*

2.2.1 須具有下列化學成分構成的混合氣體：

.1 CO 和純化氮；

.2 NO_X 和純化氮（本校準氣體所含 NO_2 的總量不得超過 NO 含量的 5%）；

.3 O_2 和純化氮；

.4 CO_2 和純化氮；以及

.5 CH_4 和純化合成空氣或 C_3H_8 和純化合成空氣。

註：允許氣體之間不起反應的其他氣體組合。

2.2.2 校準和量程氣體的實際濃度須在標定值±2%之內。所有校準氣體的濃度須以容積為基礎給出（容積百分比或容積 ppm）。

2.2.3 用作校準和量程的氣體還可通過精密混合裝置（氣體分隔器）用純化氮或純化合成空氣稀釋方法獲得。混合裝置的精確度須使得混合的校準氣體的濃度精確在±2%的範圍之內。該精確度表明用於混合的基礎氣體的精確度須至少為±1%並符合國家或國際氣體標準。對每個包含混合裝置的校準須在滿刻度的 15%和 50%之間進行核實。另外可使用線性性質的儀器檢查混合裝置，如使用 NO 氣體進行 CLD 測量。儀器量程值須通過量程氣體與儀器直接連接進行調節。須按所使用的設定值檢查混合裝置，標定值須與儀器的測定濃度相比

較。各點的差別須在標定值的±1%之內。曾用同一氣體分隔器線性化的氣體分析儀不得用來進行該氣體分隔器的線性檢查。

2.2.4 氧干擾檢查氣體須含有碳氫化合物為 350 ppmC±75 ppmC 的丙烷或甲烷。該濃度須通過對全部碳氫化合物加雜質的色譜分析或動態排氣限定至校準氣體的公差濃度。氮須為平衡氧的主要稀釋劑。所要求的混合列於表 5 中。

表 5

氧干擾檢查氣體

O_2 濃度	平衡
21（20 至 22）	氮
10（9 至 11）	氮
5（4 至 6）	氮

3 分析儀和取樣系統的操作程序

分析儀操作程序須遵循儀器製造廠的啟動和操作說明。4 到 9 節所給出的最低要求須包括在內。

4 泄漏試驗

4.1 須進行系統泄漏試驗，測試管探頭須與排氣系統脫開並且塞住端口。開啟分析儀泵，初步穩定期之後，所有流量表的讀數須為零。如不是零，須檢查取樣管路並消除缺陷。

4.2 真空端的最大許可泄漏率須為系統被檢查部分使用流量的 0.5%。分析儀流量和旁通流量可用以估算使用流量。

4.3 另一方法是在取樣管路的起點採用從零位至量程氣體的濃度步進改變。如在適當的時間以後，讀數表上顯示的濃度低於導入的濃度，即表明有校準或泄漏問題。

4.4 其他佈置如經主管機關認可，可以接受。

5 校準程序

5.1 *儀器裝配*

儀器裝配須經校準，並用標準氣體檢查校準曲線。須使用與廢氣取樣時相同的氣體流量。

5.2 *預熱時間*

預熱時間須遵循分析儀製造廠的建議。如未規定，建議至少對分析儀預熱 2 個小時。

5.3 *NDIR 和 HFID 分析儀*

如必要，須按需調校 NDIR 分析儀。HFID 的火焰須按需優化。

5.4 *校準*

5.4.1 各常用操作範圍須經校準。分析儀用於測試之前 3 個月內或做出影響校準的系統修理或更改時須經校準，或遵循 1.3.2.2 的要求。

5.4.2 須採用純淨合成空氣（或氮），將 CO，CO_2，NO_X 和 O_2 的分析儀置零。須採用純淨合成空氣將 HFID 分析儀置零。

5.4.3 須向分析儀中注入適當的校準氣體，記錄其數值並依之制定校準曲線。

5.5 *制定校準曲線*

5.5.1 一般導則

5.5.1.1 校準曲線須通過從零至排放試驗預期最高值的操作範圍內間距大致相等的（除零以外）至少 6 個校準點加以制定。

5.5.1.2 校準曲線用最小二乘法計算。可使用最優線性或非線性等式。

5.5.1.3 校準點與最小二乘法最優線的差異須不超過讀數的±2%或滿刻度的±0.3%（取大者）。

5.5.1.4 必要時須重新檢查零位設定並重複校準程序。

5.5.1.5 如能表明替代校準方法（如：計算機，電子控制範圍開關等）具有等效精確度，則這些替代校準方法經主管機關認可後可以被採用。

6 校準驗證

6.1 每次分析前，須根據下列程序對各常用操作範圍進行檢查：

.1 須用零位氣體和標定值大於測量範圍滿刻度 80%的量程氣體檢查校準；及

.2 對所考慮的 2 個點，如其值與申報的參照值的差異不超過滿刻度的±4%，則可修改調整參數。如非如此，須按照上述 5.5 的規定制定新的校準曲線。

7 NO_X 轉換器的效率試驗

用於將 NO_2 轉換成 NO 的轉換器，其效率須根據下述 7.1 至 7.10 進行試驗。

7.1 *試驗裝置*

使用圖 1 所示的試驗裝置和下述程序，須用臭氧發生器對轉換器的效率進行試驗。

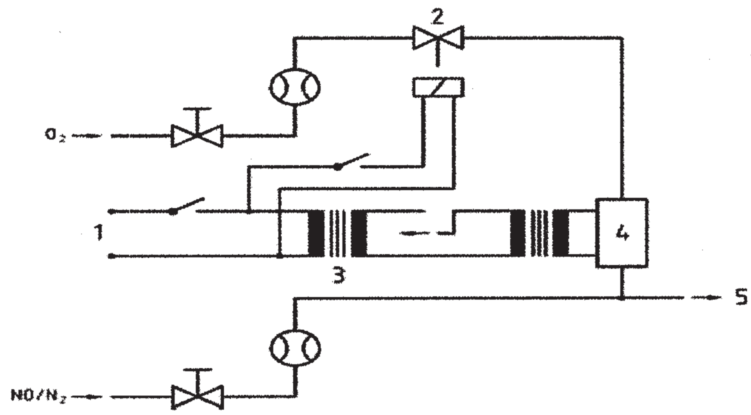


圖 *1*－二氧化氮轉換器效率裝置原理圖

1 交流電

2 電磁閥

3 自耦調壓器

4 臭氧發生器

5 至分析儀

7.2 *校準*

須在最通用的操作範圍內按照製造廠的技術規範，使用零位氣體和量程氣體（其 NO 含量須佔操作範圍的約 80%且混和氣體的 NO_2 濃度小於 NO 濃度的 5%）對 CLD 和 HCLD 進行校準。氮氧化物分析儀必須置於 NO 模式使量程氣體不通過轉換器。所顯示的濃度須予以記錄。

7.3 *計算*

須按下列方式計算氮氧化物轉換器的效率：

3. $$E_{NOx} = \left(1 + \frac{a-b}{c-d}\right) \cdot 100 \qquad (1)$$

式中：

a = 符合下述 7.6 要求的氮氧化物濃度

b = 符合下述 7.7 要求的氮氧化物濃度

c = 符合下述 7.4 要求的一氧化氮濃度

d = 符合下述 7.5 要求的一氧化氮濃度

7.4 *氧的加入*

7.4.1 經由一個 T 型附件，將氧氣或零空氣連續不斷地加入到氣流中直至所顯示的濃度約小於上述 7.2 所給定的指示校準濃度的 20%時為止。該分析儀必須置於一氧化氮模式。

7.4.2 對所示濃度（c）須予以記錄。在整個過程中臭氧發生器必須處於關閉狀態。

7.5 *臭氧發生器的啟動*

然後須啟動臭氧發生器產生足量的臭氧，以使一氧化氮濃度降至約為上述 7.2 所給定的校準濃度的 20%（最小 10%）。所示的濃度（d）須予以記錄。分析儀須置於一氧化氮模式。

7.6 *NO_X 模式*

然後須將一氧化氮分析儀轉換到氮氧化物模式，使得混和氣體（由 NO，NO_2，O_2 和 N_2 構成）通過轉換器。所示濃度（a）須予以記錄。分析儀須置於氮氧化物模式。

7.7 *關閉臭氧發生器*

然後關閉臭氧發生器。上述 7.6 所述的混合氣體通過轉換器進入探測器。所示濃度（*b*）須予以記錄。分析儀置於氮氧化物模式。

7.8 *一氧化氮模式*

在臭氧發生器關閉狀態下轉換到一氧化氮模式，同時還須切斷氧氣或合成空氣氣流。分析儀的氮氧化物讀數與按照上述 7.2 規定所測定的數值的偏差不得大於±5%。分析儀必須置於一氧化氮模式。

7.9 試驗間隔期

每次校準氮氧化物分析儀之前，均須對轉換器的效率進行試驗。

7.10 *效率要求*

轉換器的效率不得小於 90%。

8 HFID 的調整

8.1 *探測器響應的優化*

8.1.1 HFID 須按照儀器製造廠的規定進行調整。須使用含有丙烷的空氣量程氣體對最通用的操作範圍的響應進行優化。

8.1.2 當燃料和空氣流量設定於製造廠的建議值時，須將 350±75 ppmC 的量程氣體導入分析儀。給定燃油流量的響應須根據量程氣體和零位氣體的響應之差加以確定。該燃料流量須在製造廠技術規範之上和之下予以增量調整。這些燃料流量的量程和零位響應需加以記錄。量程和零位響應之間的差別須予以標繪，並對燃料流量按曲線的密集面進行調整。此係初始的流量設定，根據 8.2 和 8.3 的碳氫化合物響應係數和氧干擾檢查的結果可能需要進一步優化。

8.1.3　如果氧干擾或碳氫化合物響應係數不能滿足下述規範，空氣流量須在製造廠技術規範之上和之下予以增量調整（8.2 和 8.3 的每一流量）。

8.1.4　經主管機關認可，可使用替代程序進行優化。

8.2　*碳氫化合物響應係數*

8.2.1　須按第 5 節使用含有丙烷的空氣和純化合成氣體校準分析儀。

8.2.2　初次使用分析儀之前和較大使用間隔之後，須對響應係數加以確定。某一特定種類的碳氫化合物的響應係數（r_h）為 HFID ppmC 讀數和以 ppmC 表示的氣瓶中氣體濃度的比率。

8.2.3　試驗氣體的濃度水平須能給出滿刻度的約 80%的響應。濃度的已知精確度須為以按容積表示的比重測定標準為參照的±2%之內。此外，氣瓶須在 25℃±5℃的溫度下進行 24 小時的預處理。

8.2.4　使用的試驗氣體和建議的相對響應係數範圍如下：

- 甲烷和純淨合成氣體 $1.00 \leq r_h \leq 1.15$
- 丙烯和純淨合成氣體 $0.90 \leq r_h \leq 1.1$
- 甲苯和純淨合成氣體 $0.90 \leq r_h \leq 1.1$

這些數值與丙烷和純淨合成氣體的 r_h 值為 1 相對應。

8.3　*氧干擾檢查*

8.3.1　初次使用分析儀之前和較大使用間隔之後，須對氧干擾檢查加以確定。

8.3.2 須選擇氧干擾檢查氣體位於上 50%的範圍。進行試驗時爐的溫度須按要求設置。氧干擾氣體的規定在 2.2.4 中。

.1 分析儀須置零。

.2 分析儀須用 21%氧混合氣體設定量程。

.3 須重新檢查零位響應。如果變化超過滿刻度（FS）的 0.5%，須重複 8.3.2.1 和 8.3.2.2。

.4 須導入 5%和 10%的氧干擾檢查氣體。

.5 須重新檢查零位響應。如果變化超過滿刻度的±1%，須重複試驗。

.6 對步驟.4 中的每一混合氣體須按如下公式計算氧干擾（$\%O_2I$）：

$$\%O_2I = \frac{(B - \text{分析儀響應})}{B} \cdot 100 \qquad (2)$$

式中：

分析儀響應為（A 的 A/%FS）·（B 的%FS）

式中：

A = 8.3.2.2 所用量程氣體的碳氫化合物濃度，ppmC（百萬分之一升）

B = 8.3.2.4 所用氧干擾檢查氣體的碳氫化合物濃度（ppmC）

$$(ppmC) = \frac{A}{D} \qquad (3)$$

D = A 引起的分析儀響應的滿刻度百分比

.7 試驗前所要求的全部氧干擾檢查氣體的氧氣干擾（$\%O_2I$）%須小於±3.0%。

.8 如果氧干擾大於 3.0%，空氣流量須在製造廠技術規範之上和之下予以增量調整，對每一流量重複 8.1。

.9 如果調整空氣流之後氧干擾大於±3.0%，須改變燃料流量及此後的取樣流量，對每一新設定值重複 8.1。

.10 如果氧干擾仍然大於±3.0%，在試驗之前須修理或更換分析儀、HFID 燃料或燃燒器空氣。然後使用修理或更換的儀器或氣體重複本條。

9 CO，CO_2，NO_X 和 O_2 分析儀的干擾效應

除被分析的氣體外，其他氣體可能以多種方式干擾讀數。如果干擾氣體和被測量的氣體具有相同但程度較小的效應，則在 NDIR 和 PMD 儀器中發生正干擾。在 NDIR 儀器中由於干擾氣體增寬被測量氣體的吸收帶，和在 CLD 儀器中由於干擾氣體抑制發散均發生負干擾。下述 9.1 和 9.2 的干擾檢查須在分析儀初次使用前和較大使用間隔之後進行，但至少一年一次。

9.1 CO 分析儀的干擾檢查

水和 CO_2 可干擾 CO 分析儀的性能。因此，濃度為試驗中所用最大操作範圍滿刻度 80%到 100%的 CO_2 量程氣體，須在室溫下從水中氣泡式通過，並記錄分析儀的響應。對於使用範圍大於或等於

300 ppm 者，分析儀的響應不得大於滿刻度的 1%，而低於 300 ppm 者，則不得大於 3 ppm。

9.2 *氮氧化物分析儀抑制檢查*

對 CLD（和 HCLD）分析儀有影響的二種氣體是 CO_2 和水蒸氣。對這些氣體的抑制響應與其濃度成正比，因此，需要以試驗方法來確定在試驗過程中最高預期濃度下的抑制。

9.2.1 CO_2 抑制檢查

9.2.1.1 具有濃度為最大操作範圍滿刻度的 80%到 100%的 CO_2 量程氣體須通過 NDIR 分析儀，將該 CO_2 值記錄為 *A*。然後用 NO 量程氣體將它稀釋到約 50%且通過 NDIR 和（H）CLD，將該 CO_2 和 NO 值分別記錄為 B 和 C。然後關閉 CO_2，僅讓 NO 量程氣體通過（H）CLD，將該 NO 值記錄為 D。

9.2.1.2 對抑制須作如下計算：

$$E_{CO2} = \left[1 - \left(\frac{(C \cdot A)}{(D \cdot A) - (D \cdot B)}\right)\right] \cdot 100 \qquad (4)$$

式中：

A = 用 NDIR 測量的未經稀釋的 CO_2 濃度，容積百分比；

B = 用 NDIR 測量的經稀釋的 CO_2 濃度，容積；

C = 用（H）CLD 測量的經稀釋的 NO 濃度，ppm；以及

D = 用（H）CLD 測量的未經稀釋的 NO 濃度，ppm。

9.2.1.3 稀釋和量化 CO_2 和 NO 量程氣體值的替代方法，如動態混和/調合法，亦可採用。

9.2.2 水抑制檢查

9.2.2.1 這種檢查僅適用於濕氣體濃度測量。水抑制計算須考慮到試驗過程中水蒸氣對NO量程氣體的稀釋以及混合氣體的水蒸氣濃度與期望值的比例。

9.2.2.2 濃度為正常操作範圍滿刻度 80%到 100%的 NO 量程氣體須通過 HCLD 並將該 NO 值記錄為 D。之後，該 NO 量程氣體須在 25℃±5℃的室溫下從水中水泡式通過後再通過 HCID，將該 NO 值記錄為 C。水溫須予確定並記錄為 F。與發泡水的溫度（F）相應的混和氣體的飽和蒸氣壓力須予以確定並記錄為 G。混合氣體的水蒸氣濃度（H 以%表示）須按下式進行計算：

$$H = 100 \cdot \left(\frac{G}{P_b}\right) \tag{5}$$

預期稀釋的 NO 滿量程氣體（在水蒸氣中）濃度（D_e）須按下式進行計算：

$$D_e = D \cdot \left(1 - \frac{H}{100}\right) \tag{6}$$

對於柴油發動機的廢氣，在試驗過程中預期的最大廢氣水濃度（用%），須在燃料的原子 H/C 比為 1.8/1 的假定條件下，根據廢氣中最大 CO_2 濃度（A）作如下估算：

$$H_m = 0.9 \cdot A \tag{7}$$

並記錄 H_m。

9.2.2.3 水抑制須按下式計算：

$$E_{H2O} = 100 \cdot \left(\frac{D_e - C}{D_e} \right) \cdot \left(\frac{H_m}{H} \right) \qquad (8)$$

式中：

D_e = 預期經稀釋的 NO 濃度，ppm；

C = 經稀釋的 NO 濃度，ppm；

H_m = 最大水蒸氣濃度，%；和

H = 實際水蒸氣濃度，%。

註： 本項檢查中，NO 量程氣體包含最小的 NO_2 濃度很重要，因為在抑制計算中，對 NO_2 的水中吸收未做考慮。

9.2.3 最大允許抑制

最大允許抑制須為：

.1 根據 9.2.1 的 CO_2 抑制：滿刻度的 2%

.2 根據 9.2.2 的水抑制：滿刻度的 3%。

9.3 *O_2 分析儀干擾*

9.3.1 由氧氣以外的氣體造成的 PMD 分析儀的儀器響應是相當小的，普通廢氣成分的氧當量示於表 6 之中。

表 *6*

氧當量

氣體	O2 當量%
二氧化碳（CO2）	-0.623
一氧化碳（CO）	-0.354

一氧化氮（NO）	+44.4
二氧化氮（NO2）	+28.7
水（H2O）	-0.381

9.3.2 對實測的氧濃度須用下列公式進行修正：

$$E_{O2} = \frac{\left(O_2\text{當量} \cdot c_{\text{觀測}}\right)}{100} \quad (9)$$

9.3.3 對於 ZRDO 和 ECS 分析儀，氧以外的氣體造成的儀器干擾，須按照製造廠的建議和良好的技術操作進行校正。電氣化學傳感器須針對 CO_2 和 NO_X 的干擾進行校正。

附錄 V

母型機試驗報告和實驗數據

（參照《2008 年氮氧化物技術規則》2.4.1.5 和 5.10）

第 1 節-母型機試驗報告-見本規則 5.10

排放試驗報告編號.......... **表 1/5**

發動機：	
製造廠	
機型	
發動機族或發動機組標識	
序號	
額定轉速	rpm
額定功率	kW
中間轉速	rpm
中間轉速的最大扭矩	Nm
靜態噴射定時	壓縮空氣度（deg）在止點前
電子噴射控制	否： 是：
可變噴射定時	否： 是：
可變渦輪增壓器幾何構形	否： 是：
氣缸內徑	mm
衝程	mm
標稱壓縮比	
額定功率下平均有效壓力	kPa
額定功率下最大氣缸壓力	kPa
氣缸數目和排列	數目： V型： 直列：
輔助設備	
規定的環境條件：	
最高海水溫度	℃
最高增壓空氣溫度，如適用	℃
冷卻系統規格中間冷卻器	否： 是：
冷卻系統規格增壓空氣級	
低/高溫冷卻系統設定點	/ ℃
最大進口壓降	kPa
最大排氣背壓	kPa

燃油規格				
燃油溫度	℃			
排放試驗結果：				
循環				
氮氧化物				g/kWh
試驗標識				
日期/時間				
試驗場地/試驗台				
試驗編號				
驗船師				
報告日期和地點				
簽字				

排放試驗報告編號……….　　發動機族資料　　表 2/5

發動機族/發動機組資料（通用規範）	
燃燒循環	2衝程循環/4衝程循環
冷卻介質	空氣/水
氣缸排列	僅在設有廢氣濾清裝置時才要求填寫
進氣方法	自然進氣/增壓
船上使用的燃料類型	蒸餾/蒸餾或重燃油/雙燃料
燃燒室	開敞式燃燒室/分隔式燃燒室
閥口佈置	氣缸頭/氣缸壁
閥口尺寸和數目	
燃油系統類型	

其他特性：	
廢氣再循環	否/是
水噴射/乳化	否/是
空氣噴射	否/是
增壓冷卻系統	否/是
排氣後處理	否/是
排氣後處理類型	
雙燃料	否/是

發動機族/發動機組資料（試驗台試驗的母型機選擇）				
族/組標識				
增壓方法				
增壓空氣冷卻系統				
母型機選擇標準	最高NO_X排放值			
氣缸數				
每個氣缸最大額定功率				
額定轉速				
噴射定時（範圍）				
選擇的母型機				母型機
試驗循環				

排放試驗報告編號…….. **試驗台資料** **表 3/5**

排氣管	
直徑	mm
長度	m
隔熱層	否： 是：
取樣器位置	

測量設備					
	製造廠	型號	測量範圍	校準	
				量程氣體濃度	校準偏差
分析儀					
NO_X分析儀			ppm		%
CO分析儀			ppm		%
CO_2分析儀			%		%
O_2分析儀			%		%
HC分析儀			ppmC		%
轉速			rpm		%
扭矩			Nm		%
功率，如適用			kW		%
燃油流量					%
空氣流量					%
排氣流量					%
溫度					
增壓空氣冷卻劑進口			℃		℃
廢氣			℃		℃
進氣口空氣			℃		℃
增壓空氣			℃		℃
燃油			℃		℃
壓力					
廢氣			kPa		kPa
增壓空氣			kPa		kPa
大氣			kPa		kPa
蒸氣壓力					
吸入空氣			kPa		%

濕度					
吸入空氣			%		%

燃油特性

燃油種類				
燃油性能:			燃油成分分析:	
密度	ISO 3675	Kg/m^3	碳	%m/m
黏度	ISO 3104	mm^2/s	氫	%m/m
水	ISO 3733	%V/V	氮	%m/m
			氧	%m/m
			硫	%m/m
			（低熱值）LHV/Hu	MJ/kg

排放試驗報告編號……. **環境和氣體排放數據表** **表 4/5**

模式		1	2	3	4	5	6	7	8	9	10
功率/扭矩	%										
轉速	%										
模式開始時間											

環境數據											
大氣壓力	kPa										
進氣溫度	℃										
進氣濕度	g/kg										
進氣相對濕度*	%										
相對濕度傳感器處的空氣溫度*	℃										
進氣乾球溫度*	℃										
進氣濕球溫度*	℃										
試驗條件參數，fa											

氣體排放數據										
NO_X 濃度 乾/濕 ppm										
CO 濃度 ppm										
CO_2 濃度 %										
O_2 濃度 乾/濕 %										
HC 濃度 ppmC										
NO_X 濕度修正係數，k_{hd}										
乾/濕修正係數，k_{wr}										
NO_X 質量流量 kg/h										
CO 質量流量 kg/h										
CO_2 質量流量 kg/h										
O_2 質量流量 kg/h										
HC 質量流量 kg/h										
NO_X 比值 g/kWh										

* 如適用

排放試驗報告編號……. **發動機試驗數據** **表 5/5**

模式		1	2	3	4	5	6	7	8	9	10
功率/扭矩	%										
轉速	%										
模式開始時間											

發動機數據											
轉速	rpm										
輔機功率	kW										
功率計設定值	kW										
功率	kW										
平均有效壓力	kPa										
燃料齒條	mm										
未修正的燃油耗量	g/kWh										
燃油流量	kg/h或m^3/hr*										
空氣流量	kg/h										
排氣流量（q_{mew}）	kg/h										
排氣溫度	℃										
排氣背壓	kPa										
增壓空氣進口冷卻劑溫度	℃										
增壓空氣出口冷卻劑溫度	℃										
增壓空氣溫度	℃										
增壓空氣參照溫度	℃										
增壓空氣壓力	kPa										
燃油溫度	℃										

* 如適用

第 2 節－技術檔案中包括的母型機試驗數據－見本規則 2.4.1.5

發動機族/發動機組參照		
母型機		
型號/類型		
指定額定功率	kW	
指定額定轉速	rpm	

母型機試驗燃油		
參照燃料標號		
ISO 8217：2005 等級（DM 或 RM）		
碳	%m/m	
氫	%m/m	
硫	%m/m	
氮	%m/m	
氧	%m/m	
水	%V/V	

測量數據（母型機）									
功率/扭矩	%								
轉速	%								
模式點		1	2	3	4	5	6	7	8
發動機性能									
功率	kW								
轉速	rpm								
燃料流量	kg/h								
吸入空氣流量（濕/乾）	kg/h								
廢氣流量	kg/h								
吸入空氣溫度	℃								
增壓空氣溫度	℃								
增壓空氣參照溫度	℃								
增壓空氣壓力	kPa								
用於排放修正的 附加參數（詳細說明）									
環境條件									
大氣壓力	kPa								
吸入空氣相對濕度（RH）	%								
RH 傳感器空氣溫度*	℃								
吸入空氣乾球溫度*	℃								
吸入空氣濕球溫度*	℃								
吸入空氣絕對濕度*	g/kg								

排放濃度									
NO_X 濕/乾	ppm								
CO_2	%								
O_2 濕/乾	%								
CO	ppm								
HC	ppmC								
計算數據（母型機）									
吸入空氣濕度	g/kg								
增壓空氣濕度	g/kg								
試驗條件參數，f_a									
乾/濕修正係數，k_{wr}									
NO_X 濕度修正係數，k_{hd}									
廢氣流量	kg/h								
NO_X 排放流量	k/h								
附加排放修正係數（詳細說明）	g/kWh								
NO_X 排放	g/kWh								

試驗循環					
排放值	g/kWh				

* 如適用。

附錄 VI

廢氣質量流量計算（碳平衡法）

（參閱《2008 年氮氧化物技術規則》第 5 章）

1 引言

1.1 本附錄論述了以廢氣濃度測量和對燃料消耗的了解為基礎的廢氣質量流量計算。符號和術語說明及碳平衡測量方法公式中所用變量均概述於本規則引言中。

1.2 除另有規定外，本附錄所要求的全部計算結果均須按照本規則 5.10 記錄在發動機試驗報告中。

2 碳平衡方法，一步計算程序

2.1 本方法為以燃料消耗、燃料成分和廢氣濃度為條件的廢氣質量計算。

2.2 濕基的廢氣質量流量：

$$q_{\mathrm{mew}} = q_{\mathrm{mf}}\left(\left(\frac{\dfrac{1.4\cdot\left(w_{\mathrm{BET}}\cdot w_{\mathrm{BET}}\right)}{\left(\dfrac{\left(1.4\cdot w_{\mathrm{BET}}\right)}{f_{\mathrm{c}}}+\left(w_{\mathrm{ALF}}\cdot 0.08936\right)-1\right)\cdot\dfrac{1}{1.293}+f_{\mathrm{fd}}}}{f_{\mathrm{c}}\cdot f_{\mathrm{c}}}+\left(w_{\mathrm{ALF}}\cdot 0.08936\right)-1\right)\cdot\left(1+\frac{H_a}{1000}\right)+1\right) \quad (1)$$

式中

f_{fd} 根據公式（2），f_{c} 根據公式（3）確定

H_a 係指吸入空氣的絕對濕度，g（水）/kg（乾空氣）。但如 $H_a \geq H_{SC}$，在公式（1）中須用 H_{SC} 代替 H_a。

註： 可使用普遍接受的公式從相對濕度測量、露點測量、蒸氣壓力測量或乾/濕球測量中推算出 Ha。

2.3 乾廢氣的燃料特定常量 f_{fd} 須通過燃料成分燃燒附加容積的相加計算出：

$$f_{fd} = -0.055593 \cdot w_{ALF} + 0.008002 \cdot w_{DEL} + 0.0070046 \cdot w_{EPS} \quad (2)$$

2.4 根據公式（3），碳係數 f_c：

$$f_c = (c_{CO2d} - c_{CO2ad}) \cdot 0.5441 + \frac{c_{COd}}{18522} + \frac{c_{HCw}}{17355} \quad (3)$$

式中：

c_{CO2d} = 原始廢氣中的乾 CO_2 濃度，%

c_{CO2ad} = 環境空氣中的乾 CO_2 濃度，%=0.03%

c_{COd} = 原始廢氣中的乾 CO 濃度，ppm

c_{HCw} = 原始廢氣中的濕 HC 濃度，ppm。

附錄 VII

發動機參數檢查方法的檢查清單

（參閱《2008 年氮氧化物技術規則》6.2.2.5）

1 下列某些參數，有着一種以上的可行檢驗方法。在這種情況下，作為指南，下列方法的任何一種或一組均可充分表明符合要求。經主管機關認可，在發動機發證申請方的支持下，船舶所有人可以對適用方法做出選擇。

.1 “噴射定時”參數

.1 燃油凸輪位置（如凸輪不可調整，單個凸輪或凸輪軸），

— 選擇（根據設計）：凸輪和泵驅動裝置之間的頂桿位置，

— 套筒計量泵的選擇：可變噴射定時（VTT）指數和凸輪位置或套筒位置，或

— 其他套筒計量裝置；

.2 某些燃油齒條位置的供油起點（動壓力測量）；

.3 某些負荷點噴油閥的開啟，例如，用霍爾傳感器或加速傳感器；

.4 增壓空氣壓力，燃燒峰值壓力，增壓空氣溫度，廢氣溫度的載控操作值與氮氧化物相關曲線顯示圖相比較。此外，須確保壓縮比與初次驗證值相一致（見 1.7）。

*註：*為評估實際定時，有必要根據試驗台氮氧化物的測量結果，了解滿足排放限值的允許限度或甚至顯示定時對氮氧化物影響的曲線圖。

.2 “噴油嘴”參數：

.1 技術要求和構件標識號；

.3 “噴油泵”參數：

.1 構件標識號（說明柱塞和套筒的設計）；

.4 “燃油凸輪”參數：

.1 構件標識號（說明形狀）；

.2 某一燃油齒條位置的供油起點和終點（動壓力測量）；

.5 “噴油壓力”參數：

.1 僅對共軌系統：齒軌中載控壓力，氮氧化物相關曲線顯示圖；

.6 “燃燒室” 參數：

.1 氣缸頭和活塞頭的構件標識號；

.7 “壓縮比” 參數：

.1 檢查實際間隙；

.2 檢查活塞桿或連桿的墊片；

.8 “增壓器型式和構造” 參數：

.1 型式和規格（標識號）；

.2 載控增壓空氣壓力，氮氧化物相關曲線顯示圖；

.9 “增壓空氣冷卻器、增壓空氣加熱器” 參數：

.1 型號和規格；

.2 按參照條件修正後的載控增壓空氣溫度，氮氧化物相關曲線顯示圖；

.10 “閥定時” 參數（僅針對下死點（BDC）前具有進氣閥關閉裝置的四衝程發動機）：

.1 凸輪位置；

.2 檢查實際定時；

.11 "水噴射"參數（用於評價：顯示對氮氧化物影響的曲線圖）：

.1 載控水耗（監測）；

.12 "乳化燃油"參數（用於評價：顯示對氮氧化物影響的曲線圖）：

.1 載控燃油齒條位置（監測）；

.2 載控水耗（監測）；

.13 "廢氣再循環"參數（用於評價：顯示對氮氧化物影響的曲線圖）：

.1 再循環廢氣與載控質量流量（監測）；

.2 新鮮空氣與再循環廢氣的混和氣體，即"掃氣"中的 CO_2 濃度（監測）；

.3 "掃氣"中的 O_2 濃度（監測）；

.14 "選擇性催化還原"參數（SCR）：

.1 載控還原劑質量流量（監測）以及對 SCR 之後的 NO_X 濃度附加定期檢查（用於評價：顯示對 NO_X 影響的曲線圖）。

2 對具有無反饋控制的選擇性催化還原（SCR）的發動機，可選用的 NO_X 測量（定期抽查或監測）有助於表明無論環境條件或燃油質量是否造成原始排放的不同，SCR 的有效性仍然和發證時的狀況一致。

附錄 VIII

直接測量和監測法的實施

（參閱《2008 年氮氧化物技術規則》6.4）

1 電氣設備：材料和設計

1.1 電氣設備須用耐久、阻燃和耐潮的材料製成，使其在裝設的環境中及可能承受的溫度下不會劣化。

1.2 電氣設備的設計須使有可能接地的導電部分得到意外接觸保護。

2 分析設備

2.1 *分析儀*

2.1.1 須使用下列儀器對廢氣進行分析。非線性分析儀，允許使用線性化電路。其他系統或分析儀，如果取得與下述設備等效的結果，經主管機關認可，可以接受：

.1 氮氧化物（NO_X）分析

氮氧化物分析儀須為化學熒光探測器（CLD）或加熱式化學熒光探測器（HCLD）型。為 NO_X 測量取樣的廢氣在通過 NO_2 至 NO 的轉換器之前須保持在露點溫度之上。

*註：*對於原始廢氣，如果發動機使用 ISO 8217：2005 DM 級燃料，此溫度須大於 60℃；如果使用 ISO 8217：2005 RM 級燃料，此溫度須大於 140℃。

.2 二氧化碳（CO_2）分析

如要求，二氧化碳分析儀須為非彌散紅外（NDIR）吸收型。

.3 一氧化碳（CO）分析

如要求，一氧化碳分析儀須為（NDIR）吸收型式。

.4 碳氫化合物（HC）分析

如要求，碳氫化合物分析儀須為加熱式火焰離子探測器（HFID）型。為 HC 測量取樣的廢氣從取樣點至探測器的溫度須保持在 190℃±10℃。

.5 氧（O_2）分析

如要求，氧分析儀須為順磁探測器（PMD）、二氧化鋯傳感器（ZRDO）或電化傳感器（ECS）型。

2.2 *分析儀技術規範*

2.2.1 分析儀技術規範須與本規則附錄 III 的 1.6、1.7、1.8、1.9 和 1.10 一致。

2.2.2 分析儀範圍須使測量的排放值位於所用範圍的 15%至 100%之間。

2.2.3 分析儀須按照製造廠的建議進行安裝和維護以滿足本規則附錄 III 中 1.7、1.8、1.9 和 1.10 以及附錄 IV 中第 7 和第 9 節的要求。

3 純氣體和校準氣體

3.1 所要求的純氣體和校準氣體須符合本規則附錄 IV 的 2.1 和 2.2。所申報的的濃度須符合國家和/或國際標準。校準氣體須符合分析設備製造廠的建議。

3.2 分析儀量程氣體須處於分析儀所定量程刻度的 80%至 100%之間。

4 氣體取樣和傳輸系統

4.1 廢氣試樣須能代表從發動機所有氣缸排出的平均廢氣排放。氣體取樣系統須符合本規則 5.9.3。

4.2 廢氣試樣須從管直徑 10%至 90%內的區域抽取。

4.3 為了利於取樣管的安裝，第 5 節給出了取樣點接頭法蘭實例。

4.4 須按照分析設備製造廠的建議維持 NO_X 測量的廢氣試樣，以防止水或酸冷凝造成的 NO_2 損失。

4.5 氣體試樣不得用化學乾燥劑乾燥。

4.6　須能按照分析設備製造廠的建議驗證氣體取樣系統無進入滲漏。

4.7　須在所用取樣點附近設有附加取樣點以便利系統質量控制檢查。

5　取樣點接頭法蘭

5.1　以下為通用取樣點接頭法蘭實例，該法蘭須位於使用直接測量和監測法證實符合要求的每一發動機的排氣管上的合宜之處。

規格	尺寸
外徑	160 mm
內徑	35 mm
法蘭厚度	9 mm
螺栓圈直徑 1	130 mm
螺栓圈直徑 2	65 mm
法蘭槽口	直徑 12 mm 的孔 4 個，等距離分佈在上述螺栓圈直徑上。2 個螺栓圈直徑的孔在相同半徑對齊。在內外螺栓圈直徑孔之間的法蘭開槽口，槽口寬 12 mm
螺栓和螺帽	4 套，要求的直徑和長度
法蘭須以鋼製成，表面平整。	

5.2　法蘭須設置在與排氣管直徑對齊的以適當規格材料製成的短管上。短管長度須不超過凸出排氣管覆層所需的長度，但須足以進入法蘭的內側。短管須予以絕緣。短管須中止於可接觸到的位置，附近沒有會干擾取樣管和相關附件就位或裝設的阻礙物。

5.3　不使用時，短管須用鋼製無孔法蘭和適當耐熱材料製成的墊圈封閉。取樣法蘭和封閉無孔法蘭不使用時，須用易於移除和適當耐熱材料加以覆蓋，以防意外接觸。

6　選擇載荷點和經修改的加權因數

6.1　按照本規則 6.4.6.4，對於 E2、E3 或 D2 試驗循環，載荷點的最少數目須使本規則 3.2 規定的組合標定加權因數大於 0.5。

6.2　按照 6.1，E2 和 E3 試驗循環有必要使用 75%載荷點加上其他一個或多個載荷點。D2 試驗循環，須使用 25%或 50%載荷點加上一個或多個載荷點以使組合標定加權因數大於 0.5。

6.3　以下實例為一些載荷點的可能組合，可與各經修改的加權因數共用：

.1　E2 和 E3 試驗循環

功率	100%	75%	50%	25%
標定加權因數	0.2	0.5	0.15	0.15
選項 A	0.29	0.71		
選項 B		0.77	0.23	
選項 C	0.24	0.59		0.18
加上可取得組合標定加權因數大於 0.5 的的其他組合。因此使用 100% + 50% + 25%載荷點是不夠的。				

.2 D2 試驗循環

功率	100%	75%	50%	25%	10%
標定加權因數	0.05	0.25	0.3	0.3	0.1
選項 D			0.5	0.5	
選項 E		0.45		0.55	
選項 F		0.38	0.46		0.15
選項 G	0.06	0.28	0.33	0.33	
加上可取得組合標定加權因數大於 0.5 的的其他組合。因此使用 100% + 50% + 10%載荷點是不夠的。					

6.4 對於 C1 試驗循環，每個額定、過渡和空轉部分須至少使用一個載荷點。以下實例為載荷點的一些可能組合，可與各經修改的加權因數一起使用：

.1 C1 試驗循環

轉速	額定				過渡			空轉
扭矩	100%	75%	50%	10%	100%	75%	50%	0%
標定加權因數	0.15	0.15	0.15	0.1	0.1	0.1	0.1	0.15
選項 H		0.38			0.25			0.38
選項 I				0.29		0.29		0.43
選項 J	0.27	0.27					0.18	0.27
選項 K	0.19	0.19	0.19	0.13		0.13		0.19
加上包括每個額定、過渡和空轉轉速的至少一個載荷點的其他組合。								

6.5 經修改的加權因數計算實例：

.1 對給定的載荷點，經修改的加權因數須計算如下：

y%載荷 = 載荷 y 時的標定加權因數・（1/（獲取數據的各載荷點的載荷因數之和））

.2 對選項 A：

75%載荷：修改值計算為：0.5•（1/（0.5+0.2））=0.71

100%負荷：修改值計算為：0.2•（1/（0.5+0.2））=0.29

.3 對選項 F：

75%載荷：修改值計算為：0.25•（1/（0.25+0.3＋0.1））=0.38

.4 經修改的加權因數精確至小數點後兩位。但是，本規則公式（19）所用的值須取整。因此，在上述選項 F 中，經修改的加權因數示為 0.38 雖然精確值為 0.384615……。因此，在經修改的加權因數實例中，由於四捨五入的原因顯示值（精確至小數點後兩位）的總和可能不是 1.00。

7 功率設定點穩定性的確定

7.1 為了確定設定點穩定性，功率偏差係數須在 10 分鐘間隔期內計算，且取樣率至少為 1-Hz。結果須小於或等於百分之五（5%）。

7.2 計算偏差係數的公式如下：

$$Ave = \frac{1}{N}\sum_{j=1}^{N} x_j \qquad (1)$$

$$S.D. = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - Ave)^2} \qquad (2)$$

$$\%C.O.V. = \frac{S.D.}{Ave} \cdot 100 \leq 5\% \qquad (3)$$

式中：

%C.O.V.	功率偏差係數，%
S.D.	標準偏差
Ave	平均
N	取樣數據點總數目
x_i，x_j	功率數據點的第 i，j 個值，kW
I	標準偏差公式的下標變量
J	平均公式的下標變量

RESOLUTION MEPC.177(58)

Adopted on 10 October 2008

AMENDMENTS TO THE TECHNICAL CODE ON CONTROL OF EMISSION OF NITROGEN OXIDES FROM MARINE DIESEL ENGINES

(NO_x Technical Code 2008)

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

RECALLING Article 38(a) of the Convention on the International Maritime Organization concerning the functions of the Marine Environment Protection Committee (the Committee) conferred upon it by international conventions for the prevention and control of marine pollution,

NOTING article 16 of the International Convention for the Prevention of Pollution from Ships, 1973 (hereinafter referred to as the "1973 Convention"), article VI of the Protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973 (hereinafter referred to as the "1978 Protocol") and article 4 of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (herein after referred to as the "1997 Protocol"), which together specify the amendment procedure of the 1997 Protocol and confer upon the appropriate body of the Organization the function of considering and adopting amendments to the 1973 Convention, as modified by the 1978 and 1997 Protocols,

NOTING ALSO that, by the 1997 Protocol, Annex VI, entitled Regulations for the Prevention of Air Pollution from Ships (hereinafter referred to as "Annex VI"), is added to the 1973 Convention,

NOTING FURTHER regulation 13 of MARPOL Annex VI, which makes the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines (NO_x Technical Code) mandatory under that Annex,

HAVING CONSIDERED the draft amendments to the NO_x Technical Code,

1. ADOPTS, in accordance with article 16(2)(d) of the 1973 Convention, the amendments to the NO_x Technical Code, as set out at Annex to the present resolution;

2. DETERMINES, in accordance with article 16(2)(f)(iii) of the 1973 Convention, that the amendments shall be deemed to have been accepted on 1 January 2010, unless prior to that date, not less than one-third of the Parties or Parties the combined merchant fleets of which constitute not less than 50 per cent of the gross tonnage of the world's merchant fleet, have communicated to the Organization their objection to the amendments;

3. INVITES the Parties to note that, in accordance with article 16(2)(g)(ii) of the 1973 Convention, the said amendments shall enter into force on 1 July 2010 upon their acceptance in accordance with paragraph 2 above;

4. REQUESTS the Secretary-General, in conformity with article 16(2)(e) of the 1973 Convention, to transmit to all Parties to the 1973 Convention, as modified by the 1978 and 1997 Protocols, certified copies of the present resolution and the text of the amendments contained in the Annex;

5. REQUESTS FURTHER the Secretary-General to transmit to the Members of the Organization which are not Parties to the 1973 Convention, as modified by the 1978 and 1997 Protocols, copies of the present resolution and its Annex;

6. INVITES the Parties to MARPOL Annex VI and other Member Governments to bring the amendments to the NO_x Technical Code to the attention of shipowners, ship operators, shipbuilders, marine diesel engine manufacturers and any other interested groups.

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APPENDICES

Introduction

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On 26 September 1997, the Conference of Parties to the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78) adopted, by Conference resolution 2, the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines (NO_x Technical Code). Following the entry into force, on 19 May 2005, of MARPOL Annex VI – Regulations for the Prevention of Air Pollution from Ships, each marine diesel engine to which regulation 13 of that Annex applies must comply with the provisions of this Code. MEPC 53 in July 2005 agreed to the revision of MARPOL Annex VI and the NO_x Technical Code. That review was concluded at MEPC 58 in October 2008 and this version of the NO_x Technical Code, hereunder referred to as the Code, is an outcome of that process.

As general background information, the precursors to the formation of nitrogen oxides during the combustion process are nitrogen and oxygen. Together these compounds comprise 99% of the engine intake air. Oxygen will be consumed during the combustion process, with the amount of excess oxygen available being a function of the air/fuel ratio under which the engine is operating. The nitrogen remains largely unreacted in the combustion process; however, a small percentage will be oxidized to form various oxides of nitrogen. The nitrogen oxides (NO_x) that can be formed include nitric oxide (NO) and nitrogen dioxide (NO_2), while the amounts are primarily a function of flame or combustion temperature and, if present, the amount of organic nitrogen available from the fuel. NO_x formation is also a function of the time the nitrogen and the excess oxygen are exposed to the high temperatures associated with the diesel engine's combustion process. In other words, the higher the combustion temperature (e.g., high-peak pressure, high-compression ratio, high rate of fuel delivery, etc.), the greater the amount of NO_x formation. A slow-speed diesel engine, in general, tends to have more NO_x formation than a high-speed engine. NO_x has an adverse effect on the environment, causing acidification, formation of tropospheric ozone and nutrient enrichment, and contributes to adverse health effects globally.

The purpose of this Code is to provide mandatory procedures for the testing, survey and certification of marine diesel engines that will enable engine manufacturers, shipowners and Administrations to ensure that all applicable marine diesel engines comply with the relevant limiting emission values of NO_x as specified within regulation 13 of Annex VI. The difficulties of establishing, with precision, the actual weighted average NO_x emission of marine diesel engines in service on ships have been recognized in formulating a simple, practical set of requirements in which the means to ensure compliance with the allowable NO_x emissions are defined.

Administrations are encouraged to assess the emissions performance of marine propulsion and auxiliary diesel engines on a test bed where accurate tests can be carried out under properly controlled conditions. Establishing compliance with regulation 13 of Annex VI at this initial stage is an essential feature of this Code. Subsequent testing on board the ship may inevitably be limited in scope and accuracy, and its purpose shall be to infer or deduce the emission performance and to confirm that engines are installed, operated and maintained in accordance with the manufacturer's specifications and that any adjustments or modifications do not detract from the emissions performance established by initial testing and certification by the manufacturer.

Abbreviations, subscripts and symbols

Tables 1, 2, 3 and 4 below summarize the abbreviations, subscripts and symbols used throughout this Code, including specifications for the analytical instruments in appendix III, calibration requirements for the analytic instruments contained in appendix IV, the formulae for calculation of gas mass flow as contained in chapter 5 and appendix VI of this Code and the symbols used in respect of data for onboard verification surveys in chapter 6.

.1 Table 1: symbols used to represent the chemical components of diesel engine gas emissions and calibration and span gases addressed throughout this Code;

.2 Table 2: abbreviations for the analysers used in the measurement of gas emissions from diesel engines as specified in appendix III of this Code;

.3 Table 3: symbols and subscripts of terms and variables used in chapter 5, chapter 6, appendix IV and appendix VI of this Code; and

.4 Table 4: symbols for fuel composition used in chapter 5 and chapter 6 and appendix VI of this Code.

Table 1
Symbols and abbreviations for the chemical components

Symbol	Definition
CH_4	Methane
C_3H_8	Propane
CO	Carbon monoxide
CO_2	Carbon dioxide
HC	Hydrocarbons
H_2O	Water
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
O_2	Oxygen

Table 2
Abbreviations for Analysers for measurement of diesel engine gaseous emissions
(refer to appendix III of this Code)

CLD	Chemiluminescent detector
ECS	Electrochemical sensor
HCLD	Heated chemiluminescent detector
HFID	Heated flame ionization detector
NDIR	Non-dispersive infrared analyser
PMD	Paramagnetic detector
ZRDO	Zirconium dioxide sensor

Table 3
Symbols and subscripts for terms and variables
(refer to chapter 5, chapter 6, appendix IV and appendix VI of this Code)

Symbol	Term	Unit
A/F_{st}	Stoichiometric air to fuel ratio	1
c_x	Concentration in the exhaust (with suffix of the component nominating, d=dry or w=wet)	ppm/% (V/V)
E_{CO2}	CO_2 quench of NO_x analyser	%
E_{H2O}	Water quench of NO_x analyser	%
E_{NOx}	Efficiency of NO_x converter	%
E_{O2}	Oxygen analyser correction factor	1
λ	Excess air factor: kg dry air/(kg fuel · A/F_{st})	1
f_a	Test condition parameter	1
f_c	Carbon factor	1
f_{fd}	Fuel-specific factor for exhaust flow calculation on dry basis	1
f_{fw}	Fuel-specific factor for exhaust flow calculation on wet basis	1
H_a	Absolute humidity of the intake air (g water / kg dry air)	g/kg
H_{SC}	Humidity of the charge air	g/kg
i	Subscript denoting an individual mode	1
k_{hd}	Humidity correction factor for NO_x for diesel engines	1
k_{wa}	Dry to wet correction factor for the intake air	1
k_{wr}	Dry to wet correction factor for the raw exhaust gas	1
n_d	Engine speed	min^{-1}
n_{turb}	Turbocharger speed	min^{-1}
$\%O_2I$	HC analyser percentage oxygen interference	%
p_a	Saturation vapour pressure of the engine intake air determined using a temperature value for the intake air measured at the same physical location as the measurements for p_b and R_a	kPa
p_b	Total barometric pressure	kPa
p_C	Charge air pressure	kPa
p_r	Water vapour pressure after cooling bath of the analysis system	kPa
p_s	Dry atmospheric pressure calculated by the following formula: $p_s = p_b - R_a \cdot p_a /100$	kPa
p_{SC}	Saturation vapour pressure of the charge air	kPa
P	Uncorrected brake power	kW
P_{aux}	Declared total power absorbed by auxiliaries fitted for the test and not required by ISO 14396	kW
P_m	Maximum measured or declared power at the test engine speed under test conditions	kW

Symbol	Term	Unit
q_{mad}	Intake air mass flow rate on dry basis	kg/h
q_{maw}	Intake air mass flow rate on wet basis	kg/h
q_{mew}	Exhaust gas mass flow rate on wet basis	kg/h
q_{mf}	Fuel mass flow rate	kg/h
q_{mgas}	Emission mass flow rate of individual gas	g/h
R_a	Relative humidity of the intake air	%
r_h	Hydrocarbon response factor	1
ρ	Density	kg/m^3
s	Fuel rack position	
T_a	Intake air temperature determined at the engine intake	K
T_{caclin}	Charge air cooler, coolant inlet temperature	°C
$T_{caclout}$	Charge air cooler, coolant outlet temperature	°C
T_{Exh}	Exhaust gas temperature	°C
T_{Fuel}	Fuel oil temperature	°C
T_{Sea}	Seawater temperature	°C
T_{SC}	Charge air temperature	K
T_{SCRef}	Charge air reference temperature	K
u	Ratio of exhaust component and exhaust gas densities	1
W_F	Weighting factor	1

Table 4
Symbols for fuel composition

Symbol	Definition	Unit
w_{ALF}	H content of fuel	% m/m
w_{BET}	C content of fuel	% m/m
w_{GAM}	S content of fuel	% m/m
w_{DEL}	N content of fuel	% m/m
w_{EPS}	O content of fuel	% m/m
α	molar ratio (H/C)	1

Chapter 1

General

1.1 Purpose

1.1.1 The purpose of this Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines, hereunder referred to as the Code, is to specify the requirements for the testing, survey and certification of marine diesel engines to ensure they comply with the nitrogen oxides (NO_x) emission limits of regulation 13 of Annex VI. All references to regulations within this Code refer to Annex VI.

1.2 Application

1.2.1 This Code applies to all marine diesel engines with a power output of more than 130 kW that are installed, or are designed and intended for installation, on board any ship subject to Annex VI and to which regulation 13 applies. Regarding the requirements for survey and certification under regulation 5, this Code addresses only those requirements applicable to an engine's compliance with the applicable NO_x emission limit.

1.2.2 For the purpose of the application of this Code, Administrations are entitled to delegate all functions required of an Administration by this Code to an organization authorized to act on behalf of the Administration. In every case, the Administration assumes full responsibility for the survey and certificate.

1.2.3 For the purpose of this Code, an engine shall be considered to be operated in compliance with the applicable NO_x limit of regulation 13 if it can be demonstrated that the weighted NO_x emissions from the engine are within those limits at the initial certification, annual, intermediate and renewal surveys and such other surveys as are required.

1.3 Definitions

1.3.1 *Nitrogen Oxide (NO_x) emissions* means the total emission of nitrogen oxides, calculated as the total weighted emission of NO_2 and determined using the relevant test cycles and measurement methods as specified in this Code.

1.3.2 *Substantial modification* of a marine diesel engine means:

.1 For engines installed on ships constructed on or after 1 January 2000, *substantial modification* means any modification to an engine that could potentially cause the engine to exceed the applicable emission limit set out in regulation 13. Routine replacement of engine components by parts specified in the technical file that do not alter emission characteristics shall not be considered a "substantial modification" regardless of whether one part or many parts are replaced.

.2 For engines installed on ships constructed before 1 January 2000, *substantial modification* means any modification made to an engine that increases its existing emission characteristics established by the simplified measurement method as described in 6.3 in excess of the allowances set out in 6.3.11. These changes include, but are not limited to, changes in its operations or in its technical parameters (e.g., changing camshafts, fuel injection systems, air systems, combustion chamber configuration, or timing calibration of the engine). The installation of a certified approved method pursuant to regulation 13.7.1.1 or certification pursuant to regulation 13.7.1.2 is not considered to be a substantial modification for the purpose of the application of regulation 13.2 of the Annex.

1.3.3 *Components* are those interchangeable parts that influence the NO_x emissions performance, identified by their design/parts number.

1.3.4 *Setting* means adjustment of an adjustable feature influencing the NO_x emissions performance of an engine.

1.3.5 *Operating values* are engine data, such as cylinder peak pressure, exhaust gas temperature, etc., from the engine log that are related to the NO_x emission performance. These data are load-dependent.

1.3.6 The *EIAPP Certificate* is the Engine International Air Pollution Prevention Certificate which relates to NO_x emissions.

1.3.7 The *IAPP Certificate* is the International Air Pollution Prevention Certificate.

1.3.8 *Administration* has the same meaning as article 2, subparagraph (5) of MARPOL 73.

1.3.9 *Onboard NO_x verification procedures* mean a procedure, which may include an equipment requirement, to be used on board at initial certification survey or at the renewal, annual or intermediate surveys, as required, to verify compliance with any of the requirements of this Code, as specified by the applicant for engine certification and approved by the Administration.

1.3.10 *Marine diesel engine* means any reciprocating internal combustion engine operating on liquid or dual fuel, to which regulation 13 applies, including booster/compound systems if applied.

Where an engine is intended to be operated normally in the gas mode, i.e. with the main fuel gas and only a small amount of liquid pilot fuel, the requirements of regulation 13 have to be met only for this operation mode. Operation on pure liquid fuel resulting from restricted gas supply in cases of failures shall be exempted for the voyage to the next appropriate port for the repair of the failure.

1.3.11 *Rated power* means the maximum continuous rated power output as specified on the nameplate and in the technical file of the marine diesel engine to which regulation 13 and this Code apply.

1.3.12 *Rated speed* is the crankshaft revolutions per minute at which the rated power occurs as specified on the nameplate and in the technical file of the marine diesel engine.

1.3.13 *Brake power* is the observed power measured at the crankshaft or its equivalent, the engine being equipped only with the standard auxiliaries necessary for its operation on the test bed.

1.3.14 *Onboard conditions* mean that an engine is:

.1 installed on board and coupled with the actual equipment that is driven by the engine; and

.2 under operation to perform the purpose of the equipment.

1.3.15 A *technical file* is a record containing all details of parameters, including components and settings of an engine, that may influence the NO_x emission of the engine, in accordance with 2.4 of this Code.

1.3.16 A *record book of engine parameters* is the document used in connection with the engine parameter check method for recording all parameter changes, including components and engine settings that may influence NO_x emission of the engine.

1.3.17 An *approved method* is a method for a particular engine, or a range of engines, which, when applied to the engine, will ensure that the engine complies with the applicable NO_x limit as detailed in regulation 13.7.

1.3.18 An *existing engine* is an engine that is subject to regulation 13.7.

1.3.19 An *approved method file* is a document which describes an approved method and its means of survey.

Chapter 2

Surveys and certification

2.1 General

2.1.1 Each marine diesel engine specified in 1.2, except as otherwise permitted by this Code, shall be subject to the following surveys:

.1 A pre-certification survey that shall be such as to ensure that the engine, as designed and equipped, complies with the applicable NO_x emission limit contained in regulation 13. If this survey confirms compliance, the Administration shall issue an Engine International Air Pollution Prevention (EIAPP) Certificate.

.2 An initial certification survey that shall be conducted on board a ship after the engine is installed but before it is placed in service. This survey shall be such as to ensure that the engine, as installed on board the ship, including any modifications and/or adjustments since the pre-certification, if applicable, complies with the applicable NO_x emission limit contained in regulation 13. This survey, as part of the ship's initial survey, may lead to either the issuance of a ship's initial International Air Pollution Prevention (IAPP) Certificate or an amendment of a ship's valid IAPP Certificate reflecting the installation of a new engine.

.3 Renewal, annual and intermediate surveys, that shall be conducted as part of a ship's surveys required by regulation 5, to ensure the engine continues to comply fully with the provisions of this Code.

.4 An initial engine certification survey that shall be conducted on board a ship every time a major conversion, as defined in regulation 13, is made to an engine to ensure that the engine complies with the applicable NO_x emission limit contained in regulation 13. This will result in the issue, if applicable, of an EIAPP Certificate and the amendment of the IAPP Certificate.

2.1.2 To comply with the various survey and certification requirements described in 2.1.1, there are methods included in this Code from which the engine manufacturer, shipbuilder or shipowner, as applicable, can choose to measure, calculate, test or verify an engine for its NO_x emissions, as follows:

.1 test-bed testing for the pre-certification survey in accordance with chapter 5;

.2 onboard testing for an engine not pre-certificated for a combined pre certification and initial certification survey in accordance with the full test-bed requirements of chapter 5;

.3 onboard engine parameter check method, using the component data, engine settings and engine performance data as specified in the technical file, for confirmation of compliance at initial, renewal, annual and intermediate surveys for pre-certified engines or engines that have undergone modifications or adjustments to NO_x critical components, settings and operating values, since they were last surveyed, in accordance with 6.2;

.4 onboard simplified measurement method for confirmation of compliance at renewal, annual and intermediate surveys or confirmation of pre-certified engines for initial certification surveys, in accordance with 6.3 when required; or

.5 onboard direct measurement and monitoring method for confirmation of compliance at renewal, annual and intermediate surveys only, in accordance with 6.4.

2.2 Procedures for pre-certification of an engine

2.2.1 Prior to installation on board, every marine diesel engine (individual engine), except as allowed by 2.2.2 and 2.2.4, shall:

.1 be adjusted to meet the applicable NO_x emission limit,

.2 have its NO_x emissions measured on a test bed in accordance with the procedures specified in chapter 5 of this Code, and

.3 be pre-certified by the Administration, as documented by issuance of an EIAPP Certificate.

2.2.2 For the pre-certification of serially manufactured engines, depending on the approval of the Administration, the engine family or the engine group concept may be applied (see chapter 4). In such a case, the testing specified in 2.2.1.2 is required only for the parent engine(s) of an engine family or engine group.

2.2.3 The method of obtaining pre-certification for an engine is for the Administration to:

.1 certify a test of the engine on a test bed;

.2 verify that all engines tested, including, if applicable, those to be delivered within an engine family or engine group, meet the applicable NO_x limit; and

.3 if applicable, verify that the selected parent engine(s) is representative of an engine family or engine group.

2.2.4 There are engines that, due to their size, construction and delivery schedule, cannot be pre-certified on a test bed. In such cases, the engine manufacturer, shipowner or shipbuilder shall make application to the Administration requesting an onboard test (see 2.1.2.2). The applicant must demonstrate to the Administration that the onboard test fully meets all of the requirements of a test-bed procedure as specified in chapter 5 of this Code. Such a survey may be accepted for an individual engine or for an engine group represented by the parent engine only, but it shall not be accepted for an engine family certification. In no case shall an allowance be granted for possible deviations of measurements if an initial survey is carried out on board a ship without any valid pre-certification test. For engines undergoing an onboard certification test, in order to be issued with an EIAPP Certificate, the same procedures apply as if the engine had been pre-certified on a test bed.

2.2.5 NO_x reducing devices

.1 Where an NO_x-reducing device is to be included within the EIAPP certification, it must be recognized as a component of the engine and its presence shall be recorded in the engine's technical file. The engine shall be tested, at the pre-certification test, with the NO_x-reducing device fitted.

.2 In those cases where an NO_x-reducing device has been fitted due to failure to meet the required emission value at the pre-certification test, in order to receive an EIAPP Certificate for this assembly, the engine, including the reducing device, as installed, must be re-tested to show compliance with the applicable NO_x emission limit. However, in this case, the assembly may be re-tested in accordance with the simplified measurement method in accordance with 6.3. In no case shall the allowances given in 6.3.11 be granted.

.3 Where, in accordance with 2.2.5.2, the effectiveness of the NO_x reducing device is verified by use of the simplified measurement method, that test report shall be added as an adjunct to the pre-certification test report that demonstrated the failure of the engine alone to meet the required emission value. Both test reports shall be submitted to the Administration, and test report data, as detailed in 2.4.1.5, covering both tests shall be included in the engine's technical file.

.4 The simplified measurement method used as part of the process to demonstrate compliance in accordance with 2.2.5.2 may only be accepted in respect of the engine and NO_x-reducing device on which its effectiveness was demonstrated, and it shall not be accepted for engine family or engine group certification.

.5 In both cases as given in 2.2.5.1 and 2.2.5.2, the NO_x-reducing device shall be included on the EIAPP Certificate together with the emission value obtained with the device in operation and all other records as required by the Administration. The engine's technical file shall also contain onboard NO_x verification procedures for the device to ensure it is operating correctly.

.6 Notwithstanding 2.2.5.3 and 2.2.5.4, an NO_x-reducing device may be approved by the Administration taking into account guidelines to be developed by the Organization.

2.2.6 Where, due to changes of component design, it is necessary to establish a new engine family or engine group but there is no available parent engine, the engine builder may apply to the Administration to use the previously obtained parent engine test data modified at each specific mode of the applicable test cycle so as to allow for the resulting changes in NO_x emission values. In such cases, the engine used to determine the modification emission data shall correspond in accordance with the requirements of 4.4.6.1, 4.4.6.2 and 4.4.6.3 to the previously used parent engine. Where more than one component is to be changed the combined effect resulting from those changes is to be demonstrated by a single set of test results.

2.2.7 For pre-certification of engines within an engine family or engine group, an EIAPP Certificate shall be issued in accordance with procedures established by the Administration to the parent engine(s) and to every member engine produced under this certification to accompany the engines throughout their life whilst installed on ships under the authority of that Administration.

2.2.8 *Issue of certification by the Administration of the country in which the engine is built*

.1 When an engine is manufactured outside the country of the Administration of the ship on which it will be installed, the Administration of the ship may request the Administration of the country in which the engine is manufactured to survey the engine. Upon satisfaction that the applicable requirements of regulation 13 are complied with pursuant to this Code, the Administration of the country in which the engine is manufactured shall issue or authorize the issuance of the EIAPP Certificate.

.2 A copy of the certificate(s) and a copy of the survey report shall be transmitted as soon as possible to the requesting Administration.

.3 A certificate so issued shall contain a statement to the effect that it has been issued at the request of the Administration.

2.2.9 Guidance in respect of the pre-certification survey and certification of marine diesel engines, as described in chapter 2 of this Code, is given in the relevant flowchart in appendix II of this Code. Where discrepancies exist, the text of chapter 2 takes precedence.

2.2.10 A model form of an EIAPP Certificate is attached as appendix I to this Code.

2.3 Procedures for certification of an engine

2.3.1 For those engines that have not been adjusted or modified relative to the original specification of the manufacturer, the provision of a valid EIAPP Certificate should suffice to demonstrate compliance with the applicable NO_x limits.

2.3.2 After installation on board, it shall be determined to what extent an engine has been subjected to further adjustments and/or modifications that could affect the NO_x emission. Therefore, the engine, after installation on board, but prior to issuance of the IAPP Certificate, shall be inspected for modifications and be approved using the onboard NO_x verification procedures and one of the methods described in 2.1.2.

2.3.3 There are engines that, after pre-certification, need final adjustment or modification for performance. In such a case, the engine group concept could be used to ensure that the engine still complies with the applicable limit.

2.3.4 Every marine diesel engine installed on board a ship shall be provided with a technical file. The technical file shall be prepared by the applicant for engine certification and approved by the Administration, and is required to accompany an engine throughout its life on board ships. The technical file shall contain the information as specified in 2.4.1.

2.3.5 Where an NO_x-reducing device is installed and needed to comply with the NO_x limits, one of the options providing a ready means for verifying compliance with regulation 13 is the direct measurement and monitoring method in accordance with 6.4. However, depending on the technical possibilities of the device used, subject to the approval of the Administration, other relevant parameters could be monitored.

2.3.6 Where, for the purpose of achieving NO_x compliance, an additional substance is introduced, such as ammonia, urea, steam, water, fuel additives, etc., a means of monitoring the consumption of such substance shall be provided. The technical file shall provide sufficient information to allow a ready means of demonstrating that the consumption of such additional substances is consistent with achieving compliance with the applicable NO_x limit.

2.3.7 Where the engine parameter check method in accordance with 6.2 is used to verify compliance, if any adjustments or modifications are made to an engine after its pre-certification, a full record of such adjustments or modifications shall be recorded in the engine's record book of engine parameters.

2.3.8 If all of the engines installed on board are verified to remain within the parameters, components, and adjustable features recorded in the technical file, the engines should be accepted as performing within the applicable NO_x limit specified in regulation 13. In this case, provided all other applicable requirements of the Annex are complied with, an IAPP Certificate should then be issued to the ship.

2.3.9 If any adjustment or modification is made which is outside the approved limits documented in the technical file, the IAPP Certificate may be issued only if the overall NO_x emission performance is verified to be within the required limits by: onboard simplified measurement in accordance with 6.3; or, reference to the test-bed testing for the relevant engine group approval showing that the adjustments or modifications do not exceed the applicable NO_x emission limit. At surveys after the initial engine survey, the direct measurement and monitoring method in accordance with 6.4, as approved by the Administration, may alternatively be used.

2.3.10 The Administration may, at its own discretion, abbreviate or reduce all parts of the survey on board, in accordance with this Code, to an engine that has been issued an EIAPP Certificate. However, the entire survey on board must be completed for at least one cylinder and/or one engine in an engine family or engine group, if applicable, and the abbreviation may be made only if all the other cylinders and/or engines are expected to perform in the same manner as the surveyed engine and/or cylinder. As an alternative to the examination of fitted components, the Administration may conduct that part of the survey on spare parts carried on board provided they are representative of the components fitted.

2.3.11 Guidance in respect of the survey and certification of marine diesel engines at initial, renewal, annual and intermediate surveys, as described in chapter 2 of this Code, is given in the flowcharts in appendix II of this Code. Where discrepancies exist, the text of chapter 2 takes precedence.

2.4 Technical file and onboard NO_x verification procedures

2.4.1 To enable an Administration to perform the engine surveys described in 2.1, the technical file required by 2.3.4 shall, at a minimum, contain the following information:

.1 identification of those components, settings and operating values of the engine that influences its NO_x emissions including any NO_x-reducing device or system;

.2 identification of the full range of allowable adjustments or alternatives for the components of the engine;

.3 full record of the relevant engine's performance, including the engine's rated speed and rated power;

.4 a system of onboard NO_x verification procedures to verify compliance with the NO_x emission limits during onboard verification surveys in accordance with chapter 6;

.5 a copy of the relevant parent engine test data, as given in section 2 of appendix V of this Code;

.6 if applicable, the designation and restrictions for an engine that is an engine within an engine family or engine group;

.7 specifications of those spare parts/components that, when used in the engine, according to those specifications, will result in continued compliance of the engine with the applicable NO_x emission limit; and

.8 the EIAPP Certificate, as applicable.

2.4.2 As a general principle, onboard NO_x verification procedures shall enable a surveyor to easily determine if an engine has remained in compliance with the applicable requirements of regulation 13. At the same time, it shall not be so burdensome as to unduly delay the ship or to require in-depth knowledge of the characteristics of a particular engine or specialist measuring devices not available on board.

2.4.3 The onboard NO_x verification procedure shall be one of the following methods:

.1 engine parameter check method in accordance with 6.2 to verify that an engine's component, setting and operating values have not deviated from the specifications in the engine's technical file;

.2 simplified measurement method in accordance with 6.3; or

.3 direct measurement and monitoring method in accordance with 6.4.

2.4.4 When considering which onboard NO_x verification procedures should be included in an engine's technical file to verify whether an engine complies with the applicable NO_x emission limit during the required onboard verification surveys, other than at an engine's initial onboard survey, any of the three onboard NO_x verification procedures as specified in 6.1 may be applied. However, the procedures associated with the method applied are to be approved by the Administration. If the method differs from the verification procedure method specified in the technical file as originally approved, the procedure of the method needs to be either added as an amendment to the technical file or appended as an alternative to the procedure given in the technical file. Thereafter the shipowner may choose which of the methods approved in the technical file is to be used to demonstrate compliance.

2.4.5 In addition to the method specified by the engine manufacturer and given in the technical file, as approved by the Administration for the initial certification in the engine, the shipowner shall have the option of direct measurement of NO_x emissions in accordance with 6.4. Such data may take the form of spot checks logged with other engine operating data on a regular basis and over the full range of engine operation or may result from continuous monitoring and data storage. Data must be current (taken within the last 30 days) and must have been acquired using the test procedures cited in this Code. These monitoring records shall be kept on board for three months for verification purposes by a Party in accordance with regulation 10. Data shall also be corrected for ambient conditions and fuel specification, and measuring equipment must be checked for correct calibration and operation, in accordance with the approved procedures given in the onboard operating manual. Where exhaust gas after-treatment devices are fitted that influence the NO_x emissions, the measuring point(s) must be located downstream of such devices.

Chapter 3

Nitrogen oxides emission standards

3.1 Maximum allowable NO_x emission limits for marine diesel engines

3.1.1 The maximum allowable NO_x emission limit values are given by paragraphs 3, 4, 5.1.1 and 7.4 of regulation 13 as applicable. The total weighted NO_x emissions, as measured and calculated, rounded to one decimal place, in accordance with the procedures in this Code, shall be equal to or less than the applicable calculated value corresponding to the rated speed of the engine.

3.1.2 When the engine operates on test fuel oils in accordance with 5.3, the total emission of nitrogen oxides (calculated as the total weighted emission of NO_2) shall be determined using the relevant test cycles and measurement methods as specified in this Code.

3.1.3 An engine's exhaust emissions limit value, given from the formulae included in paragraph 3, 4 or 5.1.1 of regulation 13 as applicable, and the actual calculated exhaust emissions value, rounded to one decimal place for the engine, shall be stated on the engine's EIAPP Certificate. If an engine is a member engine of an engine family or engine group, it is the relevant parent engine emission value that is compared to the applicable limit value for that engine family or engine group. The limit value given here shall be the limit value for the engine family or engine group based on the highest engine speed to be included in that engine family or engine group, in accordance with paragraph 3, 4 or 5.1.1 of regulation 13, irrespective of the rated speed of the parent engine or the rated speed of the particular engine as given on the engine's EIAPP certificate.

3.1.4 In the case of an engine to be certified in accordance with paragraph 5.1.1 of regulation 13 the specific emission at each individual mode point shall not exceed the applicable NO_x emission limit value by more than 50% except as follows:

.1 The 10% mode point in the D2 test cycle specified in 3.2.5.

.2 The 10% mode point in the C1 test cycle specified in 3.2.6.

.3 The idle mode point in the C1 test cycle specified in 3.2.6.

3.2 Test cycles and weighting factors to be applied

3.2.1 For every individual engine or parent engine of an engine family or engine group, one or more of the relevant test cycles specified in 3.2.2 to 3.2.6 shall be applied for verification of compliance with the applicable NO_x emission limit contained in regulation 13.

3.2.2 For constant-speed marine diesel engines for ship main propulsion, including diesel electric drive, test cycle E2 shall be applied in accordance with table 1.

3.2.3 For an engine connected to a controllable pitch propeller, irrespective of combinator curve, test cycle E2 shall be applied in accordance with table 1.

Table 1
Test cycle for "Constant-speed main propulsion" application
(including diesel-electric drive and all controllable-pitch propeller installations)

Test cycle type E2	Speed	100%	100%	100%	100%*
	Power	100%	75%	50%	25%
	Weighting factor	0.2	0.5	0.15	0.15

3.2.4 For propeller-law-operated main and propeller-law-operated auxiliary engines, test cycle E3 shall be applied in accordance with table 2.

Table 2
Test cycle for
"Propeller-law-operated main and propeller-law-operated auxiliary engine" application

Test cycle type E3	Speed	100%	91%	80%	63%
	Power	100%	75%	50%	25%
	Weighting factor	0.2	0.5	0.15	0.15

3.2.5 For constant-speed auxiliary engines, test cycle D2 shall be applied in accordance with table 3.

Table 3
Test cycle for "Constant-speed auxiliary engine" application

Test cycle type D2	Speed	100%	100%	100%	100%	100%
	Power	100%	75%	50%	25%	10%
	Weighting factor	0.05	0.25	0.3	0.3	0.1

3.2.6 For variable-speed, variable-load auxiliary engines, not included above, test cycle C1 shall be applied in accordance with table 4.

Table 4
Test cycle for "Variable-speed, variable-load auxiliary engine" application

Test cycle type C1	Speed	Rated				Intermediate			Idle
	Torque	100%	75%	50%	10%	100%	75%	50%	0%
	Weighting factor	0.15	0.15	0.15	0.1	0.1	0.1	0.1	0.15

* There are exceptional cases, including large bore engines intended for E2 applications, in which, due to their oscillating masses and construction, engines cannot be run at low load at nominal speed without the risk of damaging essential components. In such cases, the engine manufacturer shall make application to the Administration that the test cycle as given in table 1 above may be modified for the 25% power mode with regard to the engine speed. The adjusted engine speed at 25% power, however, shall be as close as possible to the rated engine speed, as recommended by the engine manufacturer and approved by the Administration. The applicable weighting factors for the test cycle shall remain unchanged.

3.2.7 The torque figures given in test cycle C1 are percentage values that represent for a given test mode the ratio of the required torque to the maximum possible torque at this given speed.

3.2.8 The intermediate speed for test cycle C1 shall be declared by the manufacturer, taking into account the following requirements:

.1 For engines that are designed to operate over a speed range on a full load torque curve, the intermediate speed shall be the declared maximum torque speed if it occurs between 60% and 75% of rated speed.

.2 If the declared maximum torque speed is less than 60% of rated speed, then the intermediate speed shall be 60% of the rated speed.

.3 If the declared maximum torque speed is greater than 75% of the rated speed, then the intermediate speed shall be 75% of rated speed.

.4 For engines that are not designed to operate over a speed range on the full load torque curve at steady state conditions, the intermediate speed will typically be between 60% and 70% of the maximum rated speed.

3.2.9 If an engine manufacturer applies for a new test cycle application on an engine already certified under a different test cycle specified in 3.2.2 to 3.2.6, then it may not be necessary for that engine to undergo the full certification process for the new application. In this case, the engine manufacturer may demonstrate compliance by recalculation, by applying the measurement results from the specific modes of the first certification test to the calculation of the total weighted emissions for the new test cycle application, using the corresponding weighting factors from the new test cycle.

Chapter 4

Approval for serially manufactured engines: engine family and engine group concepts

4.1 General

4.1.1 To avoid certification testing of every engine for compliance with the NO_x emission limits, one of two approval concepts may be adopted, namely the engine family or the engine group concept.

4.1.2 The engine family concept may be applied to any series-produced engines that, through their design, are proven to have similar NO_x emission characteristics, are used as produced and, during installation on board, require no adjustments or modifications that could adversely affect the NO_x emissions.

4.1.3 The engine group concept may be applied to a smaller series of engines produced for similar engine application and that require minor adjustments and modifications during installation or in service on board.

4.1.4 Initially the engine manufacturer may, at its discretion, determine whether engines should be covered by the engine family or engine group concept. In general, the type of application shall be based on whether the engines will be modified, and to what extent, after testing on a test bed.

4.2 Documentation

4.2.1 All documentation for certification must be completed and suitably stamped by the duly authorized Authority as appropriate. This documentation shall also include all terms and conditions, including replacement of spare parts, to ensure that an engine is maintained in compliance with the applicable NO_x emission limit.

4.2.2 For an engine within an engine family or engine group, the required documentation for the engine parameter check method is specified in 6.2.2.

4.3 Application of the engine family concept

4.3.1 The engine family concept provides the possibility of reducing the number of engines that must be submitted for approval testing, while providing safeguards that all engines within the engine family comply with the approval requirements. In the engine family concept, engines with similar emission characteristics and design are represented by a parent engine.

4.3.2 Engines that are series-produced and not intended to be modified may be covered by the engine family concept.

4.3.3 The selection procedure for the parent engine is such that the selected engine incorporates those features that will most adversely affect the NO_x emission level. This engine, in general, shall have the highest NO_x emission level among all of the engines in the engine family.

4.3.4 On the basis of tests and engineering judgement, the manufacturer shall propose which engines belong to an engine family, which engine(s) produce the highest NO_x emissions, and which engine(s) should be selected for certification testing.

4.3.5 The Administration shall review for certification approval the selection of the parent engine within the engine family and shall have the option of selecting a different engine, either for approval or production conformity testing, in order to have confidence that all engines within the engine family comply with the applicable NO_x emission limit.

4.3.6 The engine family concept does allow minor adjustments to the engines through adjustable features. Marine diesel engines equipped with adjustable features must comply with all requirements for any adjustment within the physically available range. A feature is not considered adjustable if it is permanently sealed or otherwise not normally accessible. The Administration may require that adjustable features be set to any specification within its adjustable range for certification or in-use testing to determine compliance with the requirements.

4.3.7 Before granting an engine family approval, the Administration shall take the necessary measures to verify that adequate arrangements have been made to ensure effective control of the conformity of production. This may include, but is not limited to:

.1 the connection between the NO_x critical component part or identification numbers as proposed for the engine family and the drawing numbers (and revision status if applicable) defining those components;

.2 the means by which the Administration will be able, at the time of a survey, to verify that the drawings used for the production of the NO_x critical components correspond to the drawings established as defining the engine family;

.3 drawing revision control arrangements. Where it is proposed by a manufacturer that revisions to the NO_x critical component drawings defining an engine family may be undertaken through the life of an engine, then the conformity of production scheme would need to demonstrate the procedures to be adopted to cover the cases where revisions will, or will not, affect NO_x emissions. These procedures shall cover drawing number allocation, effect on the identification markings on the NO_x critical components and the provision for providing the revised drawings to the Administration responsible for the original engine family approval. Where these revisions may affect the NO_x emissions the means to be adopted to assess or verify performance against the parent engine performance are to be stated together with the subsequent actions to be taken regarding advising the Administration and, where necessary, the declaration of a new parent engine prior to the introduction of those modifications into service;

.4 the implemented procedures that ensure any NO_x critical component spare parts supplied to a certified engine will be identified as given in the approved technical file and hence will be produced in accordance with the drawings as defining the engine family; or

.5 equivalent arrangements as approved by the Administration.

4.3.8 *Guidance for the selection of an engine family*

4.3.8.1 The engine family shall be defined by basic characteristics that must be common to all engines within the engine family. In some cases there may be interaction of parameters; these effects must also be taken into consideration to ensure that only engines with similar exhaust emission characteristics are included within an engine family, e.g., the number of cylinders may become a relevant parameter on some engines due to the charge air or fuel system used, but with other designs, exhaust emissions characteristics may be independent of the number of cylinders or configuration.

4.3.8.2 The engine manufacturer is responsible for selecting those engines from their different models of engines that are to be included in an engine family. The following basic characteristics, but not specifications, shall be common among all engines within an engine family:

.1 combustion cycle:
- 2-stroke cycle
- 4-stroke cycle

.2 cooling medium:
- air
- water
- oil

.3 individual cylinder displacement:
- to be within a total spread of 15%

.4 number of cylinders and cylinder configuration:
- applicable in certain cases only, e.g., in combination with exhaust gas cleaning devices

.5 method of air aspiration:
- naturally aspirated
- pressure charged

.6 fuel type:
- distillate/residual fuel oil
- dual fuel

.7 combustion chamber
- open chamber
- divided chamber

.8 valve and porting, configuration, size and number:
- cylinder head
- cylinder wall

.9 fuel system type:
- pump-line-injector
- in-line
- distributor
- single element
- unit injector
- gas valve

.10 miscellaneous features:
- exhaust gas re-circulation
- water/emulsion injection
- air injection
- charge cooling system
- exhaust after-treatment
- reduction catalyst
- oxidation catalyst
- thermal reactor
- particulates trap.

4.3.8.3 If there are engines that incorporate other features that could be considered to affect NO_x exhaust emissions, these features must be identified and taken into account in the selection of the engines to be included in the engine family.

4.3.9 *Guidance for selecting the parent engine of an engine family*

4.3.9.1 The method of selection of the parent engine for NO_x measurement shall be agreed to and approved by the Administration. The method shall be based upon selecting an engine that incorporates engine features and characteristics that, from experience, are known to produce the highest NO_x emissions expressed in grams per kilowatt hour (g/kWh). This requires detailed knowledge of the engines within the engine family. Under certain circumstances, the Administration may conclude that the worst case NO_x emission rate of the engine family can best be characterized by testing a second engine. Thus, the Administration may select an additional engine for test based upon features that indicate that it may have the highest NO_x emission levels of the engines within that engine family. If the range of engines within the engine family incorporate other variable features that could be considered to affect NO_x emissions, these features must also be identified and taken into account in the selection of the parent engine.

4.3.9.2 The parent engine shall have the highest emission value for the applicable test cycle.

4.3.10 *Certification of an engine family*

4.3.10.1 The certification shall include a list, to be prepared and maintained by the engine manufacturer and approved by the Administration, of all engines and their specifications accepted under the same engine family, the limits of their operating conditions and the details and limits of engine adjustments that may be permitted.

4.3.10.2 A pre-certificate, or EIAPP Certificate, shall be issued for a member engine of an engine family in accordance with this Code that certifies that the parent engine meets the applicable NO_x limit specified in regulation 13. Where member engine pre-certification requires the measurement of some performance values, the calibration of the equipment used for those measurements shall be in accordance with the requirements of 1.3 of appendix IV of this Code.

4.3.10.3 When the parent engine of an engine family is tested and gaseous emissions measured under the most adverse conditions specified within this Code and confirmed as complying with the applicable maximum allowable emission limits as given in 3.1, the results of the test and NO_x measurement shall be recorded in the EIAPP Certificate issued for the particular parent engine and for all member engines of the engine family.

4.3.10.4 If two or more Administrations agree to accept each other's EIAPP Certificates, then an entire engine family, certified by one of these Administrations, shall be accepted by the other Administrations which entered into that agreement with the original certifying Administration, unless the agreement specifies otherwise. Certificates issued under such agreements shall be acceptable as prima facie evidence that all engines included in the certification of the engine family comply with the specific NO_x emission requirements. There is no need for further evidence of compliance with regulation 13 if it is verified that the installed engine has not been modified and the engine adjustment is within the range permitted in the engine family certification.

4.3.10.5 If the parent engine of an engine family is to be certified in accordance with an alternative standard or a different test cycle than allowed by this Code, the manufacturer must prove to the Administration that the weighted average NO_x emissions for the appropriate test cycles fall within the relevant limit values under regulation 13 and this Code before the Administration may issue an EIAPP Certificate.

4.4 Application of the engine group concept

4.4.1 Engine group engines normally require adjustment or modification to suit the onboard operating conditions, but these adjustments or modifications shall not result in NO_x emissions exceeding the applicable limits in regulation 13.

4.4.2 The engine group concept also provides the possibility for a reduction in approval testing for modifications to engines in production or in service.

4.4.3 In general, the engine group concept may be applied to any engine type having the same design features as specified in 4.4.6, but individual engine adjustment or modification after test-bed measurement is allowed. The range of engines in an engine group and choice of parent engine shall be agreed to and approved by the Administration.

4.4.4 The application for the engine group concept, if requested by the engine manufacturer or another party, shall be considered for certification approval by the Administration. If the engine owner, with or without technical support from the engine manufacturer, decides to perform modifications on a number of similar engines in the owner's fleet, the owner may apply for an engine group certification. The engine group may be based on a parent engine that is a test engine on the test bench. Typical applications are similar modifications of similar engines in similar operational conditions. If a party other than the engine manufacturer applies for engine certification, the applicant for the engine certification takes on the responsibilities of the engine manufacturer as elsewhere given within this Code.

4.4.5 Before granting an initial engine group approval for serially produced engines, the Administration shall take the necessary measures to verify that adequate arrangements have been made to ensure effective control of the conformity of production. The requirements of 4.3.7 apply *mutatis mutandis* to this section. This requirement may not be necessary for engine groups established for the purpose of engine modification on board after an EIAPP Certificate has been issued.

4.4.6 *Guidance for the selection of an engine group*

4.4.6.1 The engine group may be defined by basic characteristics and specifications in addition to the parameters defined in 4.3.8 for an engine family.

4.4.6.2 The following parameters and specifications shall be common to engines within an engine group:

.1 bore and stroke dimensions;

.2 method and design features of pressure charging and exhaust gas system:
- constant pressure;
- pulsating system;

.3 method of charge air cooling system:
- with/without charge air cooler;

.4 design features of the combustion chamber that effect NO_x emission;

.5 design features of the fuel injection system, plunger and injection cam that may profile basic characteristics that effect NO_x emission; and

.6 rated power at rated speed. The permitted ranges of engine power (kW/cylinder) and/or rated speed are to be declared by the manufacturer and approved by the Administration.

4.4.6.3 Generally, if the criteria required by 4.4.6.2 are not common to all engines within a prospective engine group, then those engines may not be considered as an engine group. However, an engine group may be accepted if only one of those criteria is not common for all of the engines within a prospective engine group.

4.4.7 *Guidance for allowable adjustment or modification within an engine group*

4.4.7.1 Minor adjustments and modifications in accordance with the engine group concept are allowed after pre-certification or final test-bed measurement within an engine group upon agreement of the parties concerned and approval of the Administration, if:

.1 an inspection of emission-relevant engine parameters and/or provisions of the onboard NO_x verification procedures of the engine and/or data provided by the engine manufacturer confirm that the adjusted or modified engine complies with the applicable NO_x emission limit. The engine test-bed results in respect of NO_x emissions may be accepted as an option for verifying onboard adjustments or modifications to an engine within an engine group; or

.2 onboard measurement confirms that the adjusted or modified engine complies with the applicable NO_x emission limit.

4.4.7.2 Examples of adjustments and modifications within an engine group that may be permitted, but are not limited to those described below:

.1 For onboard conditions, adjustment of:
- injection timing for compensation of fuel property differences,
- injection timing for maximum cylinder pressure,
- fuel delivery differences between cylinders.

.2 For performance, modification of:
- turbocharger,
- injection pump components,
- plunger specification,
- delivery valve specification,
- injection nozzles,
- cam profiles,
- intake and/or exhaust valve,
- injection cam,
- combustion chamber.

4.4.7.3 The above examples of modifications after a test-bed trial concern essential improvements of components or engine performance during the life of an engine. This is one of the main reasons for the existence of the engine group concept. The Administration, upon application, may accept the results from a demonstration test carried out on one engine, possibly a test engine, indicating the effects of the modifications on NO_x emissions that may be accepted for all engines within that engine group without requiring certification measurements on each member engine of the engine group.

4.4.8 *Guidance for the selection of the parent engine of an engine group*

4.4.8.1 The selection of the parent engine shall be in accordance with the criteria in 4.3.9, as applicable. It is not always possible to select a parent engine from small-volume production engines in the same way as the mass-produced engines (engine family). The first engine ordered may be registered as the parent engine. Furthermore at the pre-certification test where a parent engine is not adjusted to the engine-builder-defined reference or maximum tolerance operating conditions (which may include, but not limited to, maximum combustion pressure, compression pressure, exhaust back pressure, charge air temperature) for the engine group, the measured NO_x emission values shall be corrected to the defined reference and maximum tolerance conditions on the basis of emission sensitivity tests on other representative engines. The resulting corrected average weighted NO_x emission value under reference conditions is to be stated in 1.9.6 of the Supplement to the EIAPP Certificate. In no case is the effect of the reference condition tolerances to result in an emission value that would exceed the applicable NO_x emission limit as required by regulation 13. The method used to select the parent engine to represent the engine group, the reference values and the applied tolerances shall be agreed to and approved by the Administration.

4.4.9 *Certification of an engine group*

4.4.9.1 The requirements of 4.3.10 apply *mutatis mutandis* to this section.

Chapter 5

Procedures for NO_x emission measurements on a test bed

5.1 General

5.1.1 This procedure shall be applied to every initial approval testing of a marine diesel engine regardless of the location of that testing (the methods described in 2.1.2.1 and 2.1.2.2).

5.1.2 This chapter specifies the measurement and calculation methods for gaseous exhaust emissions from reciprocating internal-combustion engines under steady-state conditions, necessary for determining the average weighted value for the NO_x exhaust gas emission.

5.1.3 Many of the procedures described below are detailed accounts of laboratory methods, since determining an emissions value requires performing a complex set of individual measurements, rather than obtaining a single measured value. Thus, the results obtained depend as much on the process of performing the measurements as they depend on the engine and test method.

5.1.4 This chapter includes the test and measurement methods, test run and test report as a procedure for a test-bed measurement.

5.1.5 In principle, during emission tests, an engine shall be equipped with its auxiliaries in the same manner as it would be used on board.

5.1.6 For many engine types within the scope of this Code, the auxiliaries which may be fitted to the engine in service may not be known at the time of manufacture or certification. It is for this reason that the emissions are expressed on the basis of brake power as defined in 1.3.13.

5.1.7 When it is not appropriate to test the engine under the conditions as defined in 5.2.3, e.g., if the engine and transmission form a single integral unit, the engine may only be tested with other auxiliaries fitted. In this case the dynamometer settings shall be determined in accordance with 5.2.3 and 5.9. The auxiliary losses shall not exceed 5% of the maximum observed power. Losses exceeding 5% shall be approved by the Administration involved prior to the test.

5.1.8 All volumes and volumetric flow rates shall be related to 273 K (0°C) and 101.3 kPa.

5.1.9 Except as otherwise specified, all results of measurements, test data or calculations required by this chapter shall be recorded in the engine's test report in accordance with 5.10.

5.1.10 References in this Code to the term "charge air" apply equally to scavenge air.

5.2 Test conditions

5.2.1 *Test condition parameter and test validity for engine family approval*

5.2.1.1 The absolute temperature T_a of the engine intake air expressed in Kelvin shall be measured, and the dry atmospheric pressure p_s, expressed in kPa, shall be measured or calculated as follows:

$$p_s = p_b - 0.01 \cdot R_a \cdot p_a$$

p_a according to formula (10)

5.2.1.2 For naturally aspirated and mechanically pressure charged engines the parameter f_a shall be determined according to the following:

$$f_a = \left(\frac{99}{p_s}\right) \cdot \left(\frac{T_a}{298}\right)^{0.7} \quad (1)$$

5.2.1.3 For turbocharged engines with or without cooling of the intake air the parameter f_a shall be determined according to the following:

$$f_a = \left(\frac{99}{p_s}\right)^{0.7} \cdot \left(\frac{T_a}{298}\right)^{1.5} \quad (2)$$

5.2.1.4 For a test to be recognized as valid for engine family approval, the parameter f_a shall be such that:

$$0.93 \leq f_a \leq 1.07 \quad (3)$$

5.2.2 *Engines with charge air cooling*

5.2.2.1 The temperature of the cooling medium and the charge air temperature shall be recorded.

5.2.2.2 All engines when equipped as intended for installation on board ships must be capable of operating within the applicable NO_x emission limit of regulation 13 at an ambient seawater temperature of 25°C. This reference temperature shall be considered in accordance with the charge air cooling arrangement applicable to the individual installation as follows:

.1 Direct seawater cooling to engine charge air coolers. Compliance with the applicable NO_x limit shall be demonstrated with a charge air cooler coolant inlet temperature of 25°C.

.2 Intermediate freshwater cooling to engine charge air coolers. Compliance with the applicable NO_x limit shall be demonstrated with the charge air cooling system operating with the designed in service coolant inlet temperature regime corresponding to an ambient seawater temperature of 25°C.

Note: Demonstration of compliance at a parent engine test for a direct seawater cooled system, as given by (.1) above, does not demonstrate compliance in accordance with the higher charge air temperature regime inherent with an intermediate freshwater cooling arrangement as required by this section.

.3 For those installations incorporating no seawater cooling, either direct or indirect, to the charge air coolers, e.g., radiator-cooled freshwater systems, air/air charge air coolers, compliance with the applicable NO_x limit shall be demonstrated with the engine and charge air cooling systems operating as specified by the manufacturer with 25°C air temperature.

5.2.2.3 Compliance with the applicable NO_x emission limit as defined by regulation 13 shall be demonstrated either by testing or by calculation using the charge air reference temperatures (T_{SCRef}) specified and justified by the manufacturer, if applicable.

5.2.3 *Power*

5.2.3.1 The basis of specific emissions measurement is uncorrected brake power as defined in 1.3.11 and 1.3.13. The engine shall be submitted with auxiliaries needed for operating the engine (e.g., fan, water pump, etc.). If it is impossible or inappropriate to install the auxiliaries on the test bench, the power absorbed by them shall be determined and subtracted from the measured engine power.

5.2.3.2 Auxiliaries not necessary for the operation of the engine and that may be mounted on the engine may be removed for the test. See also 5.1.5 and 5.1.6.

5.2.3.3 Where auxiliaries have not been removed, the power absorbed by them at the test speeds shall be determined in order to calculate the dynamometer settings, except for engines where such auxiliaries form an integral part of the engine (e.g., cooling fans for air cooled engines).

5.2.4 *Engine air inlet system*

5.2.4.1 An engine air intake system or a test shop system shall be used presenting an air intake restriction within ± 300 Pa of the maximum value specified by the manufacturer for a clean air cleaner at the speed of rated power and full-load.

5.2.4.2 If the engine is equipped with an integral air inlet system, it shall be used for testing.

5.2.5 *Engine exhaust system*

5.2.5.1 An engine exhaust system or a test shop system shall be used that presents an exhaust backpressure within ± 650 Pa of the maximum value specified by the manufacturer at the speed of rated power and full load. The exhaust system shall conform to the requirements for exhaust gas sampling, as set out in 5.9.3.

5.2.5.2 If the engine is equipped with an integral exhaust system, it shall be used for testing.

5.2.5.3 If the engine is equipped with an exhaust after-treatment device, the exhaust pipe shall have the same diameter as found in-use for at least 4 pipe diameters upstream to the inlet of the beginning of the expansion section containing the after-treatment device. The distance from the exhaust manifold flange or turbocharger outlet to the exhaust after-treatment device shall be the same as in the onboard configuration or within the distance specifications of the manufacturer. The exhaust backpressure or restriction shall follow the same criteria as above, and may be set with a valve.

5.2.5.4 Where test-bed installation prevents adjustment to the exhaust gas backpressure as required, the effect on the NO_x emissions shall be demonstrated by the engine builder and, with the approval of the Administration, the emission value duly corrected as necessary.

5.2.6 *Cooling system*

5.2.6.1 An engine cooling system with sufficient capacity to maintain the engine at normal operating temperatures prescribed by the manufacturer shall be used.

5.3 Test fuel oils

5.3.1 Fuel oil characteristics may influence the engine exhaust gas emission; in particular, some fuel-bound nitrogen can be converted to NO_x during combustion. Therefore, the characteristics of the fuel oil used for the test are to be determined and recorded. Where a reference fuel oil is used, the reference code or specifications and the analysis of the fuel oil shall be provided.

5.3.2 The selection of the fuel oil for the test depends on the purpose of the test. If a suitable reference fuel oil is not available, it is recommended to use a DM-grade (distillate) marine fuel specified in ISO 8217:2005, with properties suitable for the engine type. In case a DM-grade fuel oil is not available, a RM-grade (residual) fuel oil according to ISO 8217:2005 shall be used. The fuel oil shall be analysed for its composition of all components necessary for a clear specification and determination of DM- or RM-grade. The nitrogen content shall also be determined. The fuel oil used during the parent engine test shall be sampled during the test.

5.3.3 The fuel oil temperature shall be in accordance with the manufacturer's recommendations. The fuel oil temperature shall be measured at the inlet to the fuel injection pump, or as specified by the manufacturer, and the temperature and location of measurement recorded.

5.3.4 Dual fuel engines using liquid fuel as pilot fuel shall be tested using maximum liquid to gas fuel ratio. The liquid fraction of the fuel shall comply with 5.3.1, 5.3.2 and 5.3.3.

5.4 Measurement equipment and data to be measured

5.4.1 The emission of gaseous components by the engine submitted for testing shall be measured by the methods described in appendix III of this Code that describe the recommended analytical systems for the gaseous emissions.

5.4.2 Other systems or analysers may, subject to the approval of the Administration, be accepted if they yield equivalent results to that of the equipment referenced in 5.4.1. In establishing equivalency it shall be demonstrated that the proposed alternative systems or analysers would, as qualified by using recognized national or international standards, yield equivalent results when used to measure diesel engine exhaust emission concentrations in terms of the requirements referenced in 5.4.1.

5.4.3 For introduction of a new system the determination of equivalency shall be based upon the calculation of repeatability and reproducibility, as described in ISO 5725-1 and ISO 5725-2, or any other comparable recognized standard.

5.4.4 This Code does not contain details of flow, pressure, and temperature measuring equipment. Instead, only the accuracy requirements of such equipment necessary for conducting an emissions test are given in 1.3.1 of appendix IV of this Code.

5.4.5 *Dynamometer specification*

5.4.5.1 An engine dynamometer with adequate characteristics to perform the appropriate test cycle described in 3.2 shall be used.

5.4.5.2 The instrumentation for torque and speed measurement shall allow the measurement accuracy of the shaft power within the given limits. Additional calculations may be necessary.

5.4.5.3 The accuracy of the measuring equipment shall be such that the maximum permissible deviations given in 1.3.1 of appendix IV of this Code are not exceeded.

5.5 Determination of exhaust gas flow

5.5.1 The exhaust gas flow shall be determined by one of the methods specified in 5.5.2, 5.5.3 or 5.5.4.

5.5.2 *Direct measurement method*

5.5.2.1 This method involves the direct measurement of the exhaust flow by flow nozzle or equivalent metering system and shall be in accordance with a recognized international standard.

Note: Direct gaseous flow measurement is a difficult task. Precautions shall be taken to avoid measurement errors which will result in emission value errors.

5.5.3 *Air and fuel measurement method*

5.5.3.1 The method for determining exhaust emission flow using the air and fuel measurement method shall be conducted in accordance with a recognized international standard.

5.5.3.2 This involves measurement of the air flow and the fuel flow. Air flow-meters and fuel flow-meters with an accuracy defined in 1.3.1 of appendix IV of this Code shall be used.

5.5.3.3 The exhaust gas flow shall be calculated as follows:

$$q_{mew} = q_{maw} + q_{mf} \qquad (4)$$

5.5.3.4 The air flow-meter shall meet the accuracy specifications of appendix IV of this Code, the CO_2 analyser used shall meet the specifications of appendix III of this Code, and the total system shall meet the accuracy specifications for the exhaust gas flow as given in appendix IV of this Code.

5.5.4 *Fuel flow and carbon balance method*

5.5.4.1 This involves exhaust mass flow rate calculation from fuel consumption, fuel composition and exhaust gas concentrations using the carbon balance method, as specified in appendix VI of this Code.

5.6 Permissible deviations of instruments for engine-related parameters and other essential parameters

5.6.1 The calibration of all measuring instruments including both the measuring instruments as detailed under appendix IV of this Code and additional measuring instruments required in order to define an engine's NO_x emission performance, for example the measurement of peak cylinder or charge air pressures, shall be traceable to standards recognized by the Administration and shall comply with the requirements as set out in 1.3.1 of appendix IV of this Code.

5.7 Analysers for determination of the gaseous components

5.7.1 The analysers to determine the gaseous emissions shall meet the specifications as set out in appendix III of this Code.

5.8 Calibration of the analytical instruments

5.8.1 Each analyser used for the measurement of an engine's gaseous emissions shall be calibrated in accordance with the requirements of appendix IV of this Code.

5.9 Test run

5.9.1 *General*

5.9.1.1 Detailed descriptions of the recommended sampling and analysing systems are contained in 5.9.2 to 5.9.4 and appendix III of this Code. Since various configurations may produce equivalent results, exact conformance with these figures is not required. Additional components, such as instruments, valves, solenoids, pumps, and switches, may be used to provide additional information and coordinate the functions of the component systems. Other components which are not needed to maintain the accuracy on some systems may, with the agreement of the Administration, be excluded if their exclusion is based upon good engineering judgement.

5.9.1.2 The treatment of inlet restriction (naturally aspirated engines) or charge air pressure (turbo-charged engines) and exhaust back pressure shall be in accordance with 5.2.4 and 5.2.5 respectively.

5.9.1.3 In the case of a pressure charged engine, the inlet restriction conditions shall be taken as the condition with a clean air inlet filter and the pressure charging system working within the bounds as declared, or to be established, for the engine family or engine group to be represented by the parent engine test result.

5.9.2 *Main exhaust components: CO, CO_2, HC, NO_x and O_2*

5.9.2.1 An analytical system for the determination of the gaseous emissions in the raw exhaust gas shall be based on the use of analysers given in 5.4.

5.9.2.2 For the raw exhaust gas, the sample for all components may be taken with one sampling probe or with two sampling probes located in close proximity and internally split to the different analysers. Care must be taken that no condensation of exhaust components (including water and sulphuric acid) occurs at any point of the analytical system.

5.9.2.3 Specifications and calibration of these analysers shall be as set out in appendices III and IV of this Code, respectively.

5.9.3 *Sampling for gaseous emissions*

5.9.3.1 The sampling probes for the gaseous emissions shall be fitted at least 10 pipe diameters after the outlet of the engine, turbocharger, or last after-treatment device, whichever is furthest downstream, but also at least 0.5 m or 3 pipe diameters upstream of the exit of the exhaust gas system, whichever is greater. For a short exhaust system that does not have a location that meets both of these specifications, an alternative sample probe location shall be subject to approval by the Administration.

5.9.3.2 The exhaust gas temperature shall be at least 190°C at the HC sample probe, and at least 70°C at the sample probes for other measured gas species where they are separate from the HC sample probe.

5.9.3.3 In the case of a multi-cylinder engine with a branched exhaust manifold, the inlet of the probe shall be located sufficiently far downstream so as to ensure that the sample is representative of the average exhaust emissions from all cylinders. In the case of a multi-cylinder engine having distinct groups of manifolds, it is permissible to acquire a sample from each group individually and calculate an average exhaust emission. Alternatively, it would also be permissible to acquire a sample from a single group to represent the average exhaust emission provided that it can be justified to the Administration that the emissions from other groups are identical. Other methods, subject to the approval of the Administration, that have been shown to correlate with the above methods may be used. For exhaust emission calculation, the total exhaust mass flow shall be used.

5.9.3.4 The exhaust gas sampling system shall be leakage tested in accordance with section 4 of appendix IV of this Code.

5.9.3.5 If the composition of the exhaust gas is influenced by any exhaust after-treatment system, the exhaust gas sample shall be taken downstream of that device.

5.9.3.6 The inlet of the probe shall be located as to avoid ingestion of water that is injected into the exhaust system for the purpose of cooling, tuning or noise reduction.

5.9.4 *Checking of the analysers*

5.9.4.1 The emission analysers shall be set at zero and spanned in accordance with section 6 of appendix IV of this Code.

5.9.5 *Test cycles*

5.9.5.1 An engine shall be tested in accordance with the test cycles as defined in 3.2. This takes into account the variations in engine application.

5.9.6 *Test sequence*

5.9.6.1 After the procedures in 5.9.1 to 5.9.5 have been completed, the test sequence shall be started. The engine shall be operated in each mode, in any order, in accordance with the appropriate test cycles defined in 3.2.

5.9.6.2 During each mode of the test cycle after the initial transition period, the specified speed shall be held within ± 1% of the rated speed or ± 3 min^{-1}, whichever is greater, except for low idle, which shall be within the tolerances declared by the manufacturer. The specified torque shall be held so that the average over the period during which the measurements are being taken is within ± 2% of the rated torque at the engine's rated speed.

5.9.7 *Analyser response*

5.9.7.1 When stabilized, the output of the analysers shall be recorded both during the test and during all zero and span response checks, using a data acquisition system or a strip chart recorder. The recording period shall not be less than 10 minutes when analysing exhaust gas or not less than 3 minutes for each zero and span response check. For data acquisition systems, a minimum sampling frequency of 3 per minute shall be used. Measured concentrations of CO, HC and NO_x are to be recorded in terms of, or equivalent to, ppm to at least the nearest whole number. Measured concentrations of CO_2 and O_2 are to be recorded in terms of, or equivalent to, % to not fewer than two decimal places.

5.9.8 *Engine conditions*

5.9.8.1 The engine speed, load and other essential parameters shall be measured at each mode point only after the engine has been stabilized. The exhaust gas flow shall be measured or calculated and recorded.

5.9.9 *Re-checking the analysers*

5.9.9.1 After the emission test, the zero and span responses of the analysers shall be re-checked using a zero gas and the same span gas as used prior to the measurements. The test shall be considered acceptable if:

.1 the difference between the responses to the zero gas before and after the test is less than 2% of the initial span gas concentration; and

.2 the difference between the responses to the span gas before and after the test is less than 2% of the initial span gas concentration.

5.9.9.2 Zero- and span-drift correction shall not be applied to the analyser responses recorded in accordance with 5.9.7.

5.10 Test report

5.10.1 For every individual engine or parent engine tested to establish an engine family or engine group, the engine manufacturer shall prepare a test report that shall contain the necessary data to fully define the engine performance and enable calculation of the gaseous emissions including the data as set out in section 1 of appendix V of this Code. The original of the test report shall be maintained on file with the engine manufacturer and a certified true copy shall be maintained on file by the Administration.

5.11 Data evaluation for gaseous emissions

5.11.1 For the evaluation of the gaseous emissions, the data recorded for at least the last 60 seconds of each mode shall be averaged, and the concentrations of CO, CO_2, HC, NO_x and O_2 during each mode shall be determined from the averaged recorded data and the corresponding zero and span check data. The averaged results shall be given in terms of % to not fewer than two decimal places for CO_2 and O_2 species and in terms of ppm to at least the nearest whole number for CO, HC and NO_x species.

5.12 Calculation of the gaseous emissions

5.12.1 The final results for the test report shall be determined by following the steps in 5.12.2 to 5.12.6.

5.12.2 *Determination of the exhaust gas flow*

5.12.2.1 The exhaust gas flow rate (q_{mew}) shall be determined for each mode in accordance with one of the methods described in 5.5.2 to 5.5.4.

5.12.3 *Dry/wet correction*

5.12.3.1 If the emissions are not measured on a wet basis, the measured concentration shall be converted to a wet basis according to the following formulae:

$$c_{\mathrm{w}} = k_{\mathrm{w}} \cdot c_{\mathrm{d}} \qquad (5)$$

5.12.3.2 For the raw exhaust gas:

.1 Complete combustion where exhaust gas flow is to be determined in accordance with direct measurement method in 5.5.2 or air and fuel measurement method in 5.5.3 either of the following formulae shall be used:

$$k_{\mathrm{wr1}} = \left(1 - \frac{1.2442 \cdot H_{\mathrm{a}} + 111.19 \cdot w_{\mathrm{ALF}} \cdot \frac{q_{\mathrm{mf}}}{q_{\mathrm{mad}}}}{773.4 + 1.2442 \cdot H_{a} + \frac{q_{\mathrm{mf}}}{q_{\mathrm{mad}}} \cdot f_{\mathrm{fw}} \cdot 1000} \right) \cdot 1.008 \qquad (6)$$

or

$$k_{\mathrm{wr1}} = \left(1 - \frac{1.2442 \cdot H_{\mathrm{a}} + 111.19 \cdot w_{\mathrm{ALF}} \cdot \frac{q_{\mathrm{mf}}}{q_{\mathrm{mad}}}}{773.4 + 1.2442 \cdot H_{\mathrm{a}} + \frac{q_{\mathrm{mf}}}{q_{\mathrm{mad}}} \cdot f_{\mathrm{fw}} \cdot 1000} \right) \Bigg/ \left(1 - \frac{p_{\mathrm{r}}}{p_{\mathrm{b}}} \right) \qquad (7)$$

with:

$f_{fw} = 0.055594 \cdot w_{ALF} + 0.0080021 \cdot w_{DEL} + 0.0070046 \cdot w_{EPS}$ (8)

H_a is the absolute humidity of intake air, in g water per kg dry air

Note: H_a may be derived from relative humidity measurement, dewpoint measurement, vapour pressure measurement or dry/wet bulb measurement using the generally accepted formulae.

$$H_a = 6.22 \cdot p_a \cdot R_a / (p_b - 0.01 \cdot R_a \cdot p_a) \quad (9)$$

where:

p_a = saturation vapour pressure of the intake air, kPa

$$p_a = (4.856884 + 0.2660089 \cdot t_a + 0.01688919 \cdot t_a^2 - 7.477123 \cdot 10^{-5} \cdot t_a^3 + 8.10525 \cdot 10^{-6} \cdot t_a^4 - 3.115221 \cdot 10^{-8} \cdot t_a^5) \cdot (101.32 / 760) \quad (10)$$

with:

t_a = temperature of the intake air, °C ; $t_a = T_a - 273.15$

p_b = total barometric pressure, kPa

p_r = water vapour pressure after cooling bath of the analysis system, kPa

p_r = 0.76 kPa for cooling bath temperature 3°C

.2 Incomplete combustion, CO more than 100 ppm or HC more than 100 ppmC at one or more mode points, where exhaust gas flow is determined in accordance with direct measurement method 5.5.2, air and fuel measurement method 5.5.3 and in all cases where the carbon-balance method 5.5.4 is used – the following equation shall be used:

Note: The unit for the CO and CO_2 concentrations in (11) and (13) is %.

$$k_{wr2} = \frac{1}{1 + \alpha \cdot 0.005 \cdot (c_{CO2d} + c_{COd}) - 0.01 \cdot c_{H2d} + k_{w2} - \frac{p_r}{p_b}} \quad (11)$$

with:

$$\alpha = 11.9164 \cdot \frac{w_{ALF}}{w_{BET}} \quad (12)$$

$$c_{H2d} = \frac{0.5 \cdot \alpha \cdot c_{COd} \cdot (c_{COd} + c_{CO2d})}{c_{COd} + 3 \cdot c_{CO2d}} \quad (13)$$

$$k_{w2} = \frac{1.608 \cdot H_a}{1000 + (1.608 \cdot H_a)} \quad (14)$$

5.12.3.3 For the intake air:

$$k_{wa} = 1 - k_{w2} \quad (15)$$

5.12.4 *NO_x correction for humidity and temperature*

5.12.4.1 As the NO_x emission depends on ambient air conditions, the NO_x concentration shall be corrected for ambient air temperature and humidity with the factors in accordance with 5.12.4.5 or 5.12.4.6 as applicable.

5.12.4.2 Other reference values for humidity instead of 10.71 g/kg at the reference temperature of 25°C shall not be used.

5.12.4.3 Other correction formulae may be used if they can be justified, validated and are approved by the Administration.

5.12.4.4 Water or steam injected into the charge air (air humidification) is considered an emission control device and shall therefore not be taken into account for humidity correction. Water that condensates in the charge cooler will change the humidity of the charge air and therefore shall be taken into account for humidity correction.

5.12.4.5 For compression ignition engines:

$$k_{hd} = \frac{1}{1 - 0.0182 \cdot (H_a - 10.71) + 0.0045 \cdot (T_a - 298)} \quad (16)$$

where:

T_a = the temperature of the air at the inlet to the air filter in K;
H_a = the humidity of the intake air at the inlet to the air filter in g water per kg dry air.

5.12.4.6 For compression ignition engines with intermediate air cooler the following alternative equation shall be used:

$$k_{hd} = \frac{1}{1 - 0.012 \cdot (H_a - 10.71) - 0.00275 \cdot (T_a - 298) + 0.00285 \cdot (T_{SC} - T_{SCRef})} \quad (17)$$

where:

T_{SC} is the temperature of the charge air;
T_{SCRef} is the temperature of the charge air at each mode point corresponding to a seawater temperature of 25°C as specified in 5.2.2. T_{SCRef} is to be specified by the manufacturer.

To take the humidity in the charge air into account, the following consideration is added:

H_{SC} = humidity of the charge air, g water per kg dry air in which:
$H_{SC} = 6.22 \cdot p_{SC} \cdot 100 / (p_C - p_{SC})$

where:

p_{SC} = saturation vapour pressure of the charge air, kPa
p_C = charge air pressure, kPa

However if $H_a \geq H_{SC}$, then H_{SC} shall be used in place of H_a in formula (17).

5.12.5 *Calculation of the emission mass flow rates*

5.12.5.1 The emission mass flow rate of the respective component in the raw exhaust gas for each mode shall be calculated in accordance with 5.12.5.2 from the measured concentration as obtained in accordance with 5.11.1, the applicable u_{gas} value from table 5 and the exhaust gas mass flow rate in accordance with 5.5.

Table 5

Coefficient u_{gas} and fuel-specific parameters for raw exhaust gas

Gas		NO_x	CO	HC	CO_2	O_2
ρ_{gas} kg/m³		2.053	1.250	*	1.9636	1.4277
	ρ_e **	Coefficient u_{gas} ***				
Fuel oil	1.2943	0.001586	0.000966	0.000479	0.001517	0.001103

* depending on fuel

** ρ_e is the normal density of the exhaust gas

*** at $\lambda = 2$, wet air, 273 K, 101.3 kPa

Values for u given in table 5 are based on ideal gas properties.

5.12.5.2 The following formulae shall be applied:

$$q_{mgas} = u_{gas} \cdot c_{gas} \cdot q_{mew} \cdot k_{hd} \text{ (for NO}_x\text{)} \quad (18)$$

$$q_{mgas} = u_{gas} \cdot c_{gas} \cdot q_{mew} \text{ (for other gases)} \quad (18a)$$

where:

q_{mgas} = emission mass flow rate of individual gas, g/h
u_{gas} = ratio between density of exhaust component and density of exhaust gas, see table 5
c_{gas} = concentration of the respective component in the raw exhaust gas, ppm, wet
q_{mew} = exhaust mass flow, kg/h, wet
k_{hd} = NO_x humidity correction factor

Note: In the case of CO_2 and O_2 measurement, the concentration will normally be reported in terms of %. With regard to the application of formula 18a, these concentrations will need to be expressed in ppm. 1.0 % = 10000 ppm.

5.12.5.3 For the calculation of NO_x, the humidity correction factor k_{hd} as determined according to 5.12.4 shall be used.

5.12.5.4 The measured concentration shall be converted to a wet basis according to 5.12.3 if not already measured on a wet basis.

5.12.6 *Calculation of the specific emission*

5.12.6.1 The emission shall be calculated for all individual components in accordance with the following:

1. $$\mathrm{gas}_x = \frac{\sum_{i=1}^{i=n} \left(q_{\mathrm{mgasi}} \cdot W_{\mathrm{Fi}} \right)}{\sum_{i=1}^{i=n} \left(P_{\mathrm{i}} \cdot W_{\mathrm{Fi}} \right)} \quad (19)$$

where:

2. $$P = P_{\mathrm{m}} + P_{\mathrm{aux}} \quad (20)$$

and

q_{mgas} is the mass flow of individual gas;
P_{m} is the measured power of the individual mode;
P_{aux} is the power of the auxiliaries fitted to the engine of the individual mode.

5.12.6.2 The weighting factors and the number of modes (n) used in the above calculation shall be according to the provisions of 3.2.

5.12.6.3 The resulting average weighted NO_x emission value for the engine as determined by formula (19) shall then be compared to the applicable emission limit given in regulation 13 to determine if the engine is in compliance.

Chapter 6

Procedures for demonstrating compliance with NO_x emission limits on board

6.1 General

6.1.1 After installation of a pre-certificated engine on board a ship, every marine diesel engine shall have an onboard verification survey conducted as specified in 2.1.1.2 to 2.1.1.4 to verify that the engine continues to comply with the applicable NO_x emission limit contained in regulation 13. Such verification of compliance shall be determined by using one of the following methods:

.1 engine parameter check method in accordance with 6.2 to verify that an engine's component, settings and operating values have not deviated from the specifications in the engine's technical file;

.2 simplified measurement method in accordance with 6.3; or

.3 direct measurement and monitoring method in accordance with 6.4.

6.2 Engine parameter check method

6.2.1 *General*

6.2.1.1 Engines that meet the following conditions shall be eligible for an engine parameter check method:

.1 engines that have received a pre-certificate (EIAPP Certificate) on the test bed and those that received a certificate (EIAPP Certificate) following an initial certification survey in accordance with 2.2.4; and

.2 engines that have undergone modifications or adjustments to the designated engine components and adjustable features since they were last surveyed.

6.2.1.2 When a diesel engine is designed to run within the applicable NO_x emission limit, it is most likely that within the marine life of the engine, the NO_x emission limit may be adhered to. The applicable NO_x emission limit may, however, be contravened by adjustments or modification to the engine. Therefore, an engine parameter check method shall be used to verify whether the engine is still within the applicable NO_x emission limit.

6.2.1.3 Engine component checks, including checks of settings and an engine's operating values, are intended to provide an easy means of deducing the emissions performance of the engine for the purpose of verification that an engine with no, or minor, adjustments or modifications complies with the applicable NO_x emission limit. Where the measurement of some operating values is required, the calibration of the equipment used for those measurements shall be in accordance with the requirements of appendix IV of this Code.

6.2.1.4 The purpose of such checks is to provide a ready means of determining that an engine is correctly adjusted in accordance with the manufacturer's specification and remains in a condition of adjustment consistent with the initial certification by the Administration as being in compliance with regulation 13 as applicable.

6.2.1.5 If an electronic engine management system is employed, this shall be evaluated against the original settings to ensure that appropriate parameters are operating within "as-built" limits.

6.2.1.6 For the purpose of assessing compliance with regulation 13, it is not always necessary to measure the NO_x emissions to know that an engine, not equipped with an after-treatment device, is likely to comply with the applicable NO_x emission limit. It may be sufficient to know that the present state of the engine corresponds to the specified components, calibration or parameter adjustment state at the time of initial certification. If the results of an engine parameter check method indicate the likelihood that the engine complies with the applicable NO_x mission limit, the engine may be re-certified without direct NO_x measurement.

6.2.1.7 For an engine equipped with a NO_x-reducing device, it will be necessary to check the operation of the device as part of the engine parameter check method.

6.2.2 *Documentation for an engine parameter check method*

6.2.2.1 Every marine diesel engine shall have a technical file as required in 2.3.4 that identifies the engine's components, settings or operating values that influence exhaust emissions and must be checked to ensure compliance.

6.2.2.2 An engine's technical file shall contain all applicable information, relevant to the NO_x emission performance of the engine, on the designated engine's components, adjustable features and parameters at the time of the engine's pre-certification or onboard certification, whichever occurred first.

6.2.2.3 Dependent on the specific design of the particular engine, different onboard NO_x-influencing modifications and adjustments are possible and usual. These include the engine parameters as follows:

.1 injection timing,
.2 injection nozzle,
.3 injection pump,
.4 fuel cam,
.5 injection pressure for common rail systems,
.6 combustion chamber,
.7 compression ratio,
.8 turbocharger type and build,
.9 charge air cooler, charge air pre-heater,
.10 valve timing,
.11 NO_x abatement equipment "water injection",
.12 NO_x abatement equipment "emulsified fuel" (fuel water emulsion),
.13 NO_x abatement equipment "exhaust gas recirculation",
.14 NO_x abatement equipment "selective catalytic reduction", or
.15 other parameter(s) specified by the Administration.

6.2.2.4 The actual technical file of an engine may, based on the recommendations of the applicant for engine certification and the approval of the Administration, include less components and/or parameters than discussed in section 6.2.2.3 depending on the particular engine and the specific design.

6.2.2.5 For some parameters, different survey possibilities exist. As approved by the Administration, the shipowner, supported by the applicant for engine certification, may choose what method is applicable. Any one of, or a combination of, the methods listed in the checklist for the engine parameter check method given in appendix VII of this Code may be sufficient to show compliance.

6.2.2.6 Technical documentation in respect of engine component modification for inclusion in an engine's technical file shall include details of that modification and its influence on NO_x emissions, and it shall be supplied at the time when the modification is carried out. Test-bed data obtained from a later engine that is within the applicable range of the engine group concept may be accepted.

6.2.2.7 The shipowner or person responsible for a ship equipped with a marine diesel engine required to undergo an engine parameter check method shall maintain on board the following documentation in relation to the onboard NO_x verification procedures:

.1 a record book of engine parameters for recording all changes, including like-for-like replacements, and adjustments within the approved ranges made relative to an engine's components and settings;

.2 an engine parameter list of an engine's designated components and settings and/or the documentation of an engine's load-dependent operating values submitted by an applicant for engine certification and approved by the Administration; and

.3 technical documentation of an engine component modification when such a modification is made to any of the engine's designated engine components.

6.2.2.8 Descriptions of any changes affecting the designated engine parameters, including adjustments, parts replacements and modifications to engine parts, shall be recorded chronologically in the record book of engine parameters. These descriptions shall be supplemented with any other applicable data used for the assessment of the engine's NO_x emissions.

6.2.3 *Procedures for an engine parameter check method*

6.2.3.1 An engine parameter check method shall be carried out using the two procedures as follows:

.1 a documentation inspection of engine parameter(s) shall be carried out in addition to other inspections and include inspection of the record book of engine parameters and verification that engine parameters are within the allowable range specified in the engine's technical file; and

.2 an actual inspection of engine components and adjustable features shall be carried out as necessary. It shall then be verified, also referring to the results of the documentation inspection, that the engine's adjustable features are within the allowable range specified in the engine's technical file.

6.2.3.2 The surveyor shall have the option of checking one or all of the identified components, settings or operating values to ensure that the engine with no, or minor, adjustments or modifications complies with the applicable NO_x emission limit and that only components of the approved specification, as given by 2.4.1.7, are being used. Where adjustments and/or modifications in a specification are referenced in the technical file, they must fall within the range recommended by the applicant for engine certification and approved by the Administration.

6.3 Simplified measurement method

6.3.1 *General*

6.3.1.1 The following simplified test and measurement procedure specified in this section shall be applied only for onboard confirmation tests and renewal, annual and intermediate surveys when required. Every first engine testing on a test bed shall be carried out in accordance with the procedure specified in chapter 5. Corrections for ambient air humidity and temperature in accordance with 5.12.4 are essential, as ships are sailing in cold/hot and dry/humid climates, which may cause a difference in NO_x emissions.

6.3.1.2 To gain meaningful results for onboard confirmation tests and onboard renewal, annual and intermediate surveys, as an absolute minimum, the gaseous emission concentrations of NO_x and CO_2 shall be measured in accordance with the appropriate test cycle. The weighting factors (W_F) and the number of modes (n) used in the calculation shall be in accordance with 3.2.

6.3.1.3 The engine torque and engine speed shall be measured but, to simplify the procedure, the permissible deviations of instruments (see 6.3.7) for measurement of engine-related parameters for onboard verification purposes are different from those permissible deviations allowed under the test-bed testing method. If it is difficult to measure the torque directly, the brake power may be estimated by any other means recommended by the applicant for engine certification and approved by the Administration.

6.3.1.4 In practical cases, it is often impossible to measure the fuel oil consumption once an engine has been installed on board a ship. To simplify the procedure on board, the results of the measurement of the fuel oil consumption from an engine's pre-certification test-bed testing may be accepted. In such cases, especially concerning residual fuel oil operation (RM-grade fuel oil according to ISO 8217:2005), an estimation with a corresponding estimated error shall be made. Since the fuel oil flow rate used in the calculation (q_{mf}) must relate to the fuel oil composition determined in respect of the fuel sample drawn during the test, the measurement of q_{mf} from the test-bed testing shall be corrected for any difference in net calorific values between the test bed and test fuel oils. The consequences of such an error on the final emissions shall be calculated and reported with the results of the emission measurement.

6.3.1.5 Except as otherwise specified, all results of measurements, test data or calculations required by this chapter shall be recorded in the engine's test report in accordance with 5.10.

6.3.2 *Engine parameters to be measured and recorded*

6.3.2.1 Table 6 lists the engine parameters that shall be measured and recorded during onboard verification procedures.

Table 6

Engine parameters to be measured and recorded

Symbol	Parameter	Dimension
H_a	Absolute humidity (mass of engine intake air water content related to mass of dry air)	g/kg
$n_{d,i}$	Engine speed (at the i^{th} mode during the cycle)	min^{-1}
$n_{turb,i}$	Turbocharger speed (if applicable) (at the i^{th} mode during the cycle)	min^{-1}
p_b	Total barometric pressure (in ISO 3046-1, 1995: p_x = Px = site ambient total pressure)	kPa
$p_{C,i}$	Charge air pressure after the charge air cooler (at the i^{th} mode during the cycle)	kPa
P_i	Brake power (at the i^{th} mode during the cycle)	kW
$q_{mf,i}$	Fuel oil flow (at the i^{th} mode during the cycle)	kg/h
s_i	Fuel rack position (of each cylinder, if applicable) (at the i^{th} mode during the cycle)	
T_a	Intake air temperature at air inlet (in ISO 3046-1, 1995: T_x = TTx = site ambient thermodynamic air temperature)	K
$T_{SC,i}$	Charge air temperature after the charge air cooler (if applicable) (at the i^{th} mode during the cycle)	K
T_{caclin}	Charge air cooler, coolant inlet temperature	°C
$T_{caclout}$	Charge air cooler, coolant outlet temperature	°C
$T_{Exh,i}$	Exhaust gas temperature at the sampling point (at the i^{th} mode during the cycle)	°C
T_{Fuel}	Fuel oil temperature before the engine	°C
T_{Sea}	Seawater temperature	°C

6.3.3 *Brake power*

6.3.3.1 The point regarding the ability to obtain the required data during onboard NO_x testing is particularly relevant to brake power. Although the case of directly coupled gearboxes is considered in chapter 5 (5.1.7), an engine, as may be presented on board, could, in many applications, be arranged such that the measurements of torque (as obtained from a specially installed strain gauge) may not be possible due to the absence of a clear shaft. Principal in this context would be generators, but engines may also be coupled to pumps, hydraulic units, compressors, etc.

6.3.3.2 The engines driving the machinery given in 6.3.3.1 would typically have been tested against a water brake at the manufacture stage prior to the permanent connection of the power consuming unit when installed on board. For generators it should not pose a problem to use voltage and amperage measurements together with a manufacturer's declared generator efficiency. For propeller-law-governed equipment, a declared speed power curve may be applied together with ensured capability to measure engine speed, either from the free end or by ratio of, for example, the camshaft speed.

6.3.4 *Test fuel oils*

6.3.4.1 Generally all emission measurements shall be carried out with the engine running on marine diesel fuel oil of an ISO 8217:2005, DM-grade.

6.3.4.2 To avoid an unacceptable burden to the shipowner, the measurements for confirmation tests or re-surveys may, based on the recommendation of the applicant for engine certification and the approval of the Administration, be allowed with an engine running on residual fuel oil of an ISO 8217:2005, RM-grade. In such a case the fuel-bound nitrogen and the ignition quality of the fuel oil may have an influence on the NO_x emissions of the engine.

6.3.5 *Sampling for gaseous emissions*

6.3.5.1 The general requirements described in 5.9.3 shall be also applied for onboard measurements.

6.3.5.2 The installation on board of all engines shall be such that these tests may be performed safely and with minimal interference to the engine. Adequate arrangements for the sampling of the exhaust gas and the ability to obtain the required data shall be provided on board a ship. The uptakes of all engines shall be fitted with an accessible standard sampling point. An example of a sample point connecting flange is given in section 5 of appendix VIII of this Code.

6.3.6 *Measurement equipment and data to be measured*

6.3.6.1 The emission of gaseous pollutants shall be measured by the methods described in chapter 5.

6.3.7 *Permissible deviation of instruments for engine-related parameters and other essential parameters*

6.3.7.1 Tables 3 and 4 contained in section 1.3 of appendix IV of this Code list the permissible deviation of instruments to be used in the measurement of engine-related parameters and other essential parameters during onboard verification procedures.

6.3.8 *Determination of the gaseous components*

6.3.8.1 The analytical measuring equipment and the methods described in chapter 5 shall be applied.

6.3.9 *Test cycles*

6.3.9.1 Test cycles used on board shall conform to the applicable test cycles specified in 3.2.

6.3.9.2 Engine operation on board under a test cycle specified in 3.2 may not always be possible, but the test procedure shall, based on the recommendation of the engine manufacturer and approval by the Administration, be as close as possible to the procedure defined in 3.2. Therefore, values measured in this case may not be directly comparable with test-bed results because measured values are very much dependent on the test cycles.

6.3.9.3 If the number of measuring points on board is different than those on the test bed, the measuring points and the weighting factors shall be in accordance with the recommendations of the applicant for engine certification and approved by the Administration, taking into account the provisions of 6.4.6.

6.3.10 *Calculation of gaseous emissions*

6.3.10.1 The calculation procedure specified in chapter 5 shall be applied, taking into account the special requirements of this simplified measurement procedure.

6.3.11 *Allowances*

6.3.11.1 Due to the possible deviations when applying the simplified measurement procedures of this chapter on board a ship, an allowance of 10% of the applicable limit value may be accepted for confirmation tests and renewal, annual and intermediate surveys only.

6.3.11.2 The NO_x emission of an engine may vary depending on the ignition quality of the fuel oil and the fuel-bound nitrogen. If there is insufficient information available on the influence of the ignition quality on the NO_x formation during the combustion process and the fuel-bound nitrogen conversion rate also depends on the engine efficiency, an allowance of 10% may be granted for an onboard test run carried out on an RM-grade fuel oil (ISO 8217:2005), except that there will be no allowance for the pre-certification test on board. The fuel oil used shall be analysed for its composition of carbon, hydrogen, nitrogen, sulphur and, to the extent given in ISO 8217:2005, any additional components necessary for a clear specification of the fuel oil.

6.3.11.3 In no case shall the total granted allowance for both the simplification of measurements on board and the use of residual fuel oil of an ISO 8217:2005, RM-grade fuel oil, exceed 15% of the applicable limit value.

6.4 Direct measurement and monitoring method

6.4.1 *General*

6.4.1.1 The following direct measurement and monitoring procedure may be applied for onboard verification at renewal, annual and intermediate surveys.

6.4.1.2 Due attention is to be given to the safety implications related to the handling and proximity of exhaust gases, the measurement equipment and the storage and use of cylindered pure and calibration gases. Sampling positions and access staging shall be such that this monitoring may be performed safely and will not interfere with the engine.

6.4.2 *Emission species measurement*

6.4.2.1 Onboard NO_x monitoring includes, as an absolute minimum, the measurement of gaseous emission concentrations of NO_x (as $NO + NO_2$).

6.4.2.2 If exhaust gas mass flow is to be determined in accordance with the carbon balance method in accordance with appendix VI of this Code, then CO_2 shall also be measured. Additionally CO, HC and O_2 may be measured.

6.4.3 *Engine performance measurements*

6.4.3.1 Table 7 lists the engine performance parameters that shall be measured, or calculated, and recorded at each mode point during onboard NO_x monitoring.

Table 7
Engine parameters to be measured and recorded

Symbol	Parameter	Dimension
n_d	Engine speed	min^{-1}
p_C	Charge air pressure at receiver	kPa
P	Brake power (as specified below)	kW
P_{aux}	Auxiliary power (if relevant)	kW
T_{sc}	Charge air temperature at receiver (if applicable)	K
T_{caclin}	Charge air cooler, coolant inlet temperature (if applicable)	°C
$T_{caclout}$	Charge air cooler, coolant outlet temperature (if applicable)	°C
T_{Sea}	Seawater temperature (if applicable)	°C
q_{mf}	Fuel oil flow (as specified below)	kg/h

6.4.3.2 Other engine settings necessary to define engine-operating conditions, e.g., waste-gate, charge air bypass, turbocharger status, shall be determined and recorded.

6.4.3.3 The settings and operating conditions of any NO_x-reducing devices shall be determined and recorded.

6.4.3.4 If it is difficult to measure power directly, uncorrected brake power may be estimated by any other means as approved by the Administration. Possible methods to determine brake power include, but are not limited to:

.1 indirect measurement in accordance with 6.3.3; or

.2 by estimation from nomographs.

6.4.3.5 The fuel oil flow (actual consumption rate) shall be determined by:

.1 direct measurement; or

.2 test-bed data in accordance with 6.3.1.4.

6.4.4 *Ambient condition measurements*

6.4.4.1 Table 8 lists the ambient condition parameters that shall be measured, or calculated, and recorded at each mode point during onboard NO_x monitoring.

Table 8

Ambient condition parameters to be measured and recorded

Symbol	Parameter	Dimension
H_a	Absolute humidity (mass of engine intake air water content related to mass of dry air)	g/kg
p_b	Total barometric pressure (in ISO 3046-1, 1995: p_x=P_x=site ambient total pressure)	kPa
T_a	Temperature at air inlet (in ISO 3046-1, 1995: T_x=TT_x=site ambient thermodynamic air temperature)	K

6.4.5 *Engine performance and ambient condition monitoring equipment*

6.4.5.1 The engine performance and ambient condition monitoring equipment shall be installed and maintained in accordance with manufacturers' recommendations such that requirements of section 1.3 and tables 3 and 4 of appendix IV of this Code are met in respect of the permissible deviations.

6.4.6 *Test cycles*

6.4.6.1 Engine operation on board under a specified test cycle may not always be possible, but the test procedure, as approved by the Administration, shall be as close as possible to the procedure defined in 3.2. Therefore, values measured in this case may not be directly comparable with test-bed results because measured values are very much dependant on the test cycle.

6.4.6.2 In the case of the E3 test cycle, if the actual propeller curve differs from the E3 curve, the load point used shall be set using the engine speed, or the corresponding mean effective pressure (MEP) or mean indicated pressure (MIP), given for the relevant mode of that cycle.

6.4.6.3 Where the number of measuring points on board is different from those on the test bed, the number of measurement points and the associated revised weighting factors shall be approved by the Administration.

6.4.6.4 Further to 6.4.6.3, where the E2, E3 or D2 test cycles are applied, a minimum of load points shall be used of which the combined nominal weighting factor, as given in 3.2, is greater than 0.5.

6.4.6.5 Further to 6.4.6.3, where the C1 test cycle is applied, a minimum of one load point shall be used from each of the rated, intermediate and idle speed sections. If the number of measuring points on board is different from those on the test bed, the nominal weighting factors at each load point shall be increased proportionally in order to sum to unity (1.0).

6.4.6.6 With regard to the application of 6.4.6.3, guidance in respect of the selection of load points and revised weighting factors is given in section 6 of appendix VIII of this Code.

6.4.6.7 The actual load points used to demonstrate compliance shall be within ± 5% of the rated power at the modal point except in the case of 100% load, where the range shall be +0 to –10%. For example, at the 75% load point the acceptable range shall be 70% – 80% of rated power.

6.4.6.8 At each selected load point, except idle, and after the initial transition period (if applicable), the engine power shall be maintained at the load set point within a 5% coefficient of variance (%C.O.V.) over a 10-minute interval. A worked example of the coefficient of variance calculation is given in section 7 of appendix VIII of this Code.

6.4.6.9 Regarding the C1 test cycle, the idle speed tolerance shall be declared, subject to the approval of the Administration.

6.4.7 *Test condition parameter*

6.4.7.1 The test condition parameter specified in 5.2.1 shall not apply to onboard NO_x monitoring. Data under any prevailing ambient condition shall be acceptable.

6.4.8 *Analyser in-service performance*

6.4.8.1 Analysing equipment shall be operated in accordance with manufacturer's recommendations.

6.4.8.2 Prior to measurement, zero and span values shall be checked and the analysers shall be adjusted as necessary.

6.4.8.3 After measurement, analyser zero and span values shall be verified as being within that permitted by 5.9.9.

6.4.9 *Data for emission calculation*

6.4.9.1 The output of the analysers shall be recorded both during the test and during all response checks (zero and span). These data shall be recorded on a strip chart recorder or other types of data recording devices. Data recording precision shall be in accordance with 5.9.7.1.

6.4.9.2 For the evaluation of the gaseous emissions, a 1-Hertz minimum chart reading of a stable 10-minute sampling interval of each load point shall be averaged. The average concentrations of NO_x, and, if required CO_2, and, optionally, CO, HC and O_2, shall be determined from the averaged chart readings and the corresponding calibration data.

6.4.9.3 As a minimum, emission concentrations, engine performance and ambient condition data shall be recorded over the aforementioned 10-minute period.

6.4.10 *Exhaust gas flow rate*

6.4.10.1 Exhaust gas flow rate shall be determined:

.1 in accordance with 5.5.2 or 5.5.3; or

.2 in accordance with 5.5.4 and appendix VI of this Code, with not measured species set to zero and c_{CO2d} set to 0.03%.

6.4.11 *Fuel oil composition*

6.4.11.1 Fuel oil composition, to calculate gas mass flow wet, q_{mf}, shall be provided by one of the following:

.1 fuel oil composition, carbon, hydrogen, nitrogen and oxygen, by analysis (default oxygen value may be adopted); or

.2 default values as given in table 9.

Table 9
Default fuel oil parameters

	Carbon	Hydrogen	Nitrogen	Oxygen
	w_{BET}	w_{ALF}	w_{DEL}	w_{EPS}
Distillate fuel oil (ISO 8217:2005, DM grade)	86.2%	13.6%	0.0%	0.0%
Residual fuel oil (ISO 8217:2005, RM grade)	86.1%	10.9%	0.4%	0.0%

6.4.12 *Dry/wet correction*

6.4.12.1 If not already measured on a wet basis, the gaseous emissions concentrations shall be converted to a wet basis according to:

.1 direct measurement of the water component; or

.2 dry/wet correction calculated in accordance with 5.12.3.

6.4.13 *NO_x correction for humidity and temperature*

6.4.13.1 NO_x correction for humidity and temperature shall be in accordance with 5.12.4. The reference charge air temperature (T_{SCRef}) shall be stated and approved by the Administration. The T_{SCRef} values are to be referenced to 25°C seawater temperature and in the application of the T_{SCRef} value due allowance shall be made for the actual seawater temperature.

6.4.14 *Calculation of emission flow rates and specific emissions*

6.4.14.1 The calculation of emission flow rates and specific emissions shall be in accordance with 5.12.5 and 5.12.6.

6.4.15 *Limit value and allowances*

6.4.15.1 In the case of the application of 6.4.6.3 the emission value obtained shall, subject to the approval of the Administration, be corrected as follows:

$$\text{Corrected gas}_x = \text{gas}_x \cdot 0.9 \qquad (21)$$

6.4.15.2 The emission value, gas_x or corrected gas_x as appropriate, shall be compared to the applicable NO_x emission limit value as given in regulation 13 together with the allowance values as given in 6.3.11.1, 6.3.11.2 and 6.3.11.3 in order to verify that an engine continues to comply with the requirements of regulation 13.

6.4.16 *Data for demonstrating compliance*

6.4.16.1 Compliance is required to be demonstrated at renewal, annual and intermediate surveys or following a substantial modification as per 1.3.2. In accordance with 2.4.5, data are required to be current; that is within 30 days. Data are required to be retained on board for at least three months. These time periods shall be taken to be when the ship is in operation. Data within that 30-day period either may be collected as a single test sequence across the required load points or may be obtained on two or more separate occasions when the engine load corresponds to that required by 6.4.6.

6.4.17 *Form of approval*

6.4.17.1 The direct measurement and monitoring method shall be documented in an onboard monitoring manual. The onboard monitoring manual shall be submitted to the Administration for approval. The approval reference of that onboard monitoring manual shall be entered under section 3 of the supplement to the EIAPP Certificate. The Administration may issue a new EIAPP Certificate, with the details in section 3 of the supplement duly amended, if the method is approved after the issue of the first EIAPP Certificate, i.e. following the pre-certification survey.

6.4.18 *Survey of equipment and method*

6.4.18.1 The survey of the direct measurement and monitoring method shall take into account, but is not limited to:

.1 the data obtained and developed from the required measurements; and

.2 the means by which those data have been obtained, taking into account the information given in the onboard monitoring manual, as required by 6.4.14.

Chapter 7

Certification of an existing engine

7.1 Where an existing engine is to comply with regulation 13.7, then the entity responsible for obtaining emissions certification shall apply to the approving Administration for certification.

7.2 Where an application for approved method approval includes gaseous emission measurements and calculations, those are to be in accordance with chapter 5.

7.3 Emission and performance data obtained from one engine may be shown to apply to a range of engines.

7.4 The approved method for achieving compliance with regulation 13.7 shall include a copy of the approved method file that is required to accompany the engine throughout its life on board ship.

7.5 A description of the engine's onboard verification procedure shall be included in the approved method file.

7.6 After installation of the approved method, a survey shall be conducted in accordance with the approved method file. If this survey confirms compliance, the Administration shall amend the ship's IAPP Certificate accordingly.

Appendix I

Form of EIAPP Certificate
(Refer to 2.2.10 of the NO_x Technical Code 2008)

ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE

Issued under the provisions of the Protocol of 1997, as amended by resolution MEPC.176(58) in 2008, to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 related thereto (hereinafter referred to as "the Convention") under the authority of the Government of:

....
(full designation of the country)

by ....
(full designation of the competent person or organization authorized under the provisions of the Convention)

Engine manufacturer	Model number	Serial number	Test cycle(s)	Rated power (kW) and speed (rpm)	Engine approval number

THIS IS TO CERTIFY:

1 That the above-mentioned marine diesel engine has been surveyed for pre-certification in accordance with the requirements of the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines 2008 made mandatory by Annex VI of the Convention; and

2 That the pre-certification survey shows that the engine, its components, adjustable features, and technical file, prior to the engine's installation and/or service on board a ship, fully comply with the applicable regulation 13 of Annex VI of the Convention.

This certificate is valid for the life of the engine subject to surveys in accordance with regulation 5 of Annex VI of the Convention, installed in ships under the authority of this Government.

Issued at:

....
(Place of issue of certificate)

(dd/mm/yyyy) .... *(Date of issue)*

....
(Signature of duly authorized official issuing the certificate)

(Seal or stamp of the authority, as appropriate)

SUPPLEMENT TO ENGINE INTERNATIONAL AIR POLLUTION PREVENTION CERTIFICATE (EIAPP CERTIFICATE)

RECORD OF CONSTRUCTION, TECHNICAL FILE AND MEANS OF VERIFICATION

Notes:

1 This Record and its attachments shall be permanently attached to the EIAPP Certificate. The EIAPP Certificate shall accompany the engine throughout its life and shall be available on board the ship at all times.

2 The Record shall be at least in English, French or Spanish. If an official language of the issuing country is also used, this shall prevail in case of a dispute or discrepancy.

3 Unless otherwise stated, regulations mentioned in this Record refer to regulations of Annex VI of the Convention and the requirements for an engine's technical file and means of verifications refer to mandatory requirements from the revised NO_x Technical Code 2008.

1 Particulars of the engine

1.1 Name and address of manufacturer ....

1.2 Place of engine build ....

1.3 Date of engine build ....

1.4 Place of pre-certification survey ....

1.5 Date of pre-certification survey ....

1.6 Engine type and model number ....

1.7 Engine serial number ....

1.8 If applicable, the engine is a parent engine ☐ or a member engine ☐ of the following engine family ☐ or engine group ☐ ....

1.9 Individual engine or engine family/engine group details:

1.9.1 Approval reference ....

1.9.2 Rated power (kW) and rated speed (rpm) values or ranges ....

1.9.3 Test cycle(s) ....

1.9.4 Parent engine(s) test fuel oil specification ....

1.9.5 Applicable NO_x emission limit (g/kWh), regulation 13.3, 13.4, or 13.5.1 (delete as appropriate) ....

1.9.6 Parent engine(s) emission value (g/kWh) ....

2 Particulars of the technical file

The technical file, as required by chapter 2 of the NO_x Technical Code 2008, is an essential part of the EIAPP Certificate and must always accompany an engine throughout its life and always be available on board a ship.

2.1 Technical file identification/approval number ....

2.2 Technical file approval date ....

3 Specifications for the onboard NO_x verification procedures

The specifications for the onboard NO_x verification procedures, as required by chapter 6 of the NO_x Technical Code 2008, are an essential part of the EIAPP Certificate and must always accompany an engine through its life and always be available on board a ship.

3.1 Engine parameter check method:
3.1.1 Identification/approval number ....
3.1.2 Approval date ....
3.2 Direct measurement and monitoring method:
3.2.1 Identification/approval number ....
3.2.2 Approval date ....

Alternatively the simplified measurement method in accordance with 6.3 of the NO_x Technical Code 2008 may be utilized.

Issued at:

....

(Place of issue of certificate)

(dd/mm/yyyy) ....

(Date of issue) *(Signature of duly authorized official issuing the certificate)*

(Seal or stamp of the authority, as appropriate)

Appendix II

Flowcharts for survey and certification of marine diesel engines
(Refer to 2.2.9 and 2.3.11 of the NO_x Technical Code 2008)

Guidance for compliance with survey and certification of marine diesel engines, as described in chapter 2 of this Code, is given in figures 1, 2 and 3 of this appendix:

Figure 1: Pre-certification survey at the manufacturer's facility

Figure 2: Initial survey on board a ship

Figure 3: Renewal, annual or intermediate survey on board a ship

Note: These flowcharts do not show the criteria for the certification of an existing engine as required by regulation 13.7.

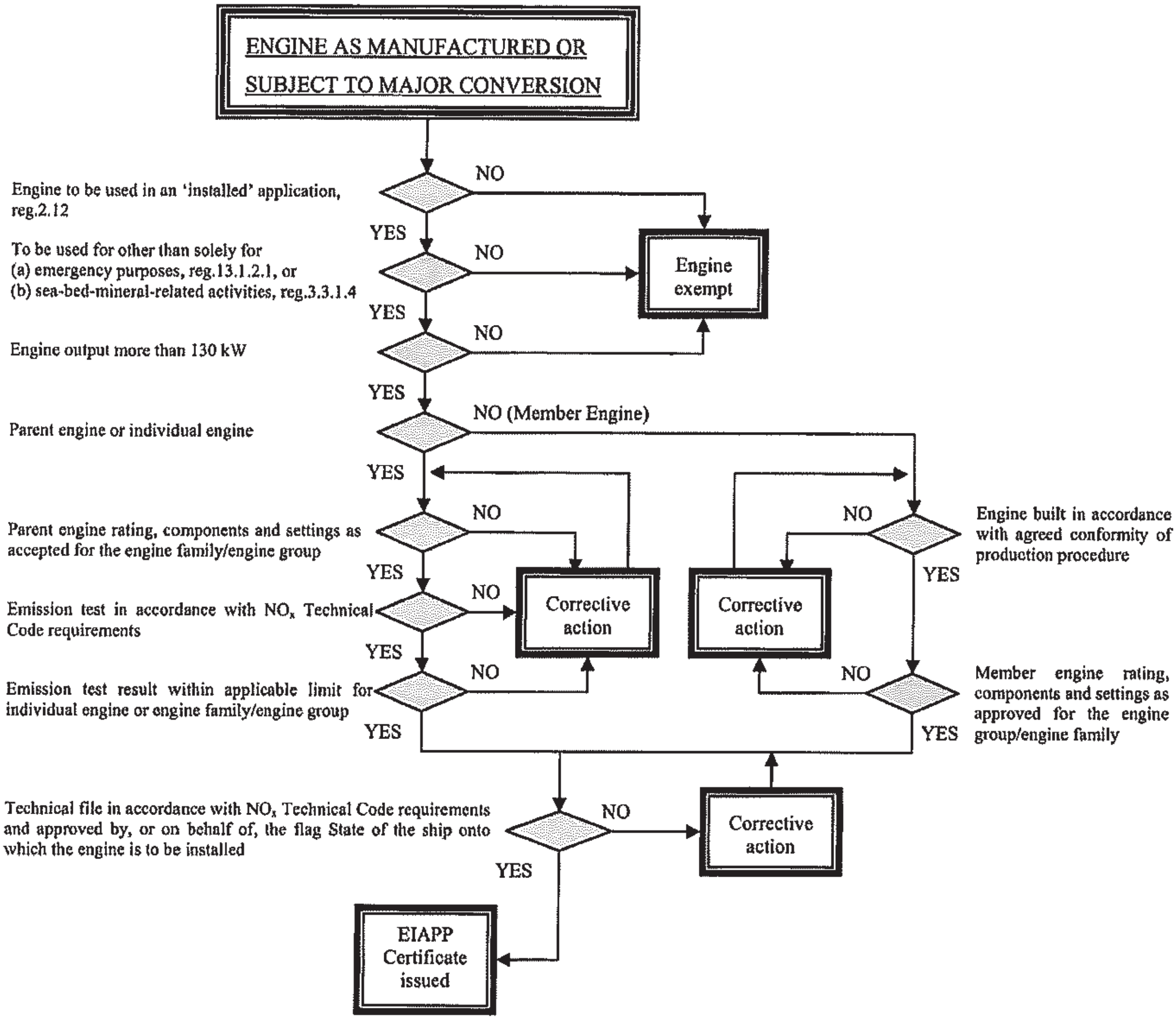

Figure 1 – Pre-certification survey at the manufacturer's facility

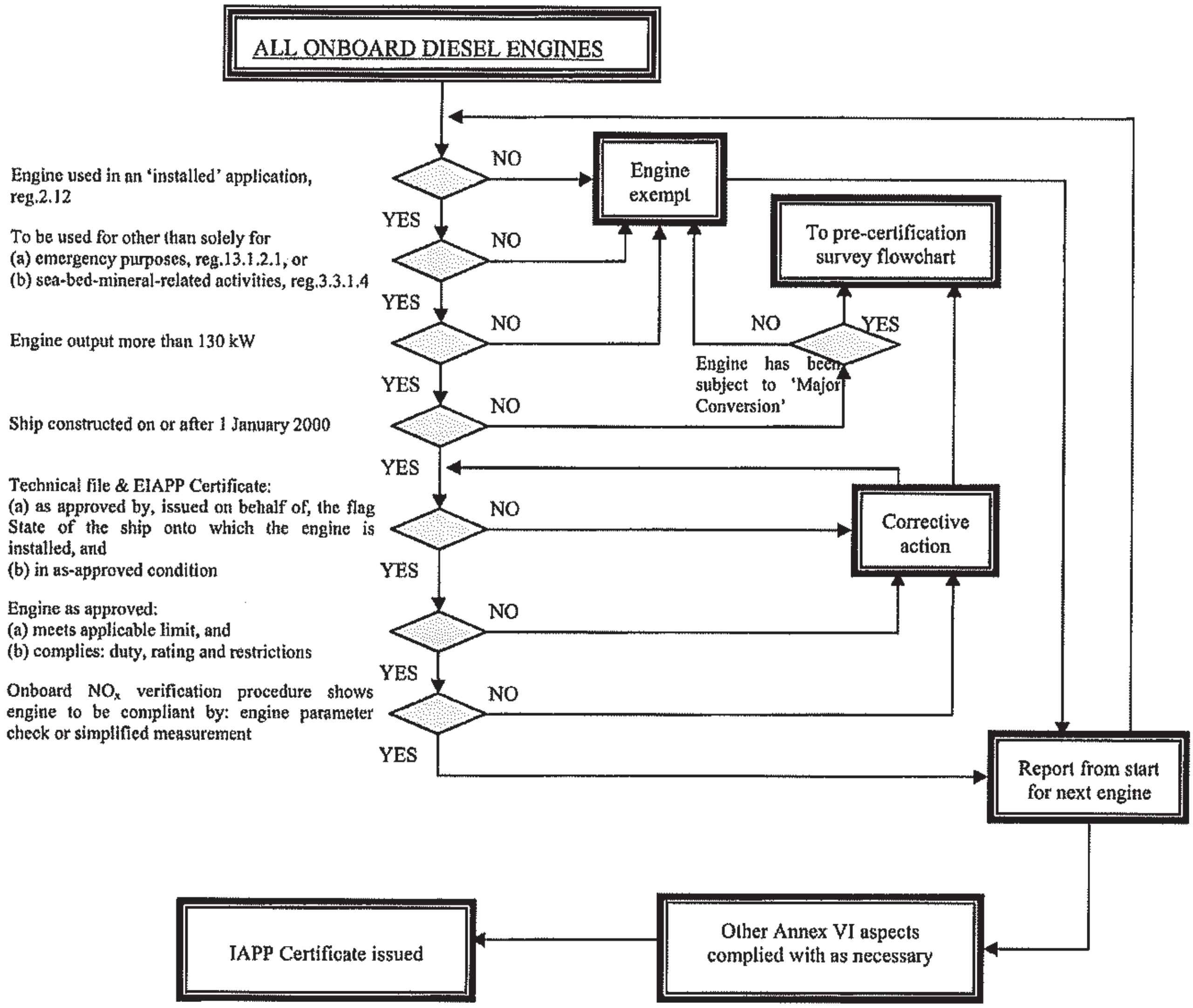

Figure 2 – Initial survey on board a ship

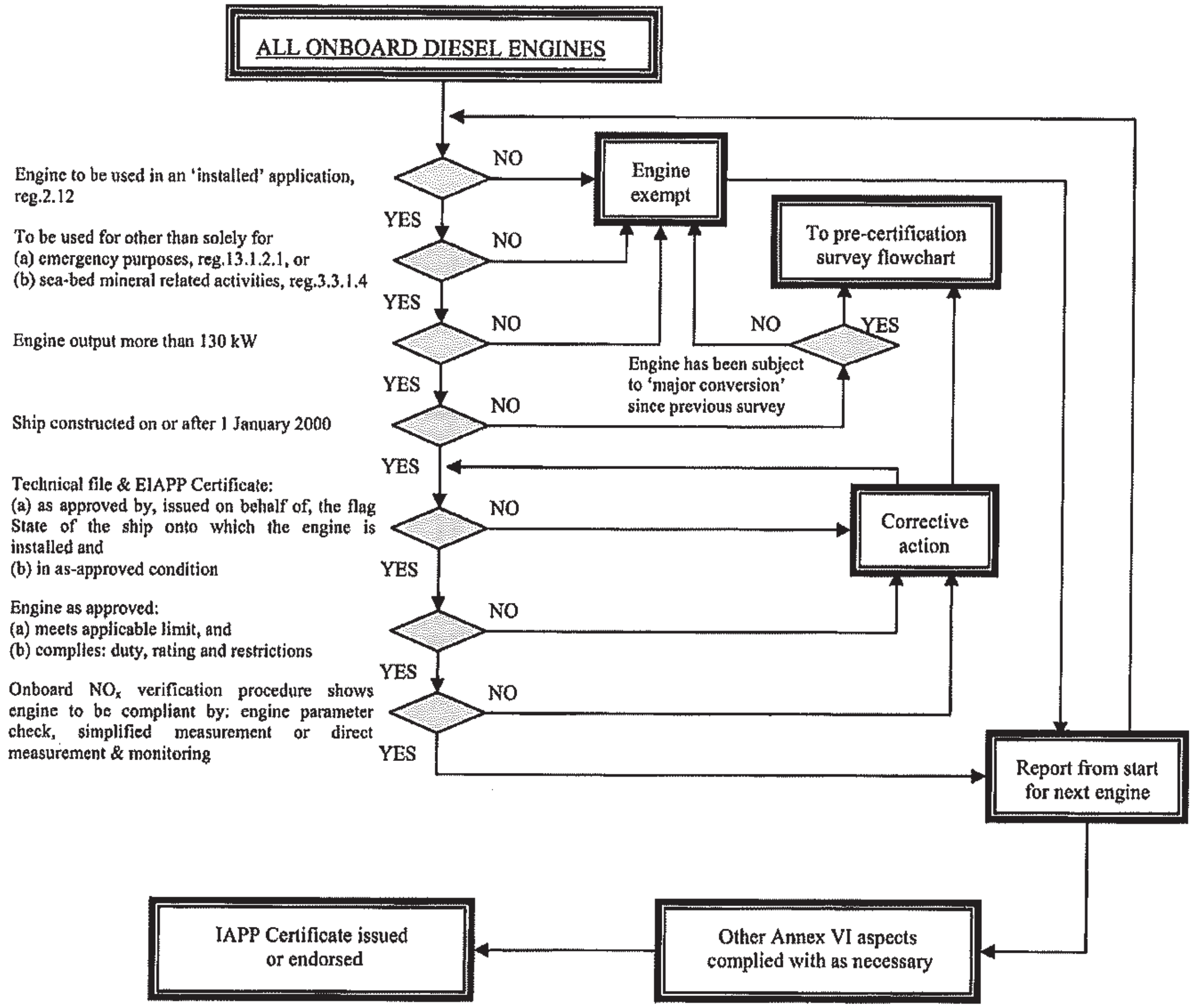

Figure 3 – Renewal, annual or intermediate survey on board a ship

Appendix III

Specifications for analysers to be used in the determination of gaseous components of marine diesel engine emissions

(Refer to chapter 5 of the NO_x Technical Code 2008)

1 General

1.1 The components included in an exhaust gas analysis system for the determination of the concentrations of CO, CO_2, NO_x, HC and O_2 are shown in figure 1. All components in the sampling gas path must be maintained at the temperatures specified for the respective systems.

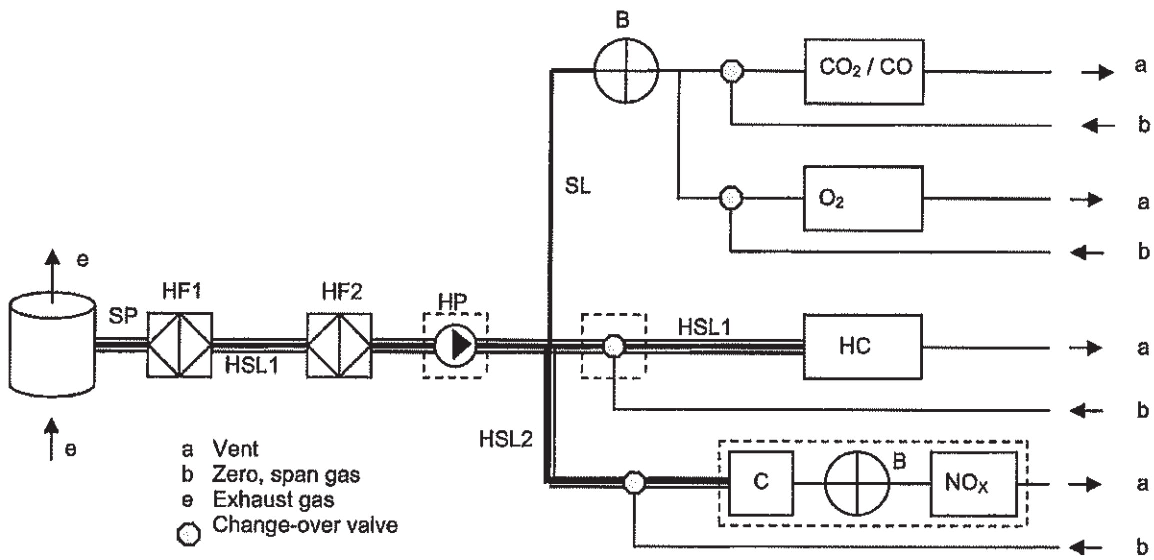

Figure 1 – Arrangement of exhaust gas analysis system

1.2 An exhaust gas analysis system shall include the following components. In accordance with chapter 5 of this Code equivalent arrangements and components may, subject to approval by the Administration, be accepted.

.1 SP – Raw exhaust gas sampling probe

A stainless steel, straight, closed-end, multi-hole probe. The inside diameter shall not be greater than the inside diameter of the sampling line. The wall thickness of the probe should not be greater than 1 mm. There should be a minimum of three holes in three different radial planes sized to sample approximately the same flow.

For the raw exhaust gas, the sample for all components may be taken with one sampling probe or with two sampling probes located in close proximity and internally split to the different analysers.

Note: If exhaust pulsations or engine vibrations are likely to affect the sampling probe, the wall thickness of the probe may be enlarged subject to the approval of the Administration.

.2 HSL1 – Heated sampling line

The sampling line provides a gas sample from a single probe to the split point(s) and the HC analyser. The sampling line shall be made of stainless steel or polytetrafluoroethylene (PTFE) and have a 4 mm minimum and a 13.5 mm maximum inside diameter.

The exhaust gas temperature at the sampling probe shall not be less than 190°C. The temperature of the exhaust gas from the sampling point to the analyser shall be maintained by using a heated filter and a heated transfer line with a wall temperature of 190°C ± 10°C.

If the temperature of the exhaust gas at the sampling probe is above 190°C, a wall temperature greater than 180°C shall be maintained.

Immediately before the heated filter and the HC analyser a gas temperature of 190°C ± 10°C shall be maintained.

.3 HSL2 – Heated NO_x sampling line

The sampling line shall be made of stainless steel or PTFE and maintain a wall temperature of 55°C to 200°C, up to the converter C when using a cooling unit B, and up to the analyser when a cooling unit B is not used.

.4 HF1 – Heated pre-filter (optional)

The required temperature shall be the same as for HSL1.

.5 HF2 – Heated filter

The filter shall extract any solid particles from the gas sample before the analyser. The temperature shall be the same as for HSL1. The filter shall be changed as necessary.

.6 HP – Heated sampling pump (optional)

The pump shall be heated to the temperature of HSL1.

.7 SL – Sampling line for CO, CO_2 and O_2

The line shall be made of PTFE or stainless steel. It may be heated or unheated.

.8 CO_2/CO – Carbon dioxide and carbon monoxide analysers

Non-dispersive infrared (NDIR) absorption. Either separate analysers or two functions incorporated into a single analyser unit.

.9 HC – Hydrocarbon analyser

Heated flame ionization detector (HFID). The temperature shall be kept at 180°C to 200°C.

.10 NO_x – Nitrogen oxides analyser

Chemiluminescent detector (CLD) or heated chemiluminescent detector (HCLD). If a HCLD is used, it shall be kept at a temperature of 55°C to 200°C.

Note: In the arrangement shown NO_x is measured on a dry basis. NO_x may also be measured on a wet basis in which case the analyser shall be of the HCLD type.

.11 C – Converter

A converter shall be used for the catalytic reduction of NO_2 to NO prior to analysis in the CLD or HCLD.

.12 O_2 – Oxygen analyser

Paramagnetic detector (PMD), zirconium dioxide (ZRDO) or electrochemical sensor (ECS).

Note: In the arrangement shown O_2 is measured on a dry basis. O_2 may also be measured on a wet basis in which case the analyser shall be of the ZRDO type.

.13 B – Cooling unit

To cool and condense water from the exhaust sample. The cooler shall be maintained at a temperature of 0°C to 4°C by ice or refrigerator. If water is removed by condensation, the sample gas temperature or dew point shall be monitored either within the water trap or downstream. The sample gas temperature or dew point shall not exceed 7°C.

1.3 The analysers shall have a measuring range appropriate for the accuracy required to measure the concentrations of the exhaust gas components (see 1.6) and 5.9.7.1 of this Code. It is recommended that the analysers be operated such that the measured concentration falls between 15% and 100% of full scale, where full scale refers to the measurement range used.

1.4 If the full-scale value is 155 ppm (or ppmC) or less, or if read-out systems (computers, data loggers) that provide sufficient accuracy and resolution below 15% of full scale are used, concentrations below 15% of full scale are also acceptable. In this case, additional calibrations are to be made to ensure the accuracy of the calibration curves.

1.5 The electromagnetic compatibility (EMC) of the equipment shall be such as to minimize additional errors.

1.6 Accuracy

1.6.1 Definitions

ISO 5725-1: 1994/Cor 1: 1998, Accuracy (trueness and precision) of measurement methods and results – Part 1: General principles and definitions, Technical Corrigendum 1.

ISO 5725-2: 1994, Accuracy (trueness and precision) of measurement methods and results – Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method.

1.6.2 An analyser shall not deviate from the nominal calibration point by more than ± 2% of the reading over the whole measurement range except zero, or ± 0.3% of full scale, whichever is larger. The accuracy shall be determined according to the calibration requirements laid down in section 5 of appendix IV of this Code.

1.7 Precision

The precision, defined as 2.5 times the standard deviation of 10 repetitive responses to a given calibration or span gas, shall be not greater than ± 1% of full-scale concentration for each range used above 100 ppm (or ppmC) or ± 2% of each range used below 100 ppm (or ppmC).

1.8 Noise

The analyser peak-to-peak response to zero and calibration or span gases over any 10-second period shall not exceed 2% of full scale on all ranges used.

1.9 Zero drift

Zero response is defined as the mean response, including noise, to a zero gas during a 30-second time interval. The drift of the zero response during a one-hour period shall be less than 2% of full scale on the lowest range used.

1.10 Span drift

Span response is defined as the mean response, including noise, to a span gas during a 30-second time interval. The drift of the span response during a one-hour period shall be less than 2% of full scale on the lowest range used.

2 Gas drying

Exhaust gases may be measured wet or dry. A gas-drying device, if used, shall have a minimal effect on the composition of the measured gases. Chemical dryers are not an acceptable method of removing water from the sample.

3 Analysers

Sections 3.1 to 3.5 describe the measurement principles to be used. The gases to be measured shall be analysed with the following instruments. For non-linear analysers, the use of linearizing circuits is permitted.

3.1 Carbon monoxide (CO) analysis

The carbon monoxide analyser shall be of the non-dispersive infrared (NDIR) absorption type.

3.2 Carbon dioxide (CO_2) analysis

The carbon dioxide analyser shall be of the non-dispersive infrared (NDIR) absorption type.

3.3 Hydrocarbon (HC) analysis

The hydrocarbon analyser shall be of the heated flame ionization detector (HFID) type with detector, valves, pipe-work and associated components heated so as to maintain a gas temperature of 190°C ± 10°C.

3.4 Nitrogen oxides (NO_x) analysis

The nitrogen oxides analyser shall be of the chemiluminescent detector (CLD) or heated chemiluminescent detector (HCLD) type with an NO_2/NO converter, if measured on a dry basis. If measured on a wet basis, a HCLD with converter maintained above 55°C shall be used, provided the water quench check (see section 9.2.2 of appendix IV of this Code) is satisfied. For both CLD and HCLD, the sampling path shall be maintained at a wall temperature of 55°C to 200°C up to the converter for dry measurement, and up to the analyser for wet measurement.

3.5 Oxygen (O_2) analysis

The oxygen analyser shall be of the paramagnetic detector (PMD), zirconium dioxide (ZRDO) or electrochemical sensor (ECS) type.

Appendix IV

Calibration of the analytical and measurement instruments
(Refer to chapters 5 and 6 of the NO_x Technical Code 2008)

1 Introduction

1.1 Each analyser used for the measurement of an engine's parameters shall be calibrated as often as necessary in accordance with the requirements of this appendix.

1.2 Except as otherwise specified, all results of measurements, test data or calculations required by this appendix shall be recorded in the engine's test report in accordance with section 5.10 of this Code.

1.3 *Accuracy of measuring instruments*

1.3.1 The calibration of all measuring instruments shall comply with the requirements as set out in tables 1, 2, 3 and 4 and shall be traceable to standards recognized by the Administration. Additional engine measurements may be required by the Administration, and such additional measuring instruments used shall comply with the appropriate deviation standard and calibration validity period.

1.3.2 The instruments shall be calibrated:

.1 in time intervals not greater than as given in tables 1, 2, 3 and 4; or

.2 in accordance with alternative calibration procedures and validity periods subject to such proposals being submitted in advance of the tests and approved by the Administration.

Note: The deviations given in tables 1, 2, 3, and 4 refer to the final recorded value, which is inclusive of the data acquisition system.

Table 1
Permissible deviations and calibration validity periods of instruments for engine-related parameters for measurements on a test bed

No.	Measurement instrument	Permissible deviation	Calibration validity period (months)
1	Engine speed	± 2% of reading or ± 1% of engine's maximum value, whichever is larger	3
2	Torque	± 2% of reading or ± 1% of engine's maximum value, whichever is larger	3

No.	Measurement instrument	Permissible deviation	Calibration validity period (months)
3	Power (where measured directly)	± 2% of reading or ± 1% of engine's maximum value, whichever is larger	3
4	Fuel consumption	± 2% of engine's maximum value	6
5	Air consumption	± 2% of reading or ± 1% of engine's maximum value, whichever is larger	6
6	Exhaust gas flow	± 2.5% of reading or ± 1.5% of engine's maximum value, whichever is larger	6

Table 2

Permissible deviations and calibration interval periods of instruments for other essential parameters for measurements on a test bed

No.	Measurement instrument	Permissible deviation	Calibration validity period (months)
1	Temperatures ≤ 327°C	± 2°C absolute	3
2	Temperatures > 327°C	± 1% of reading	3
3	Exhaust gas pressure	± 0.2 kPa absolute	3
4	Charge air pressure	± 0.3 kPa absolute	3
5	Atmospheric pressure	± 0.1 kPa absolute	3
6	Other pressures ≤ 1000 kPa	± 20 kPa absolute	3
7	Other pressures > 1000 kPa	± 2% of reading	3
8	Relative humidity	± 3% absolute	1

Table 3

Permissible deviations and calibration validity periods of instruments for engine-related parameters for measurements on board a ship when the engine is already pre-certified

No.	Measurement instrument	Permissible deviation	Calibration validity period (months)
1	Engine speed	± 2% of engine's maximum value	12
2	Torque	± 5% of engine's maximum value	12
3	Power (where measured directly)	± 5% of engine's maximum value	12
4	Fuel consumption	± 4% of engine's maximum value	12
5	Air consumption	± 5% of engine's maximum value	12
6	Exhaust gas flow	± 5% of engine's maximum value	12

Table 4

Permissible deviations calibration validity period of instruments for other essential parameters for measurements on board a ship when the engine is already pre-certified

No.	Measurement instrument	Permissible deviation	Calibration validity period (months)
1	Temperatures ≤ 327°C	± 2°C absolute	12
2	Temperatures > 327°C	± 15°C absolute	12
3	Exhaust gas pressure	± 5% of engine's maximum value	12
4	Charge air pressure	± 5% of engine's maximum value	12
5	Atmospheric pressure	± 0.5% of reading	12
6	Other pressures	± 5 % of reading	12
7	Relative humidity	± 3% absolute	6

2 Calibration gases and zero and span check gases

The shelf life of all calibration gases and span and zero check gases shall be respected. The expiry date of the calibration gases and the zero and span check gases, stated by the manufacturer, shall be recorded.

2.1 *Pure gases (including zero check gases)*

2.1.1 The required purity of the gases is defined by the contamination limits given below. The following gases shall be available:

.1 purified nitrogen (contamination ≤ 1 ppmC, ≤ 1 ppm CO, ≤ 400 ppm CO_2, ≤ 0.1 ppm NO);

.2 purified oxygen (purity > 99.5% volume O_2);

.3 hydrogen-helium mixture (40 ± 2% hydrogen, balance helium), (contamination ≤ 1 ppmC, ≤ 400 ppm CO_2); and

.4 purified synthetic air (contamination ≤ 1 ppmC, ≤ 1 ppm CO, ≤ 400 ppm CO_2, ≤ 0.1 ppm NO (oxygen content 18% – 21% volume).

2.2 *Calibration and span gases*

2.2.1 Mixtures of gases having the following chemical compositions shall be available:

.1 CO and purified nitrogen;

.2 NO_x and purified nitrogen the amount of NO_2 contained in this calibration gas shall not exceed 5% of the NO content);

.3 O_2 and purified nitrogen;

.4 CO_2 and purified nitrogen; and

.5 CH_4 and purified synthetic air or C_3H_8 and purified synthetic air.

Note: Other gas combinations are allowed provided the gases do not react with one another.

2.2.2 The true concentration of a calibration and span gas must be within ± 2% of the nominal value. All concentrations of calibration and span gases shall be given on a volume basis (volume per cent or volume ppm).

2.2.3 The gases used for calibration and span may also be obtained by means of precision blending devices (gas dividers), diluting with purified N_2 or with purified synthetic air. The accuracy of the mixing device must be such that the concentration of the blended calibration gases is accurate to within ±2%. This accuracy implies that primary gases used for blending must be known to an accuracy of at least ±1%, traceable to national or international gas standards. The verification shall be performed at between 15 and 50% of full scale for each calibration incorporating a blending device. Optionally, the blending device may be checked with an instrument that by nature is linear, e.g., using NO gas with a CLD. The span value of the instrument shall be adjusted with the span gas directly connected to the instrument. The blending device shall be checked at the used settings and the nominal value shall be compared to the measured concentration of the instrument. This difference shall in each point be within ±1% of the nominal value. This linearity check of the gas divider shall not be performed with a gas analyser that was previously linearized with the same gas divider.

2.2.4 Oxygen interference check gases shall contain propane or methane with 350 ppmC ± 75 ppmC hydrocarbon. The concentration shall be determined to calibration gas tolerances by chromatographic analysis of total hydrocarbons plus impurities or by dynamic bleeding. Nitrogen shall be the predominant diluent with the balance oxygen. Blends required are listed in table 5.

Table 5

Oxygen interference check gases

O_2 concentration	Balance
21 (20 to 22)	Nitrogen
10 (9 to 11)	Nitrogen
5 (4 to 6)	Nitrogen

3 Operating procedure for analysers and sampling system

The operating procedure for analysers shall follow the start-up and operating instructions of the instrument manufacturer. The minimum requirements given in sections 4 to 9 shall be included.

4 Leakage test

4.1 A system leakage test shall be performed. The probe shall be disconnected from the exhaust system and the end plugged. The analyser pump shall be switched on. After an initial stabilization period all flow meters shall read zero. If not, the sampling lines shall be checked and the fault corrected.

4.2 The maximum allowable leakage rate on the vacuum side shall be 0.5% of the in-use flow rate for the portion of the system being checked. The analyser flows and bypass flows may be used to estimate the in-use flow rates.

4.3 Another method is the introduction of a concentration step change at the beginning of the sampling line by switching from zero to span gas. If after an adequate period of time the reading shows a lower concentration compared to the introduced concentration, this points to calibration or leakage problems.

4.4 Other arrangements may be acceptable subject to approval of the Administration.

5 Calibration procedure

5.1 *Instrument assembly*

The instrument assembly shall be calibrated and the calibration curves checked against standard gases. The same gas flow rates shall be used as when sampling exhaust.

5.2 *Warming-up time*

The warming-up time shall be according to the recommendations of the analyser's manufacturer. If not specified, a minimum of two hours is recommended for warming up the analysers.

5.3 *NDIR and HFID analysers*

The NDIR analyser shall be tuned, as necessary. The HFID flame shall be optimized as necessary.

5.4 *Calibration*

5.4.1 Each normally used operating range shall be calibrated. Analysers shall be calibrated not more than 3 months before being used for testing or whenever a system repair or change is made that can influence calibration, or as per provided for by 1.3.2.2.

5.4.2 Using purified synthetic air (or nitrogen) the CO, CO_2, NO_x and O_2 analysers shall be set at zero. The HFID analyser shall be set to zero using purified synthetic air.

5.4.3 The appropriate calibration gases shall be introduced to the analysers, the values recorded, and the calibration curve established accordingly.

5.5 *Establishment of the calibration curve*

5.5.1 General Guidance

5.5.1.1 The calibration curve shall be established by at least 6 calibration points (excluding zero) approximately equally spaced over the operating range from zero to the highest value expected during emissions testing.

5.5.1.2 The calibration curve shall be calculated by the method of least-squares. A best-fit linear or non-linear equation may be used.

5.5.1.3 The calibration points shall not differ from the least-squares best-fit line by more than ± 2% of reading or ± 0.3% of full scale, whichever is larger.

5.5.1.4 The zero setting shall be rechecked and the calibration procedure repeated, if necessary.

5.5.1.5 If it can be shown that alternative calibration methods (e.g., computer, electronically controlled range switch, etc.) can give equivalent accuracy, then these alternatives may be used subject to the approval by the Administration.

6 Verification of the calibration

6.1 Each normally used operating range shall be checked prior to each analysis in accordance with the following procedure:

.1 the calibration shall be checked by using a zero gas and a span gas whose nominal value shall be more than 80% of full scale of the measuring range; and

.2 if, for the two points considered, the value found does not differ by more than ± 4% of full scale from the declared reference value, the adjustment parameters may be modified. If this is not the case, a new calibration curve shall be established in accordance with 5.5 above.

7 Efficiency test of the NO_x converter

The efficiency of the converter used for the conversion of NO_2 into NO shall be tested as given in 7.1 to 7.10 below.

7.1 *Test set-up*

Using the test set-up as schematically shown in figure 1 and the procedure below, the efficiency of converter shall be tested by means of an ozonator.

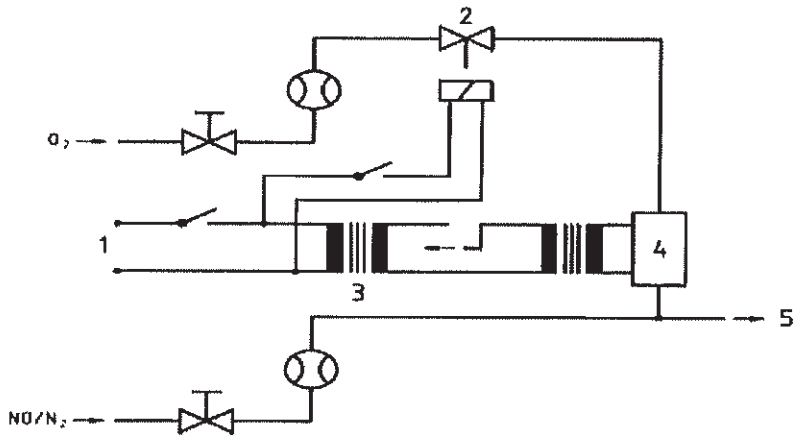

Figure 1 – Schematic representation of NO_2 converter efficiency device

1 AC
2 Solenoid valve
3 Variac
4 Ozonator
5 To analyser

7.2 *Calibration*

The CLD and the HCLD shall be calibrated in the most common operating range following the manufacturer's specifications using zero and span gas (the NO content of which must amount to about 80% of the operating range and the NO_2 concentration of the gas mixture to less than 5% of the NO concentration). The NO_x analyser must be in the NO mode so that the span gas does not pass through the converter. The indicated concentration shall be recorded.

7.3 *Calculation*

The efficiency of the NO_x converter shall be calculated as follows:

3. $$E_{NOx} = \left(1 + \frac{a-b}{c-d}\right) \cdot 100 \qquad (1)$$

where:

a = NO_x concentration according to 7.6 below
b = NO_x concentration according to 7.7 below
c = NO concentration according to 7.4 below
d = NO concentration according to 7.5 below.

7.4 *Adding of oxygen*

7.4.1 Via a T-fitting, oxygen or zero air is added continuously to the gas flow until the concentration indicated is about 20% less than the indicated calibration concentration given in 7.2 above. The analyser must be in the NO mode.

7.4.2 The indicated concentration (*c*) shall be recorded. The ozonator must be kept deactivated throughout the process.

7.5 *Activation of the ozonator*

The ozonator shall then be activated to generate enough ozone to bring the NO concentration down to about 20% (minimum 10%) of the calibration concentration given in 7.2 above. The indicated concentration (*d*) shall be recorded. The analyser must be in the NO mode.

7.6 *NO_x mode*

The NO analyser shall then be switched to the NO_x mode so that the gas mixture (consisting of NO, NO_2, O_2 and N_2) now passes through the converter. The indicated concentration (*a*) shall be recorded. The analyser must be in the NO_x mode.

7.7 *Deactivation of the ozonator*

The ozonator is then deactivated. The mixture of gases described in 7.6 above passes through the converter into the detector. The indicated concentration (*b*) shall be recorded. The analyser is in the NO_x mode.

7.8 *NO mode*

Switched to NO mode with the ozonator deactivated, the flow of oxygen or synthetic air shall also be shut off. The NO_x reading of the analyser shall not deviate by more than 5% from the value measured according to 7.2 above. The analyser must be in the NO mode.

7.9 *Test interval*

The efficiency of the converter shall be tested prior to each calibration of the NO_x analyser.

7.10 *Efficiency requirement*

The efficiency of the converter shall not be less than 90%.

8 Adjustment of the HFID

8.1 *Optimization of the detector response*

8.1.1 The HFID shall be adjusted as specified by the instrument manufacturer. A propane in air span gas shall be used to optimize the response on the most common operating range.

8.1.2 With the fuel and air flow rates set at the manufacturer's recommendations, a 350 ± 75 ppmC span gas shall be introduced to the analyser. The response at a given fuel flow shall be determined from the difference between the span gas response and the zero gas response. The fuel flow shall be incrementally adjusted above and below the manufacturer's specification. The span and zero response at these fuel flows shall be recorded. The difference between the span and zero response shall be plotted and the fuel flow adjusted to the rich side of the curve. This is the initial flow rate setting, which may need further optimization depending on the results of the hydrocarbon response factors and the oxygen interference check according to 8.2 and 8.3.

8.1.3 If the oxygen interference or the hydrocarbon response factors do not meet the following specifications, the air flow shall be incrementally adjusted above and below the manufacturer's specifications, 8.2 and 8.3 for each flow.

8.1.4 The optimization may optionally be conducted using alternative procedures subject to the approval of the Administration.

8.2 *Hydrocarbon response factors*

8.2.1 The analyser shall be calibrated using propane in air and purified synthetic air, according to 5.

8.2.2 Response factors shall be determined when introducing an analyser into service and after major service intervals. The response factor (r_h) for a particular hydrocarbon species is the ratio of the HFID ppmC reading to the gas concentration in the cylinder expressed in terms of ppmC.

8.2.3 The concentration of the test gas must be at a level to give a response of approximately 80% of full scale. The concentration must be known to an accuracy of ± 2% in reference to a gravimetric standard expressed in volume. In addition, the gas cylinder must be preconditioned for 24 hours at a temperature of 25°C ± 5°C.

8.2.4 The test gases to be used and the recommended relative response factor ranges are as follows:

- Methane and purified synthetic air $1.00 \leq r_h \leq 1.15$
- Propylene and purified synthetic air $0.90 \leq r_h \leq 1.1$
- Toluene and purified synthetic air $0.90 \leq r_h \leq 1.1$.

These values are relative to a r_h of 1 for propane and purified synthetic air.

8.3 *Oxygen interference check*

8.3.1 The oxygen interference check shall be determined when introducing an analyser into service and after major service intervals.

8.3.2 A range shall be chosen where the oxygen interference check gases will fall in the upper 50%. The test shall be conducted with the oven temperature set as required. The oxygen interference gases are specified in 2.2.4.

.1 The analyser shall be zeroed.

.2 The analyser shall be spanned with the 21% oxygen blend.

.3 The zero response shall be re-checked. If it has changed more than 0.5% of full scale (FS) steps 8.3.2.1 and 8.3.2.2 shall be repeated.

.4 The 5% and 10% oxygen interference check gases shall be introduced.

.5 The zero response shall be rechecked. If it has changed more than ± 1% of full scale, the test shall be repeated.

.6 The oxygen interference ($\%O_2I$) shall be calculated for each mixture in step .4 as follows:

$$\%O_2I = \frac{(B - analyser\,response)}{B} \cdot 100 \qquad (2)$$

where:

analyser response is (A/% FS at A) · (%FS at B)

where:

A = hydrocarbon concentration in ppmC (microlitres per litre) of the span gas used in 8.3.2.2

B = hydrocarbon concentration (ppmC) of the oxygen interference check gases used in 8.3.2.4

$$(ppmC) = \frac{A}{D} \qquad (3)$$

D = percentage of full scale analyser response due to A.

.7 The % of oxygen interference ($\%O_2I$) shall be less than ± 3.0% for all required oxygen interference check gases prior to testing.

.8 If the oxygen interference is greater than ± 3.0%, the air flow above and below the manufacturer's specifications shall be incrementally adjusted, repeating 8.1 for each flow.

.9 If the oxygen interference is greater than ± 3.0% after adjusting the air flow, the fuel flow, and thereafter the sample flow shall be varied, repeating 8.1 for each new setting.

.10 If the oxygen interference is still greater than ± 3.0%, the analyser, HFID fuel, or burner air shall be repaired or replaced prior to testing. This clause shall then be repeated with the repaired or replaced equipment or gases.

9 Interference effects with CO, CO_2, NO_x and O_2 analysers

Gases other than the one being analysed can interfere with the reading in several ways. Positive interference occurs in NDIR and PMD instruments where the interfering gas gives the same effect as the gas being measured, but to a lesser degree. Negative interference occurs in NDIR instruments by the interfering gas broadening the absorption band of the measured gas, and in CLD instruments by the interfering gas quenching the radiation. The interference checks in 9.1 and 9.2 shall be performed prior to an analyser's initial use and after major service intervals, but at least once per year.

9.1 *CO analyser interference check*

Water and CO_2 can interfere with the CO analyser performance. Therefore, a CO_2 span gas having a concentration of 80% to 100% of full scale of the maximum operating range used during testing shall be bubbled through water at room temperature and the analyser response recorded. The analyser response must not be more than 1% of full scale for ranges equal to or above 300 ppm or more than 3 ppm for ranges below 300 ppm.

9.2 *NO_x analyser quench checks*

The two gases of concern for CLD (and HCLD) analysers are CO_2 and water vapour. Quench responses to these gases are proportional to their concentrations, and therefore require test techniques to determine the quench at the highest expected concentrations experienced during testing.

9.2.1 CO_2 quench check

9.2.1.1 A CO_2 span gas having a concentration of 80% to 100% of full scale of the maximum operating range shall be passed through the NDIR analyser and the CO_2 value recorded as *A*. It shall then be diluted approximately 50% with NO span gas and passed through the NDIR and (H)CLD, with the CO_2 and NO values recorded as *B* and *C*, respectively. The CO_2 shall then be shut off and only the NO span gas be passed through the (H)CLD and the NO value recorded as *D*.

9.2.1.2 The quench shall be calculated as follows:

$$E_{CO2} = \left[1 - \left(\frac{(C \cdot A)}{(D \cdot A) - (D \cdot B)}\right)\right] \cdot 100 \qquad (4)$$

where:

A = the undiluted CO_2 concentration measured with NDIR in percentage by volume;
B = the diluted CO_2 concentration measured with NDIR in percentage by volume;
C = the diluted NO concentration measured with (H)CLD in ppm; and
D = the undiluted NO concentration measured with (H)CLD in ppm.

9.2.1.3 Alternative methods of diluting and quantifying of CO_2 and NO span gas values such as dynamic mixing/blending, can be used.

9.2.2 Water quench check

9.2.2.1 This check applies to wet gas concentration measurements only. Calculation of water quench must consider dilution of the NO span gas with water vapour and scaling of water vapour concentration of the mixture to that expected during testing.

9.2.2.2 An NO span gas having a concentration of 80% to 100% of full scale of the normal operating range shall be passed through the HCLD and the NO value recorded as D. The NO span gas shall then be bubbled through water at a temperature of 25°C ± 5°C and pass through the HCLD and the NO value recorded as C. The water temperature shall be determined and recorded as F. The mixture's saturation vapour pressure that corresponds to the bubbler water temperature (F) shall be determined and recorded as G. The water vapour concentration (H in %) of the mixture shall be calculated as follows:

$$H = 100 \cdot \left(\frac{G}{p_b} \right) \quad (5)$$

The expected diluted NO span gas (in water vapour) concentration (D_e) shall be calculated as follows:

$$D_e = D \cdot \left(1 - \frac{H}{100} \right) \quad (6)$$

For diesel engine exhaust, the maximum exhaust water concentration (in %) expected during testing shall be estimated, under the assumption of a fuel atom H/C ratio of 1.8/1, from the maximum CO_2 concentration A in the exhaust gas as follows:

$$H_m = 0.9 \cdot A \quad (7)$$

and H_m is recorded.

9.2.2.3 The water quench shall be calculated as follows:

$$E_{H2O} = 100 \cdot \left(\frac{D_e - C}{D_e} \right) \cdot \left(\frac{H_m}{H} \right) \quad (8)$$

where:

D_e = the expected diluted NO concentration in ppm;
C = the diluted NO concentration in ppm;
H_m = the maximum water vapour concentration in %; and
H = the actual water vapour concentration in %.

Note: It is important that the NO span gas contains minimal NO_2 concentration for this check, as absorption of NO_2 in water has not been accounted for in the quench calculations.

9.2.3 Maximum allowable quench

The maximum allowable quench shall be:

.1 CO_2 quench according to 9.2.1: 2% of full scale.
.2 Water quench according to 9.2.2: 3% of full scale.

9.3 *O_2 analyser interference*

9.3.1 Instrument response of a PMD analyser caused by gases other than oxygen is comparatively slight. The oxygen equivalents of the common exhaust gas constituents are shown in table 6.

Table 6
Oxygen equivalents

Gas	O_2 equivalent %
Carbon dioxide (CO_2)	– 0.623
Carbon monoxide (CO)	– 0.354
Nitric oxide (NO)	+ 44.4
Nitrogen dioxide (NO_2)	+ 28.7
Water (H_2O)	– 0.381

9.3.2 The observed oxygen concentration shall be corrected by the following formula:

$$E_{O2} = \frac{(Equivalent\ O_2 \cdot c_{observed})}{100} \qquad (9)$$

9.3.3 For ZRDO and ECS analysers, instrument interference caused by gases other than oxygen shall be compensated in accordance with the manufacturer's recommendations and with good engineering practice. Electrochemical sensors shall be compensated for CO_2 and NO_x interference.

Appendix V

Parent engine test report and test data
(Refer to 2.4.1.5 and 5.10 of the NO_x Technical Code 2008)

Section 1 – Parent engine test report – see 5.10 of the Code

Emissions test report No. .... **Sheet 1/5**

Engine		
Manufacturer		
Engine type		
Engine family or engine group identification		
Serial number		
Rated speed		rpm
Rated power		kW
Intermediate speed		rpm
Maximum torque at intermediate speed		Nm
Static injection timing		deg CA BTDC
Electronic injection control	No: Yes:	
Variable injection timing	No: Yes:	
Variable turbocharger geometry	No: Yes:	
Bore		mm
Stroke		mm
Nominal compression ratio		
Mean effective pressure, at rated power		kPa
Maximum cylinder pressure, at rated power		kPa
Cylinder number and configuration	Number:	V: In-line:
Auxiliaries		
Specified ambient conditions:		
Maximum seawater temperature		°C
Maximum charge air temperature, if applicable		°C
Cooling system spec. intermediate cooler	No: Yes:	
Cooling system spec. charge air stages		
Low/high temperature cooling system set points	/	°C
Maximum inlet depression		kPa
Maximum exhaust back pressure		kPa
Fuel oil specification		
Fuel oil temperature		°C

Emissions test results:				
Cycle				
NO_x				g/kWh
Test identification				
Date/time				
Test site/bench				
Test number				
Surveyor				
Date and place of report				
Signature				

Emissions test report No. .... **Engine family information** **Sheet 2/5**

Engine family/engine group information (common specifications)	
Combustion cycle	2-stroke cycle/4-stroke cycle
Cooling medium	Air/Water
Cylinder configuration	Required to be written, only if the exhaust cleaning devices are applied
Method of aspiration	Natural aspired/Pressure charged
Fuel type to be used on board	Distillate/distillate or heavy fuel/dual
Combustion chamber	Open chamber/Divided chamber
Valve port configuration	Cylinder head/Cylinder wall
Valve port size and number	
Fuel system type	

Miscellaneous features:	
Exhaust gas recirculation	No/Yes
Water injection/emulsion	No/Yes
Air injection	No/Yes
Charge cooling system	No/Yes
Exhaust after-treatment	No/Yes
Exhaust after-treatment type	
Dual fuel	No/Yes

Engine family/engine group information (selection of parent engine for test-bed test)					
Family/group identification					
Method of pressure charging					
Charge air cooling system					
Criteria of the selection of parent engine	Highest NO_x emission value				
Number of cylinders					
Max. rated power per cylinder					
Rated speed					
Injection timing (range)					
Selected parent engine					Parent
Test cycle(s)					

Emissions test report No. .... **Test cell information** **Sheet 3/5**

Exhaust pipe	
Diameter	mm
Length	m
Insulation	No: Yes:
Probe location	

Measurement equipment					
	Manufacturer	Model	Measurement ranges	Calibration	
				Span gas conc.	Deviation of calibration
Analyser					
NO_x Analyser			ppm		%
CO Analyser			ppm		%
CO_2 Analyser			%		%
O_2 Analyser			%		%
HC Analyser			ppmC		%
Speed			rpm		%
Torque			Nm		%
Power, if applicable			kW		%
Fuel flow					%
Air flow					%
Exhaust flow					%
Temperatures					
Charge air coolant inlet			°C		°C
Exhaust gas			°C		°C
Inlet air			°C		°C
Charge air			°C		°C
Fuel			°C		°C
Pressures					
Exhaust gas			kPa		kPa
Charge air			kPa		kPa
Atmospheric			kPa		kPa
Vapour pressure					
Intake air			kPa		%
Humidity					
Intake air			%		%

Fuel characteristics

Fuel type				
Fuel properties:			**Fuel elemental analysis:**	
Density	ISO 3675	kg/m^3	Carbon	% m/m
Viscosity	ISO 3104	mm^2/s	Hydrogen	% m/m
Water	ISO 3733	% V/V	Nitrogen	% m/m
			Oxygen	% m/m
			Sulphur	% m/m
			LHV/Hu	MJ/kg

Emissions test report No. .... **Ambient and gaseous emissions data** **Sheet 4/5**

Mode		1	2	3	4	5	6	7	8	9	10
Power/torque	%										
Speed	%										
Time at beginning of mode											

Ambient data											
Atmospheric pressure	kPa										
Intake air temperature	°C										
Intake air humidity	g/kg										
Relative humidity (RH) of intake air*	%										
Air temperature at RH sensor*	°C										
Dry bulb temperature of intake air*	°C										
Wet bulb temperature of intake air*	°C										
Test condition parameter, *fa*											

Gaseous emissions data:											
NO_x concentration dry/wet	ppm										
CO concentration	ppm										
CO_2 concentration	%										
O_2 concentration dry/wet	%										
HC concentration	ppmC										
NO_x humidity correction factor, k_{hd}											
Dry/wet correction factor, k_{wr}											
NO_x mass flow	kg/h										
CO mass flow	kg/h										
CO_2 mass flow	kg/h										
O_2 mass flow	kg/h										
HC mass flow	kg/h										
NO_x specific	g/kWh										

* As applicable.

Emissions test report No. .... **Engine test data** **Sheet 5/5**

Mode		1	2	3	4	5	6	7	8	9	10
Power/torque	%										
Speed	%										
Time at beginning of mode											

Engine data											
Speed	rpm										
Auxiliary power	kW										
Dynamometer setting	kW										
Power	kW										
Mean effective pressure	kPa										
Fuel rack	mm										
Uncorrected spec. fuel consumption	g/kWh										
Fuel flow	kg/h or m^3/h*										
Air flow	kg/h										
Exhaust flow (q_{mew})	kg/h										
Exhaust temperature	°C										
Exhaust back pressure	kPa										
Charge air coolant temperature in	°C										
Charge air coolant temperature out	°C										
Charge air temperature	°C										
Charge air reference temperature	°C										
Charge air pressure	kPa										
Fuel oil temperature	°C										

* As applicable.

Section 2 – Parent engine test data to be included in the technical file – see 2.4.1.5 of the Code

Engine family/engine group reference		
Parent engine		
Model/type		
Nominated rated power	kW	
Nominated rated speed	rpm	

Parent engine test fuel oil		
Reference fuel designation		
ISO 8217: 2005 grade (DM or RM)		
Carbon	% m/m	
Hydrogen	% m/m	
Sulphur	% m/m	
Nitrogen	% m/m	
Oxygen	% m/m	
Water	% V/V	

Measured data (parent engine)									
Power/torque	%								
Speed	%								
Mode point		1	2	3	4	5	6	7	8
Engine performance									
Power	kW								
Speed	rpm								
Fuel flow	kg/h								
Intake air flow (wet/dry)	kg/h								
Exhaust gas flow	kg/h								
Intake air temperature	°C								
Charge air temperature	°C								
Charge air reference temperature	°C								
Charge air pressure	kPa								
Additional parameter(s) used for emission corrections (specify)									
Ambient conditions									
Atmospheric pressure	kPa								
Relative humidity (RH) of intake air	%								
Air temperature at RH sensor*	°C								
Dry bulb temperature of intake air*	°C								
Wet bulb temperature of intake air*	°C								
Absolute humidity of intake air*	g/kg								

Emission concentrations									
NO_x wet/dry	ppm								
CO_2	%								
O_2 wet/dry	%								
CO	ppm								
HC	ppmC								
Calculated data (parent engine)									
Intake air humidity	g/kg								
Charge air humidity	g/kg								
Test condition parameter, f_a									
Dry/wet correction factor, k_{wr}									
NO_x humidity correction factor, k_{hd}									
Exhaust gas flow rate	kg/h								
NO_x emission flow rate	kg/h								
Additional emission correction factor(s) (specify)	g/kWh								
NO_x emission	g/kWh								

Test cycle					
Emission value	g/kWh				

* As applicable.

Appendix VI

Calculation of exhaust gas mass flow (carbon-balance method)
(Refer to chapter 5 of the NO_x Technical Code 2008)

1 Introduction

1.1 This appendix addresses the calculation of the exhaust gas mass flow based on exhaust gas concentration measurement, and on the knowledge of fuel consumption. Symbols and descriptions of terms and variables used in the formulae for the carbon-balance measurement method are summarized in the introduction of this Code.

1.2 Except as otherwise specified, all results of calculations required by this appendix shall be reported in the engine's test report in accordance with 5.10 of this Code.

2 Carbon balance method, 1-step calculation procedure

2.1 This method involves exhaust mass calculation from fuel consumption, fuel composition and exhaust gas concentrations.

2.2 Exhaust gas mass flow rate on wet basis:

$$q_{mew} = q_{mf} \cdot \left(\left(\frac{1.4 \cdot \left(w_{BET} \cdot w_{BET} \right)}{\frac{\left(\frac{\left(1.4 \cdot w_{BET} \right)}{f_c} + \left(w_{ALF} \cdot 0.08936 \right) - 1 \right) \cdot \frac{1}{1.293} + f_{fd}}{f_c \cdot f_c}} + \left(w_{ALF} \cdot 0.08936 \right) - 1 \right) \cdot \left(1 + \frac{H_a}{1000} \right) + 1 \right) \quad (1)$$

with:

f_{fd} according to equation (2), f_c according to equation (3).
H_a is the absolute humidity of intake air, in gram water per kg dry air. However, if $H_a \geq H_{SC}$, then H_{SC} shall be used in place of H_a in formula (1).

Note: H_a may be derived from relative humidity measurement, dewpoint measurement, vapour pressure measurement or dry/wet bulb measurement using the generally accepted formulae.

2.3 The fuel-specific constant f_{fd} for the dry exhaust shall be calculated by adding up the additional volumes of the combustion of the fuel elements:

$$f_{fd} = -0.055593 \cdot w_{ALF} + 0.008002 \cdot w_{DEL} + 0.0070046 \cdot w_{EPS} \quad (2)$$

2.4 Carbon factor f_c according to equation (3):

$$f_c = (c_{CO2d} - c_{CO2ad}) \cdot 0.5441 + \frac{c_{COd}}{18522} + \frac{c_{HCw}}{17355} \quad (3)$$

with

c_{CO2d} = dry CO_2 concentration in the raw exhaust, %
c_{CO2ad} = dry CO_2 concentration in the ambient air, % = 0.03%
c_{COd} = dry CO concentration in the raw exhaust, ppm
c_{HCw} = wet HC concentration in the raw exhaust, ppm.

Appendix VII

Checklist for an engine parameter check method

(Refer to 6.2.2.5 of the NO_x Technical Code 2008)

1 For some of the parameters listed below, more than one survey possibility exists. In such cases, as a guideline, any one of, or a combination of, the below-listed methods may be sufficient to show compliance. As approved by the Administration, the shipowner, supported by the applicant for engine certification, may choose which method is applicable.

.1 parameter "injection timing":

.1 Fuel cam position (individual cam or camshaft if cams are not adjustable):

- optional (dependent on design): position of a link between the cam and the pump drive,
- optional for sleeve-metered pumps: variable injection timing (VIT) index and cam position or position of the barrel, or
- other sleeve-metering device;

.2 start of delivery for certain fuel rack positions (dynamic pressure measurement);

.3 opening of injection valve for certain load points, e.g., using a Hall sensor or acceleration pick-up;

.4 load-dependent operating values for charge air pressure, combustion peak pressure, charge air temperature, exhaust gas temperature versus graphs showing the correlation with NO_x. Additionally, it shall be ensured that the compression ratio corresponds to the initial certification value (see 1.7).

Note: To assess the actual timing, it is necessary to know the allowable limits for meeting the emission limits or even graphs showing the influence of timing on NO_x, based on the test-bed measurement results.

.2 parameter "injection nozzle":

.1 specification and component identification number;

.3 parameter "injection pump":

.1 component identification number (specifying plunger and barrel design);

.4 parameter "fuel cam":

.1 component identification number (specifying shape);

.2 start and end of delivery for a certain fuel rack position (dynamic pressure measurement);

.5 parameter "injection pressure":

.1 only for common-rail systems: load-dependent pressure in the rail, graph showing correlation with NO_x;

.6 parameter "combustion chamber":

.1 component identification numbers for the cylinder head and piston head;

.7 parameter "compression ratio":

.1 check for actual clearance;

.2 check for shims in piston rod or connecting rod;

.8 parameter "turbocharger type and build":

.1 model and specification (identification numbers);

.2 load-dependent charge air pressure, graph showing the correlation with NO_x;

.9 parameter "charge air cooler, charge air heater":

.1 model and specification;

.2 load-dependent charge air temperature corrected to reference conditions, graph showing the correlation with NO_x;

.10 parameter "valve timing" (only for 4-stroke engines with inlet valve closure before bottom dead centre (BDC)):

.1 cam position;

.2 check actual timing;

.11 parameter "water injection" (for assessment: graph showing influence on NO_x):

.1 load-dependent water consumption (monitoring);

.12 parameter "emulsified fuel" (for assessment: graph showing influence on NO_x):

.1 load-dependent fuel rack position (monitoring);

.2 load-dependent water consumption (monitoring);

.13 parameter "exhaust gas recirculation" (for assessment: graph showing influence on NO_x):

.1 load-dependent mass flow of recirculated exhaust gas (monitoring);

.2 CO_2 concentration in the mixture of fresh air and recirculated exhaust gas, i.e. in the "scavenge air" (monitoring);

.3 O_2 concentration in the "scavenge air" (monitoring);

.14 parameter "selective catalytic reduction" (SCR):

.1 load-dependent mass flow of reducing agent (monitoring) and additional periodical spot checks on NO_x concentration after SCR (for assessment: graph showing influence on NO_x).

2 For engines with selective catalytic reduction (SCR) without feedback control, optional NO_x measurement (periodical spot checks or monitoring) is useful to show that the SCR efficiency still corresponds to the state at the time of certification regardless of whether the ambient conditions or the fuel quality led to different raw emissions.

Appendix VIII

Implementation of the direct measurement and monitoring method
(Refer to 6.4 of the NO_x Technical Code 2008)

1 Electrical equipment: materials and design

1.1 Electrical equipment shall be constructed of durable, flame-retardant, moisture-resistant materials that are not subject to deterioration in the installed environment and at the temperatures to which the equipment is likely to be exposed.

1.2 Electrical equipment shall be designed such that current carrying parts with potential to earth are protected against accidental contact.

2 Analysing equipment

2.1 *Analysers*

2.1.1 The exhaust gases shall be analysed with the following instruments. For non-linear analysers, the use of linearizing circuits is permitted. Other systems or analysers may be accepted, subject to the approval of the Administration, provided they yield equivalent results to that of the equipment referenced below:

.1 Nitrogen oxides (NO_x) analysis

The nitrogen oxides analyser shall be of the chemiluminescent detector (CLD) or heated chemiluminescent detector (HCLD) type. The exhaust gas sampled for NO_x measurement shall be maintained above its dewpoint temperature until it has passed through the NO_2-to-NO converter.

Note: In the case of raw exhaust gas this temperature shall be greater than 60°C if the engine is fuelled with ISO 8217: 2005 DM-grade type fuel and greater than 140°C if fuelled with ISO 8217: 2005 RM-grade type fuel.

.2 Carbon dioxide (CO_2) analysis

When required, the carbon dioxide analyser shall be of the non-dispersive infrared (NDIR) absorption type.

.3 Carbon monoxide (CO) analysis

When required, the carbon monoxide analyser shall be of the (NDIR) absorption type.

.4 Hydrocarbon (HC) analysis

When required, the hydrocarbon analyser shall be of the heated flame ionization detector (HFID) type. The exhaust gas sampled for HC measurement shall be maintained at 190°C ±10°C from the sample point to the detector.

.5 Oxygen (O_2) analysis

When required, the oxygen analyser shall be of the paramagnetic detector (PMD), zirconium dioxide (ZRDO) or electrochemical sensor (ECS) type.

2.2 *Analyser specifications*

2.2.1 The analyser specifications shall be consistent with 1.6, 1.7, 1.8, 1.9 and 1.10 of appendix III of this Code.

2.2.2 The analyser range shall be such that the measured emission value is within 15% – 100% of the range used.

2.2.3 The analysing equipment shall be installed and maintained in accordance with manufacturers' recommendations in order to meet the requirements of 1.7, 1.8, 1.9, and 1.10 of appendix III of this Code and sections 7 and 9 of appendix IV of this Code.

3 Pure and calibration gases

3.1 Pure and calibration gases, as required, shall comply with 2.1 and 2.2 of appendix IV of this Code. Declared concentrations shall be traceable to national and/or international standards. Calibration gases shall be in accordance with the analysing equipment manufacturers' recommendations.

3.2 Analyser span gases shall be between 80% – 100% of the analyser scale being spanned.

4 Gas sampling and transfer system

4.1 The exhaust gas sample shall be representative of the average exhaust emission from all the engine's cylinders. The gas sampling system shall comply with 5.9.3 of this Code.

4.2 The exhaust gas sample shall be drawn from a zone within 10% to 90% of the duct diameter.

4.3 In order to facilitate the installation of the sampling probe, an example of a sample point connection flange is given in section 5.

4.4 The exhaust gas sample for NO_x measurement shall be maintained so as to prevent NO_2 loss via water or acid condensation in accordance with analysing equipment manufacturers' recommendations.

4.5 The gas sample shall not be dried by chemical driers.

4.6 The gas sampling system shall be capable of being verified to be free of ingress leakage in accordance with analysing equipment manufacturers' recommendations.

4.7 An additional sample point adjacent to that used shall be provided to facilitate quality control checks on the system.

5 Sample point connection flange

5.1 The following is an example of a general purpose sample point connection flange, which shall be sited, as convenient, on the exhaust duct of each engine for which it may be required to demonstrate compliance by means of the direct measurement and monitoring method.

Description	Dimension
Outer diameter	160 mm
Inner diameter	35 mm
Flange thickness	9 mm
Bolt circle diameter 1	130 mm
Bolt circle diameter 2	65 mm
Flange slots	4 holes, each 12 mm diameter, equidistantly placed on each of the above bolt circle diameters. Holes on the two bolt circle diameters to be aligned on same radii. Flange to be slotted, 12 mm wide, between inner and outer bolt circle diameter holes.
Bolts and nuts	4 sets, diameter and length as required.
Flange shall be of steel and be finished with a flat face.	

5.2 The flange shall be fitted to a stub pipe of suitable gauge material aligned with the exhaust duct diameter. The stub pipe shall be no longer than necessary to project beyond the exhaust duct cladding, sufficient to enable access to the far side of the flange. The stub pipe shall be insulated. The stub pipe shall terminate at an accessible position free from nearby obstructions that would interfere with the location or mounting of a sample probe and associated fittings.

5.3 When not in use, the stub pipe shall be closed with a steel blank flange and a gasket of suitable heat resisting material. The sampling flange, and closing blank flange, when not in use, shall be covered with a readily removable and suitable heat resistant material that protects against accidental contact.

6 Selection of load points and revised weighting factors

6.1 As provided for by 6.4.6.4 of this Code, in the case of the E2, E3 or D2 test cycles, the minimum number of load points shall be such that the combined nominal weighting factors, as given in 3.2 of this Code, are greater than 0.5.

6.2 In accordance with 6.1, for the E2 and E3 test cycles it would be necessary to use the 75% load point plus one or more other load points. In the case of the D2 test cycle, either the 25% or 50% load point shall be used plus either one or more load points such that the combined nominal weighting factor is greater than 0.5.

6.3 The examples below give some of the possible combinations of load points that may be used together with the respective revised weighting factors:

.1 E2 and E3 test cycles

Power	100%	75%	50%	25%
Nominal weighting factor	0.2	0.5	0.15	0.15
Option A	0.29	0.71		
Option B		0.77	0.23	
Option C	0.24	0.59		0.18
Plus other combinations that result in a combined nominal weighting factor greater than 0.5. Hence use of the 100% + 50% + 25% load points would be insufficient.				

.2 D2 test cycle

Power	100%	75%	50%	25%	10%
Nominal weighting factor	0.05	0.25	0.3	0.3	0.1
Option D			0.5	0.5	
Option E		0.45		0.55	
Option F		0.38	0.46		0.15
Option G	0.06	0.28	0.33	0.33	
Plus other combinations that result in a combined nominal weighting factor greater than 0.5. Hence use of the 100% + 50% + 10% load points would be insufficient.					

6.4 In the case of the C1 test cycle, as a minimum, one load point from each of the rated, intermediate and idle speed sections shall be used. The examples below give some of the possible combinations of load points that may be used together with the respective revised weighting factors:

.1 C1 test cycle

Speed	Rated				Intermediate			Idle
Torque	100%	75%	50%	10%	100%	75%	50%	0%
Nominal weighting factor	0.15	0.15	0.15	0.1	0.1	0.1	0.1	0.15
Option H		0.38			0.25			0.38
Option I				0.29		0.29		0.43
Option J	0.27	0.27					0.18	0.27
Option K	0.19	0.19	0.19	0.13		0.13		0.19
Plus other combinations incorporating at least one load point at each of rated, intermediate and idle speeds.								

6.5 Examples of calculation of revised weighting factors:

.1 For a given load point, revised weighting factors shall be calculated as follows:

y% load = nominal weighting factor at load y · (1/(sum of the load factors for load points where data were acquired))

.2 For Option A:

75% load: revised value is calculated as: 0.5 · (1/(0.5 + 0.2)) = 0.71
100% load: revised value is calculated as: 0.2 · (1/(0.5 + 0.2)) = 0.29

.3 For Option F:

75% load: revised value is calculated as: 0.25 · (1/(0.25 + 0.3 + 0.1)) = 0.38

.4 The revised weighting factors are shown to two decimal places. However, the values to be applied to equation (19) of this Code shall be to the full precision. Hence in the Option F case above the revised weighting factor is shown as 0.38 although the actual calculated value is 0.384615……. Consequently, in these examples of revised weighting factors the summation of the values shown (to two decimal places) may not sum to 1.00 due to rounding.

7 Determination of power set point stability

7.1 To determine set point stability, the power coefficient of variance shall be calculated over a 10-minute interval, and the sampling rate shall be at least 1-Hz. The result shall be less than or equal to five per cent (5%).

7.2 The formulae for calculating the coefficient of variance are as follows:

$$Ave = \frac{1}{N}\sum_{j=1}^{N} x_j \quad (1)$$

$$S.D. = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - Ave)^2} \quad (2)$$

$$\%C.O.V. = \frac{S.D.}{Ave} \cdot 100 \leq 5\% \quad (3)$$

where:

%C.O.V.	power coefficient of variance in %
S.D.	standard deviation
Ave	average
N	total number of data points sampled
x_i, x_j	i^{th}, j^{th} value of power data point in kW
i	index variable in standard deviation formula
j	index variable in average formula.

第 MEPC.217（63）號決議

（2012 年 3 月 2 日通過）

《經 1978 年議定書修訂的〈1973 年國際防止船舶造成污染公約〉的 1997 年議定書》附則的修正案

（《防污公約》附則 VI 中港口接收設施的區域性安排和《2008 年氮氧化物技術規則》中設有選擇性催化還原系統的船用柴油機的發證）

海上環境保護委員會，

憶及《國際海事組織公約》第 38（a）條關於國際防止和控制海上污染公約賦予海上環境保護委員會的職能，

注意到《1973 年國際防止船舶造成污染公約》（以下稱《1973 年公約》）第 16 條，《〈1973 年國際防止船舶造成污染公約〉1978 年議定書》（以下稱《1978 年議定書》）第 VI 條，以及《經 1978 年議定書修訂的〈1973 年國際防止船舶造成污染公約〉的 1997 年議定書》（以下稱《1997 年議定書》）第 4 條共同規定的《1997 年議定書》的修正程序和賦予本組織的相關機構審議並通過經 1978 年和 1997 年議定書修訂的《1973 年公約》修正案的職能，

注意到《1973 年公約》以《1997 年議定書》納入了附則 VI《防止船舶造成空氣污染規則》（以下稱“附則 VI”），

進一步注意到《防污公約》附則 VI 第 13 條使《船用柴油機氮氧化物排放控制技術規則》（《氮氧化物技術規則》）在該附則下成為強制性規則，

還注意到第 MEPC.176（58）號決議通過的經修訂的附則 VI 和第 MEPC.177（58）號決議通過的《2008 年氮氧化物技術規則》已於 2010 年 7 月 1 日生效，

審議了經修訂的附則 VI 和《2008 年氮氧化物技術規則》的修正案草案，

1. 按照《1973 年公約》第 16（2）（d）條，**通過**附則 VI 和《2008 年氮氧化物技術規則》的修正案，其文本載於本決議附件；

2. 按照《1973 年公約》第 16（2）（f）（iii）條，**決定**該修正案於 2013 年 2 月 1 日須視為被接受，除非在該日期前，有不少於三分之一的締約國或商船合計噸位不少於世界商船總噸位 50%的締約國通知本組織其反對該修正案；

3. **請**各締約國注意，按照《1973 年公約》第 16（2）（g）（ii）條，該修正案須在按上述第 2 段被接受後，於 2013 年 8 月 1 日生效；

4. **要求**秘書長遵照《1973 年公約》第 16（2）（e）條，將本決議及其附件中的修正案文本的核證無誤副本發送給經 1978 年和 1997 年議定書修訂的《1973 年公約》的所有締約國；

5. **進一步要求**秘書長將本決議及其附件的副本發送給非經 1978 年和 1997 年議定書修訂的《1973 年公約》締約國的本組織會員國。

附件

《防污公約》附則 VI 和《2008 年氮氧化物技術規則》的修正案

《防污公約》附則 VI 的修正案：

1 *在第 17 條中新增第 1 之 2 款：*

第 1 之 2 款 當由於環境獨特而區域性安排是滿足本條第 1 款要求的唯一可行途徑時，發展中小島國可通過該安排來滿足這些要求。參加區域性安排的締約國須考慮到本組織制定的導則，制定一個《區域接收設施計劃》。

參加該安排的各締約國政府須與本組織協商，將下列內容周知本公約的締約國：

.1 《區域接收設施計劃》如何將導則考慮在內；

.2 確定的"區域船舶廢物接收中心"的詳情；和

.3 設施有限港口的詳情。

《2008 年氮氧化物技術規則》的修正案：

2 *現有第 2.2.4 款由下文替代：*

"2.2.4 未在試驗台上進行前期發證試驗的發動機

.1 有些發動機由於其尺寸、構造和交貨計劃的原因，不能在試驗台上進行前期發證測試。在這種情況下，發動機製造廠、船東或造船廠須向主管機關申請在船上進行試驗（見第 2.1.2.2 款）。申請方必須向主管機關證明該船上試驗完全滿足本規則第 5 章規定的試驗台程序的所有要求。如果初次檢驗在船上進行，且無任何有效的前期發證試驗，則無論如何不允許有任何可能的測量偏差。對於在船上進行發證試驗以取得柴油機國際防止空氣污染（EIAPP）證書的發動機，應採用與在試驗台上進行前期發證試驗相同的程序，並符合第 2.2.4.2 款的限制範圍。

.2 前期發證檢驗程序僅對單機或由母型機所代表的發動機組可以接受，但不宜接受為對發動機族的發證。”

3 *第 2.2.5.1 款由下文替代：*

“.1 如擬將氮氧化物減少裝置納入柴油機國際防止空氣污染（EIAPP）證書中，則必須將其視為發動機的一個構件並應在發動機技術案卷內記錄此構件的存在。須對裝有氮氧化物減少裝置的發動機進行試驗，除非經主管機關批准，由於技術和實際原因不宜進行組合試驗且不能使用第 2.2.4.1 款中規定的程序。在後一種情況下，須執行適用的試驗程序，組合發動機/氮氧化物減少裝置須經主管機關參照本組織制定的導則予以認可並進行前期發證試驗。但是，該前期發證試驗應符合第 2.2.4.2 款的限制範圍。”

RESOLUTION MEPC.217(63)
Adopted on 2 March 2012

AMENDMENTS TO THE ANNEX OF THE PROTOCOL OF 1997 TO AMEND THE INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973, AS MODIFIED BY THE PROTOCOL OF 1978 RELATING THERETO

(Regional arrangements for port reception facilities under MARPOL Annex VI and Certification of marine diesel engines fitted with Selective Catalytic Reduction systems under the NO_x Technical Code 2008)

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

RECALLING Article 38(a) of the Convention on the International Maritime Organization concerning the functions of the Marine Environment Protection Committee conferred upon it by international conventions for the prevention and control of marine pollution,

NOTING article 16 of the International Convention for the Prevention of Pollution from Ships, 1973 (hereinafter referred to as the "1973 Convention"), article VI of the Protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973 (hereinafter referred to as the "1978 Protocol") and article 4 of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (hereinafter referred to as the "1997 Protocol"), which together specify the amendment procedure of the 1997 Protocol and confer upon the appropriate body of the Organization the function of considering and adopting amendments to the 1973 Convention, as modified by the 1978 and 1997 Protocols,

NOTING that, by the 1997 Protocol, Annex VI entitled Regulations for the Prevention of Air Pollution from Ships was added to the 1973 Convention (hereinafter referred to as "Annex VI"),

NOTING FURTHER regulation 13 of MARPOL Annex VI which makes the Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines (NO_x Technical Code) mandatory under that Annex,

NOTING ALSO that both the revised Annex VI adopted by resolution MEPC.176(58) and the NO_x Technical Code 2008 adopted by resolution MEPC.177(58) entered into force on 1 July 2010,

HAVING CONSIDERED draft amendments to the revised Annex VI and the NO_x Technical Code 2008,

1. ADOPTS, in accordance with article 16(2)(d) of the 1973 Convention, the amendments to Annex VI and the NO_x Technical Code 2008, the text of which is set out in thet annex to the present resolution;

2. DETERMINES, in accordance with article 16(2)(f)(iii) of the 1973 Convention, that the amendments shall be deemed to have been accepted on 1 February 2013, unless prior to that date, not less than one third of the Parties or Parties the combined merchant fleets of which constitute not less than 50 per cent of the gross tonnage of the world's merchant fleet, have communicated to the Organization their objection to the amendments;

3. INVITES the Parties to note that, in accordance with article 16(2)(g)(ii) of the 1973 Convention, the said amendments shall enter into force on 1 August 2013 upon their acceptance in accordance with paragraph 2 above;

4. REQUESTS the Secretary-General, in conformity with article 16(2)(e) of the 1973 Convention, to transmit to all Parties to the 1973 Convention, as modified by the 1978 and 1997 Protocols, certified copies of the present resolution and the text of the amendments contained in the annex;

5. REQUESTS FURTHER the Secretary-General to transmit to the Members of the Organization which are not Parties to the 1973 Convention, as modified by the 1978 and 1997 Protocols, copies of the present resolution and its annex.

ANNEX

AMENDMENTS TO MARPOL ANNEX VI AND THE NO_X TECHNICAL CODE 2008

Amendments to MARPOL Annex VI

1 *New paragraph 1bis is added to regulation 17:*

1*bis* Small Island Developing States may satisfy the requirements in paragraph 1 of this regulation through regional arrangements when, because of those States' unique circumstances, such arrangements are the only practical means to satisfy these requirements. Parties participating in a regional arrangement shall develop a Regional Reception Facilities Plan, taking into account the guidelines developed by the Organization.

The Government of each Party participating in the arrangement shall consult with the Organization for circulation to the Parties of the present Convention:

.1 how the Regional Reception Facilities Plan takes into account the Guidelines;

.2 particulars of the identified Regional Ships Waste Reception Centres; and

.3 particulars of those ports with only limited facilities.

Amendments to the NO_X Technical Code 2008

2 *Existing paragraph 2.2.4 is replaced by the following:*

"2.2.4 *Engines not pre-certified on a test-bed*

.1 There are engines which, due to their size, construction and delivery schedule, cannot be pre-certified on a test-bed. In such cases, the engine manufacturer, shipowner or shipbuilder shall make application to the Administration requesting an onboard test (see 2.1.2.2). The applicant must demonstrate to the Administration that the onboard test fully meets all of the requirements of a test-bed procedure as specified in chapter 5 of this Code. In no case shall an allowance be granted for possible deviations of measurements if an initial survey is carried out on board a ship without any valid pre-certification test. For engines undergoing an onboard certification test, in order to be issued with an EIAPP Certificate, the same procedures apply as if the engine had been pre-certified on a test-bed, subject to the limitations given in paragraph 2.2.4.2.

.2 This pre-certification survey procedure may be accepted for an Individual Engine or for an Engine Group represented by the Parent Engine only, but it shall not be accepted for an Engine Family certification."

3 *Paragraph 2.2.5.1 is replaced by the following:*

".1 Where a NO_x-reducing device is to be included within the EIAPP certification, it must be recognized as a component of the engine, and its presence shall be recorded in the engine's Technical File. The engine shall be tested with the NO_x-reducing device fitted unless, due to technical and practical reasons, the combined testing is not appropriate and the procedures specified in paragraph 2.2.4.1 cannot be applied, subject to approval by the Administration. In the latter case, the applicable test procedure shall be performed and the combined engine/NO_x-reducing device shall be approved and pre-certified by the Administration taking into account guidelines developed by the Organization. However, this pre-certification is subject to the limitations given in paragraph 2.2.4.2."

二零一七年七月二十五日於行政長官辦公室

辦公室主任 柯嵐

Gabinete do Chefe do Executivo, aos 25 de Julho de 2017. — A Chefe do Gabinete, *O Lam*.

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