

標題

MARPOL 附属書 IV / 汚水浄化装置の排水基準及び性能試験等に関する改正ガイドライン (MEPC.159(55)) の適用に関する解釈について

ClassNK

テクニカル インフォメーション

No. TEC-0766

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各位

2006年10月に開催されたIMO第55回海洋環境保護委員会(MEPC55)において、汚水浄化装置の排水基準及び性能試験等に関するガイドライン IMO 決議 MEPC.2(VI)の改正であるIMO決議 MEPC.159(55) “Revised Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants”が採択され、2010年1月1日から施行となります。

この適用に関する解釈として、IACSは2007年2月に以下の統一解釈 MPC88 を策定し、2007年7月に開催されたIMO第56回海洋環境保護委員会(MEPC56)に提出し、既に合意されております。

(一部抜粋)

Interpretation

For application of Resolution MEPC.159(55), the phrase “installed on board a ship on or after 1 January 2010” shall be interpreted as follows:

- (a) For new ships, installations on board ships the keels of which are laid or which are at a similar stage of construction on or after 1 January 2010.
- (b) For existing ships, new installations with a contractual delivery date to the ship on or after 1 January 2010 or, in the absence of a contractual delivery date, the actual delivery of the equipment to the ship on or after 1 January 2010.

従いまして、新基準の適用は以下のとおりとなります。

- (a) 新船(2010年1月1日以降に起工又は同等段階にある船舶)
搭載されるすべての汚水浄化装置に適用
- (b) 現存船(2009年12月31日以前に起工又は同等段階にあった船舶)
2010年1月1日以降に搭載される汚水浄化装置に適用
※ 搭載日については、当該装置の契約上の納入日とする。ただし、契約上の納入日が不明な場合には、実際の納入日とする。

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NOTES:

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参考に適用例を次表に示します。

起工日	契約上の納入日*	搭載日	完工日	適用基準
2009/12/31 以前	2009/12/31 以前	2009/12/31 以前	2009/12/31 以前	MEPC.2(VI)
2009/12/31 以前	2009/12/31 以前	2009/12/31 以前	2010/1/1 以降	MEPC.2(VI)
2009/12/31 以前	2009/12/31 以前	2010/1/1 以降	2010/1/1 以降	MEPC.2(VI)
2009/12/31 以前	2010/1/1 以降	2010/1/1 以降	2010/1/1 以降	MEPC.159(55)
2010/1/1 以降	2009/12/31 以前	2010/1/1 以降	2010/1/1 以降	MEPC.159(55)
2010/1/1 以降	2010/1/1 以降	2010/1/1 以降	2010/1/1 以降	MEPC.159(55)

*: 契約上の納入日が不明な場合には、実際の納入日(建造中であれば造船所への、就航船であれば船舶への)とする。

また、参考に「MEPC.2(VI)とMEPC.159(55)の比較表」を添付致します。

なお、本件に関してご不明な点は、以下の部署にお問い合わせください。

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添付:

1. IMO 決議 MEPC.159(55)
2. IACS 統一解釈 MPC88
3. MEPC.2(IV)とMEPC.159(55)の比較表

ANNEX 26

RESOLUTION MEPC.159(55)
Adopted on 13 October 2006

**REVISED GUIDELINES ON IMPLEMENTATION OF EFFLUENT STANDARDS
AND PERFORMANCE TESTS FOR SEWAGE TREATMENT PLANTS**

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 resolution MEPC.2(VI) adopted on 3 December 1976 by which the Marine Environment Protection Committee adopted, at its sixth session, the Recommendation on International Effluent Standards and Guidelines for Performance Tests for Sewage Treatment Plants and invited Governments to apply the Effluent Standards and Guidelines for approving sewage treatment plants; to take steps to establish testing programmes in accordance with the Guidelines for Performance Tests; and provide the Organization with a list of sewage treatment plants meeting the standards,

NOTING ALSO resolution MEPC.115(51) adopted on 1 April 2004 by which the Marine Environment Protection Committee adopted, at its fifty-first session, the revised MARPOL Annex IV and which entered into force on 1 August 2005,

NOTING FURTHER the provisions of regulation 9.1.1 of MARPOL Annex IV, in which reference is made to the above-mentioned guidelines,

RECOGNIZING that resolution MEPC.2(VI) should be amended in order that current trends for the protection of the marine environment and developments in the design and effectiveness of commercially available sewage treatment plants be reflected; and the proliferation of differing unilateral more stringent standards that might be imposed worldwide be avoided,

HAVING CONSIDERED the recommendation made by the Sub-Committee on Bulk Liquids and Gases, at its tenth session,

1. ADOPTS the Revised Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants, the text of which is set out in the Annex to this resolution;
2. INVITES Governments to:
 - (a) implement the Revised Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants and apply them so that all equipment installed on board on or after 1 January 2010 meets the Revised Guidelines in so far as is reasonable and practicable; and

- (b) provide the Organization with information on experiences gained from their application and, in particular, on successful testing of equipment against the Standards;

3. FURTHER INVITES Governments to issue an appropriate “Certificate of type approval for Sewage Treatment Plants” as referred to in paragraph 5.4.2 and the annex of the Revised Guidelines and to recognize such certificates issued under the authority of other Governments as having the same validity as certificates issued by them; and

4. SUPERSEDES the Recommendation on International Effluent Standards and Guidelines for Performance Tests for Sewage Treatment Plants contained in resolution MEPC.2(VI).

ANNEX

**REVISED GUIDELINES ON IMPLEMENTATION OF EFFLUENT STANDARDS
AND PERFORMANCE TESTS FOR SEWAGE TREATMENT PLANTS**

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REVISED GUIDELINES ON IMPLEMENTATION OF EFFLUENT STANDARDS AND PERFORMANCE TESTS FOR SEWAGE TREATMENT PLANTS

1 INTRODUCTION

1.1 The Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) adopted resolution MEPC.2(VI) Recommendation on International Effluent Standards and Guidelines for Performance Tests for Sewage Treatment Plants in 1976.

1.2 This document contains the Revised Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants (Guidelines). These Guidelines are intended to assist Administrations in establishing operational performance testing programmes for sewage treatment plants for the purpose of type approval under regulation 9.1.1 of Annex IV of the Convention.

1.3 These Guidelines apply to sewage treatment plants installed on board on or after 1 January 2010.

2 DEFINITIONS

Annex IV – the revised Annex IV of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) as amended by resolution MEPC.115(51).

Convention – the International Convention for the Prevention of Pollution from Ships 1973/1978 (MARPOL 73/78).

Geometric mean – the n th root of the product of n numbers.

Greywater – is drainage from dishwater, shower, laundry, bath and washbasin drains.

Testing onboard – testing carried out on a sewage treatment plant that has been installed upon a ship.

Testing ashore – testing carried out on a sewage treatment plant prior to installation e.g. in the factory.

Thermotolerant coliforms – the group of coliform bacteria which produce gas from lactose in 48 hours at 44.5°C. These organisms are sometimes referred to as “faecal coliforms”; however, the term “thermotolerant coliforms” is now accepted as more appropriate, since not all of these organisms are of faecal origin.

3 GENERAL

3.1 An approved sewage treatment plant must meet the standards in section 4 and the tests outlined in these Guidelines. It should also be noted that, when ships are operating approved sewage treatment plants, Annex IV also provides that the effluent shall not produce visible floating solids or cause discolouration of the surrounding water.

3.2 It is acknowledged that the performance of sewage treatment plants may vary considerably when the system is tested ashore under simulated shipboard conditions or onboard a ship under actual operating conditions. Where testing ashore demonstrates that a system complies with the standards, but subsequent onboard testing does not meet the standards, the Administration should determine the reason and take it into account when deciding whether to type approve the plant.

3.3 It is recognized that Administrations may wish to modify the specific details outlined in these Guidelines to take account of very large, very small or unique sewage treatment plants.

4 STANDARDS

4.1 For the purpose of regulation 4.1 of Annex IV, a sewage treatment plant should satisfy the following effluent standards when tested for its Certificate of Type Approval by the Administration:

.1 Thermotolerant Coliform Standard

The geometric mean of the thermotolerant coliform count of the samples of effluent taken during the test period should not exceed 100 thermotolerant coliforms/100 ml as determined by membrane filter, multiple tube fermentation or an equivalent analytical procedure.

.2 Total Suspended Solids (TSS) Standard

- (a) The geometric mean of the total suspended solids content of the samples of effluent taken during the test period shall not exceed 35 mg/l.
- (b) Where the sewage treatment plant is tested onboard ship, the maximum total suspended solids content of the samples of effluent taken during the test period may be adjusted to take account of the total suspended solid content of the flushing water. In allowing this adjustment in maximum TSS, Administrations shall ensure sufficient tests of TSS are taken of the flushing water throughout the testing period to establish an accurate geometric mean to be used as the adjustment figure (defined as x). In no cases shall the maximum allowed TSS be greater than 35 plus x mg/l.

Method of testing should be by:

- .1 filtration of representative sample through a 0.45 μm filter membrane, drying at 105°C and weighing; or
 - .2 centrifuging of a representative sample (for at least five minutes with mean acceleration of 2,800-3,200 g), drying at least 105°C and weighing; or
 - .3 other internationally accepted equivalent test standard.
- .3 Biochemical Oxygen Demand and Chemical Oxygen Demand

Administrations should satisfy themselves that the sewage treatment plant is designed to reduce both soluble and insoluble organic substances to meet the requirement that, the geometric mean of 5-day Biochemical Oxygen Demand (BOD₅) of the samples of effluent taken during the test period does not exceed 25 mg/l and the Chemical Oxygen Demand (COD) does not exceed 125 mg/l. The test method standard should be ISO 15705:2002 for COD and ISO 5815-1:2003 for BOD₅, or other internationally accepted equivalent test standards.

.4 pH

The pH of the samples of effluent taken during the test period shall be between 6 and 8.5.

.5 Zero or non-detected values

For thermotolerant coliforms, zero values should be replaced with a value of 1 thermotolerant coliform/100 ml to allow the calculation of the geometric mean. For total suspended solids, biochemical oxygen demand and chemical oxygen demand, values below the limit of detection should be replaced with one half the limit of detection to allow the calculation of the geometric mean.

4.2 Where the sewage treatment plant has been tested ashore, the initial survey should include installation and commissioning of the sewage treatment plant.

5 TESTING CONSIDERATIONS

5.1 Testing of the operational performance of a sewage treatment plant should be conducted in accordance with the following subparagraphs. Unless otherwise noted, the subparagraphs apply to testing both onboard and ashore.

5.2 Raw sewage quality

5.2.1 Sewage treatment plants tested ashore - the influent should be fresh sewage consisting of faecal matter, urine, toilet paper and flush water to which, for testing purposes primary sewage sludge has been added as necessary to attain a minimum total suspended solids concentration appropriate for the number of persons and hydraulic loading for which the sewage treatment plant will be certified. The testing should take into account the type of system (for example vacuum or gravity toilets) and any water or greywater that may be added for flushing to the sewage before treatment. In any case the influent concentration of total suspended solids should be no less than 500 mg/l.

5.2.2 Sewage treatment plants tested onboard - the influent may consist of the sewage generated under normal operational conditions. In any case the average influent concentration of total suspended solids should be no less than 500 mg/l.

5.3 Duration and timing of test

5.3.1 The duration of the test period should be a minimum of 10 days and should be timed to capture normal operational conditions, taking into account the type of system and the number of persons and hydraulic loading for which the sewage treatment plant will be type approved. The test should commence after steady-state conditions have been reached by the sewage treatment plant under test.

5.4 Loading factors

5.4.1 During the test period the sewage treatment plant should be tested under conditions of minimum, average and maximum volumetric loadings.

- .1 For testing ashore, these loadings will be as laid down in the manufacturer's specifications. Figure 1 shows suggested timings for sampling each loading factor.
- .2 For testing onboard, minimum loading will represent that generated by the number of persons on the ship when it is alongside in port, and average and maximum loadings will represent those generated by the number of persons on the ship at sea and will take account of meal times and watch rotations.

5.4.2 The Administration should undertake to assess the capability of the sewage treatment plant to produce an effluent in accordance with the standards prescribed by section 4 following minimum, average and maximum volumetric loadings. The range of conditions under which the effluent standards were met should be recorded on the Certificate of Type Approval. The form of the Certificate of Type Approval and appendix is set out in the annex to these Guidelines.

5.5 Sampling methods and frequency

5.5.1 Administrations should ensure that the sewage treatment plant is installed in a manner which facilitates the collection of samples. Sampling should be carried out in a manner and at a frequency which is representative of the effluent quality. Figure 1 provides a suggested frequency for sampling, however, the frequency should take account of the residence time of the influent in the sewage treatment plant. A minimum of 40 effluent samples should be collected to allow a statistical analysis of the testing data (e.g. geometric mean, maximum, minimum, variance).

5.5.2 An influent sample should be taken and analyzed for every effluent sample taken and the results recorded to ensure compliance with section 4. If possible, additional influent and effluent samples should be taken to allow for a margin of error. Samples should be appropriately preserved prior to analysis particularly if there is to be a significant delay between collection and analysis or during times of high ambient temperature.

5.5.3 Any disinfectant residual in samples should be neutralized when the sample is collected to prevent unrealistic bacteria kill or chemical oxidation of organic matter by the disinfectant brought about by artificially extended contact times. Chlorine (if used) concentration and pH should be measured prior to neutralization.

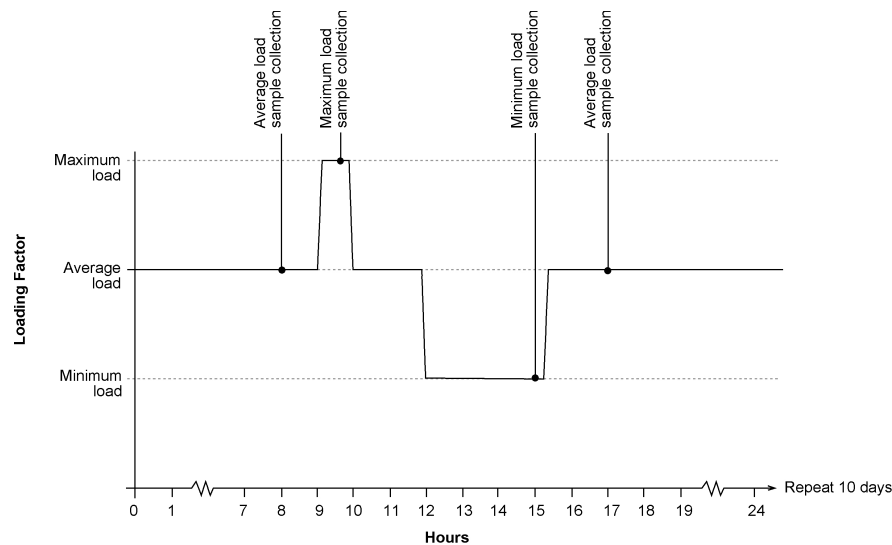


Figure 1: Suggested hydraulic loading factors and sampling frequency for testing sewage treatment plants. May be modified as necessary to take account of characteristics of individual sewage treatment plants

5.6 Analytical testing of effluent

5.6.1 The Administration should give consideration to the recording of other parameters in addition to those required (thermotolerant coliforms, total suspended solids, BOD₅, COD, pH and residual chlorine) with a view to future technological development. Parameters which might be considered include total solids, volatile solids, settleable solids, volatile suspended solids, turbidity, total phosphorus, total organic carbon, total coliforms and faecal streptococci.

5.7 Disinfectant residual

5.7.1 The potential adverse environmental effects of many disinfectant residuals and by-products, such as those associated with the use of chlorine or its compounds, are well recognized. It is, therefore, recommended that Administrations encourage the use of ozone, ultra-violet irradiation or any other disinfectants which minimize adverse environmental effects, whilst pursuing the thermotolerant coliform standard. When chlorine is used as a disinfectant, the Administration should be satisfied that the best technical practice is used to keep the disinfectant residual in the effluent below 0.5 mg/l.

5.8 Scaling considerations

5.8.1 Only full-scale marine sewage treatment plants should be accepted for testing purposes. The Administration may certify a range of the manufacturer's equipment sizes employing the same principles and technology, but due consideration must be given to limitations on performance which might arise from scaling up or scaling down. In the case of very large, very small or unique sewage treatment plants, certification may be based on results of prototype tests. Where possible, confirmatory tests should be performed on the final installation of such sewage treatment plants.

5.9 Environmental testing of the sewage treatment plant

5.9.1 The Administration should be satisfied that the sewage treatment plant can operate under conditions of tilt consistent with internationally acceptable shipboard practice.

5.9.2 Tests for certification should be carried out over the range of temperature and salinity specified by the manufacturer, and the Administration should be satisfied that such specifications are adequate for the conditions under which the equipment must operate.

5.9.3 Control and sensor components should be subjected to environmental testing to verify their suitability for marine use. The Test Specifications section in part 3 of the annex to resolution MEPC.107(49) provides guidance in this respect.

5.9.4 Any limitation on the conditions of operation should be recorded on the Certificate.

5.9.5 The Administration should also consider requiring the manufacturer to include in the operating and maintenance manuals, a list of chemicals and materials suitable for use in the operation of the sewage treatment plant.

5.10 Other considerations

5.10.1 The type and model of the sewage treatment plant and the name of the manufacturer should be noted by means of a durable label firmly affixed directly to the sewage treatment plant. This label should include the date of manufacture and any operational or installation limits considered necessary by the manufacturer or the Administration.

5.10.2 Administrations should examine the manufacturer's installation, operating and maintenance manuals for adequacy and completeness. The ship should have on board at all times a manual detailing the operational and maintenance procedures for the sewage treatment plant.

5.10.3 Qualifications of testing facilities should be carefully examined by the Administration as a prerequisite to their participation in the testing programme. Every attempt should be made to assure uniformity among the various facilities.

6 RENEWAL AND ADDITIONAL SURVEYS

6.1 Administrations should endeavour to ensure, when conducting renewal or additional surveys in accordance with regulations 4.1.2 and 4.1.3 of Annex IV, that the sewage treatment plant continues to perform in accordance with the conditions outlined in regulation 4.1.1 of Annex IV.

7 FAMILIARIZATION OF SHIP PERSONNEL IN THE USE OF THE SEWAGE TREATMENT PLANT

7.1 Recognizing that the appropriate regulations relating to familiarization are contained within the Ships Safety Management Systems under the International Safety Management Code, Administrations are reminded that ship staff training should include familiarization in the operation and maintenance of the sewage treatment plant.

ANNEX

FORM OF CERTIFICATE OF TYPE APPROVAL
FOR SEWAGE TREATMENT PLANTS AND APPENDIX

BADGE OR CIPHER

NAME OF ADMINISTRATION

**CERTIFICATE OF TYPE APPROVAL
FOR SEWAGE TREATMENT PLANTS**

This is to certify that the Sewage Treatment Plant, Type, having a designed hydraulic loading of cubic metres per day, (m³/day), an organic loading of kg per day Biochemical Oxygen Demand (BOD) and of the design shown on Drawings Nos. .. manufactured by

has been examined and satisfactorily tested in accordance with the International Maritime Organization resolution MEPC.159(55) to meet the operational requirements referred to in regulation 9.1.1 of Annex IV of the International Convention for the Prevention of Pollution from Ships, 1973/78 as modified by resolution MEPC.115(51).

The tests on the sewage treatment plant were carried out ashore at* onboard at* and completed on

The sewage treatment plant was tested and produced an effluent which, on analysis, produces:

- (i) a geometric mean of no more than 100 thermotolerant coliforms/100 ml;
- (ii) a geometric mean of total suspended solids of 35 mg/l if tested ashore or the maximum total suspended solids not exceeding 35 plus x mg/l for the ambient water used for flushing purposes if tested on board;
- (iii) a geometric mean of 5-day Biochemical Oxygen Demand (BOD₅) of no more than 25 mg/l;
- (iv) a geometric mean of Chemical Oxygen Demand of no more than 125 mg/l;
- (v) pH of the effluent is between 6 and 8.5.

The Administration is satisfied that the sewage treatment plant can operate at angles of inclination of 22.5° in any plane from the normal operating position.

Details of the tests and the results obtained are shown on the Appendix to this Certificate.

A plate or durable label containing data of the manufacturer's name, type and serial numbers, hydraulic loading and date of manufacture is to be fitted on each sewage treatment plant.

A copy of this Certificate shall be carried on board any ship equipped with the above described sewage treatment plant.

Official stamp _____ Signed

Administration of

Dated this.....day.....of.....20....

* Delete as appropriate.

BADGE OR CIPHER

**APPENDIX TO
CERTIFICATE OF TYPE APPROVAL FOR SEWAGE TREATMENT PLANTS**

Test results and details of tests conducted on samples from the Sewage Treatment Plant in accordance with resolution MEPC.159(55):

Sewage Treatment Plant, Type

Manufactured by

Organization conducting the test

Designed hydraulic loading m³/day

Designed organic loading kg/day BOD

Number of effluent samples tested

Number of influent samples tested

Raw sewage (influent) qualitymg/l Total Suspended Solids

Maximum hydraulic loading m³/day

Minimum hydraulic loading m³/day

Average hydraulic loading m³/day

Geometric Mean of Total
Suspended Solids mg/l

Geometric Mean of the thermotolerant
coliform count coliforms/100 ml

Geometric Mean of BOD₅ mg/l

Type of disinfectant used

If Chlorine - residual Chlorine:

Maximum mg/l

Minimum mg/l

Geometric Mean mg/l

Was the sewage treatment plant tested with:

Fresh Water flushing? Yes/No*

Salt Water flushing? Yes/No*

Fresh and Salt Water flushing? Yes/No*

Greywater added? Yes – proportion: /No*

Was the sewage treatment plant tested against the environmental conditions specified in section 5.9 of resolution MEPC.159(55):

Temperature Yes/No*

Humidity Yes/No*

Inclination Yes/No*

Vibration Yes/No*

Reliability of Electrical and Electronic Equipment Yes/No*

Limitations and the conditions of operation are imposed:

Salinity

Temperature

Humidity

Inclination

Vibration

Results of other parameters tested

Official stamp Signed

Administration of Dated this day of 20

* Delete as appropriate.

MPC 88

Annex IV of MARPOL 73/78 Regulation 9.1.1

(Feb
2007)

Regulation 9 Sewage systems

Regulation 9.1.1 reads:

1 Every ship which, in accordance with regulation 2, is required to comply with the provisions of this Annex shall be equipped with one of the following sewage systems:

.1 a sewage treatment plant which shall be of a type approved by the Administration, in compliance with the standards and test methods developed by the Organization”.....*

The footnote to regulation 9.1.1 reads:

**Reference is made to the international specifications for effluent standards, construction and testing of sewage treatment systems adopted by the Organization by resolution MEPC.2(VI) on 3 December 1976. For existing ships, national specifications are acceptable.*

Operative paragraph 2(a) of resolution MEPC.159(55), which supersedes resolution MEPC.2(VI), and paragraph 1.3 in the Annex thereto read:

“2. INVITES Governments to:

(a) implement the Revised Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants and apply them so that all equipment installed on board on or after 1 January 2010 meets the Revised Guidelines in so far as is reasonable and practicable; and....”

“1.3 These Guidelines apply to sewage treatment plants installed on board on or after 1 January 2010.”

Interpretation

For application of resolution MEPC.159(55), the phrase *“installed on board a ship on or after 1 January 2010”* shall be interpreted as follows:

- (a) For new ships, installations on board ships the keels of which are laid or which are at a similar stage of construction on or after 1 January 2010.
- (b) For existing ships, new installations with a contractual delivery date to the ship on or after 1 January 2010 or, in the absence of a contractual delivery date, the actual delivery of the equipment to the ship on or after 1 January 2010.

Note:

This UI is to be uniformly implemented by IACS Societies from 1 July 2007.

End of Document

MEPC.2(VI)と MEPC.159(55)の比較表 ((参考))

		MPEC.2(VI)	MEPC.159(55)
Thermotolerant Coliform Count ^{*1} (大腸菌群数)		not exceed 250 faecal coliforms / 100 ml M.P.N. (most probable number)	not exceed 100 thermotolerant coliforms / 100 ml
Total Suspended Solids Content ^{*4} (浮遊物質質量)	ashore ^{*2}	not exceed 50 mg / l	not exceed 35 mg / l
	onboard ^{*2}	not more than 100 mg / l	not exceed 35 plus x mg / l (x: adjustment figure) ^{*3}
5-day Biochemical Oxygen Demand (BOD ₅) ^{*4} (5日間生物化学的酸素要求量)		not exceed 50 mg / l	not exceed 25 mg / l
Chemical Oxygen Demand (COD) ^{*4} (化学的酸素要求量)		要求値なし	not exceed 125 mg / l
pH		要求値なし	between 6 and 8.5
Raw Sewage Quality (試験汚水の規定)	ashore ^{*2}	a minimum concentration of 500 mg / l of suspended solids	Influent concentration of total suspended solids should be no less than 500 mg / l
	onboard ^{*2}	sewage generated aboard the vessel under normal operational conditions	Sewage generated under normal operational condition, but influent concentration of total suspended solids should be no less than 500 mg / l
Duration of Test (試験の継続時間)		for 10 days after steady state conditions have been reached	a minimum of 10 days and should be timed to capture normal operational conditions

*1: MPEC.2(VI)における “faecal coliform”を指す。MEPC.159(55)で “Thermotolerant coliform count”と定義された。

*2: 通常の型式試験においては “ashore”の値を適用する。試験場での試験に代わり本船上でサンプル水を入手する場合には “onboard”の値を適用する。

*3: “x”は、flushing water に含まれる分の total suspended solids

*4: MEPC.159(55)では試験方法や条件に関してより詳細に規定されている。