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K-05 MARINE SEWAGE TREATMENT PLANTS

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Foreword:

This Guide is a part of CCS Rules, which contains technical requirements, inspection and testing criteria related to classification and statutory survey of marine products.

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MARINE SEWAGE TREATMENT PLANTS

1 Application

This Guideline applies to the type approval and inspection of marine sewage treatment plants installed on the ship which applies to the application of IMO RESERLUTION MEPC.227(64).

2 Normative references

2.1 The basis of approval and inspection are to be based on the following documents:

(1) Annex IV – Regulations for the Prevention of Pollution by Sewage from Ships of MARPOL 73/78;

(2) IMO MEPC.227(64) – 2012 Guidelines On Implementation Of Effluent Standards And Performance Tests For Sewage Treatment Plants;

(3) PART 3 "Specifications for Environmental Testing for Type Approval of Pollution Prevention Equipment", Annex of IMO MEPC.107(49) – Revised Guidelines and Specifications for Pollution Prevention Equipment for Machinery Space Bilges of Ships;

2.2 The paragraphs in the above mentioned basis for approval and inspection quoted are part of this Chapter. For quoted documents marked with the date, their subsequent amendments (except corrigenda) or revisions will be inapplicable, hence, it should meet the requirements of the latest edition of these documents during the product type approval, design, manufacture and inspection. However, for those quoted documents without any date marked, the latest edition applies to this Chapter.

3 Terms and definitions

3.1 For the purpose of this Guideline:

(1) Annex IV – the revised Annex IV of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the 1978 and 1997 Protocols (MARPOL), as amended by resolutions MEPC.115(51) and MEPC.200(62).

(2) Dilution (Qd) – is dilution water, grey water, process water, and/or seawater introduced to the sewage treatment plant after the influent sample point and after the influent flow measurement device, see figure 1.

⑶ Effluent (Qe) – treated wastewater produced by the sewage treatment plant, see figure 1.

⑷ Influent (Qi) – Liquid containing sewage, grey water or other liquid streams, to be processed by the treatment plant, see figure 1.

⑸ Dilution compensation factor Qi/Qe – Parameters for the correction of the discharge by dilution.

⑹ Hydraulic loading – system design flow rate of waste water (Qi) into the sewage treatment plant.

⑺ Grey water – is drainage from dishwater, galley sink, shower, laundry, bath and washbasin drains and does not include drainage from toilets, urinals, hospitals, and animal spaces, as defined in regulation 1.3 of MARPOL Annex IV and does not include drainage from cargo spaces.

⑻ Flush water – transport medium used to carry sewage or other wastes from toilets or urinals to the treatment system.

⑼ Geometric mean – the nth root of the product of n numbers.

⑽ Sewage means:

① drainage and other wastes from any form of toilets and urinals;

② drainage from medical premises (dispensary, sick bay, etc) via wash basins, wash tubs and scuppers located in such premises;

③ drainage from spaces containing living animals; or

④ other waste waters when mixed with the drainages defined above.

⑾ Sewage treatment plant means a plant which is applied to reduce the index of thermotolerant coliforms, suspended solids and biochemical oxygen demand in sewage by means of biochemical, electrolysis methods.

⑿ Chemical oxygen demand (COD) means the amount of oxidant consumed during the treatment of the water sample under specific conditions. This index is to reflect the reducing substances in water and also the index to measure the content of organic substances in water,

in mg/l.

⑿ Total suspended solidity (TSS) means solidity which is in a suspension state in water. Method of testing is to be by filtration of representative sample through a 0.45 μm filter membrane, drying at 105 ℃ and weighing; or centrifuging of a representative sample (for at least five minutes with mean acceleration of 2,800-3,200 g), drying at least 105 ℃ and weighing; or other internationally accepted equivalent test standard, in mg/l.

⒀ 5-day biochemical oxygen demand (BOD5): biochemical oxygen demand means the difference of the dissolved oxygen of the water samples before and after storage for incubation. BOD5 means a mass concentration of dissolved oxygen consumed under specified conditions by the biological oxidation (organic matter in particular) in water at a temperature of 20±1℃, where the incubation time is 5 days, in mg/l.

⒁ Thermotolerant coliforms means the group of coliform bacteria which produce gas from lactose within 48 hours at the temperature of 44.5 ℃, in quantity (geometric mean)/100 ml.

⒂ Testing on board – testing, for the purpose of type approval, carried out on a sewage treatment plant installed on a ship.

⒃ Testing ashore – testing ashore, for the purpose of type approval, carried out on a sewage treatment plant.

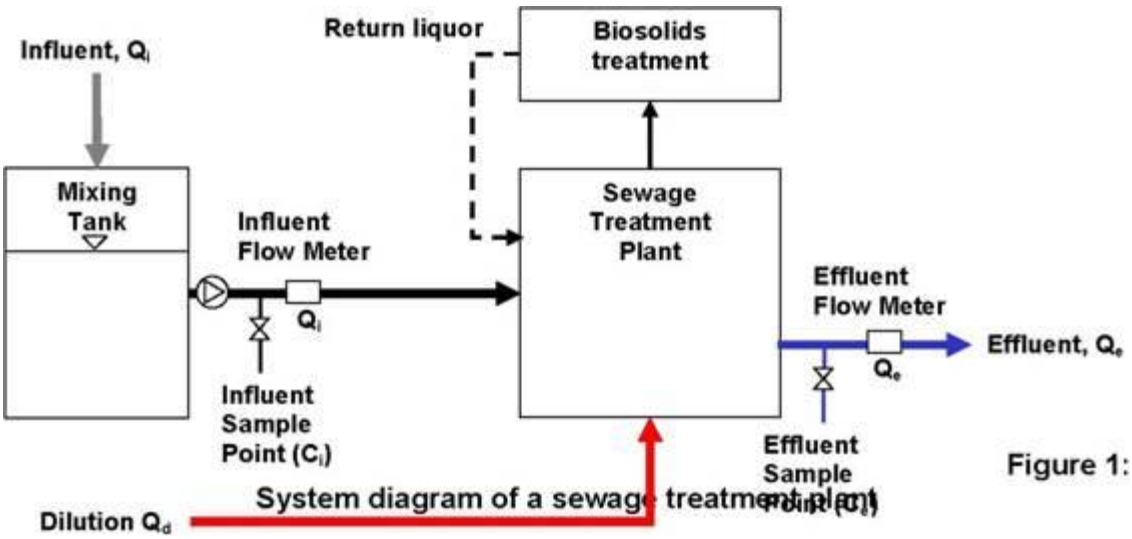

Figure 1:

4 Plans and documents

4.1 Unless specified otherwise by CCS, the following plans and technical documents are to be

submitted by the applicant to CCS when applying for approval of marine sewage treatment plants.

4.2 The following plans and documents are to be submitted to CCS for approval:

⑴ Product performance specifications, including at least the following:

① parameter of designed treatment capability: hydraulic loading and organic loading, etc.;

② range of working temperature (include environmental temperature, flushing and back flushing medium such as fresh water/sea water etc.), range of salinity of sea water for flushing/back flushing/dilution;

③ emission standard: thermotolerant coliforms, total suspended solids (TSS), chemical oxygen demand (COD), 5-day biochemical oxygen demand without nitrification (BOD5 without nitrification), residual chlorine (if chloric chemicals is used for disinfection), pH value, etc.;

④ Power supply, etc..

⑵ General assembly plan, tank plan(include internal structure), etc.;

⑶ Schematic diagram or process flow chart of main systems, safety alarm plan, etc.;

⑷ Electrical diagram(electrical schematic diagram, Control Panel diagram, secondary connection diagram, etc.);

⑸ Type test program (when applying for type approval by CCS);

⑹ Routine test/inspection program.

4.3 The following plans and documents are to be submitted to CCS for information:

⑴ Products instruction manual including at least:

① parameter of treatment capability: Average hydraulic loading, Maximum hydraulic loading, Minimum hydraulic loading, Average organic loading, Maximum organic loading and Minimum organic loading.;

② types of sewage for treatment: clearly indicating the types of sewage−black water (as

defined in 3.1(10) of this Guideline), grey water, or both of them, etc.. If the influent includes grey water, requirements for the hydraulic loading and organic loading of the grey water, proportion of the grey water/black water/flush water(reference ISO 15749-1(2004) 4.3), the requirements of deoil and removing hairs before adding grey water should be specified;

③ types of flushing and back flushing water: fresh/sea water(including range of salinity), compressed air, steam, etc.);

④ rang of working temperature(confirmed by manufacture), rang of environmental temperature, rang of working temperature of flushing and back flushing medium such as fresh water/sea water etc.;

⑤ maintained requirements: instruction of working principles and steps of operation (flowchart included), malfunction analysis and handling measures, maintenance and replacement for main equipment /parts(membrane module, ultraviolet sterilizer, ozonizer, electrolyzing cell, air pump, etc.); As sewage treatment plants with UV method, the supplier of UV lamp should provide the UV attenuation, the replacement cycle of lamp, or other requirements. Where a disinfectant is used by the equipment, the concentration and dose used are to be clearly specified;

⑥ specify that disinfectant of influent should not affect the use of the equipment;

⑦ effluent piping diagram and minimum pressure of effluent water.

(2) Treatment capability calculations: including aeration retaining time, organic loading, aeration air-supply amount (applicable to sewage treatment plant by means of biochemistry), type selection calculation for membrane, ultra-violet sterilizer(UV dose used for disinfection at the end of attenuation should be effective), ozone generator and electrolyzing cell, the rolling strength of large sewage treatment plant under service conditions of the ship, etc.. If including gray water, hydraulic loading and organic loading should be considered.;

(3) list, types and technical parameters of main accessories: such as comminuting pump, air pump, circulating pump(process pump), discharge pump, vacuum drencher pump, dosing pump, ultra-violet sterilizer, ozone generator, film and electrolyzer;

(4) Drawing of nameplate, etc..

5 Materials and components

Materials and components are to comply with relevant requirements of CCS Rules.

5.1 Main components:

(1) pump like air pump, comminuting pump, discharge pump, circulating pump(process pump), vacuum collector (vacuum drencher pump), etc. ;

(2) disinfectant equipment and parts: membrane, ultra-violet sterilizer, ozone generator, electrolyzer, etc..;

(3) electrical control equipment, moto, etc.;

5.2 The following components are to be provided with CCS Marine Product Certificate:

(1) electrical control equipment (including electrical control box, PLC controller, etc.);

(2) pump, etc..

5.3 The following components are to be provided with the qualification certificates by the manufacturer:

(1) disinfectant equipment and components, water treatment equipment and components: membrane, ozone generator, electrolyzer, etc.;

(2) valve, meter, etc.;

5.3 The following components are to be provided with CCS approval Certificate:

(1) motor.

6 Design and technical requirements

6.1 Sewage treatment plant is to be capable of operating normally when:

(1) the ship has a $\pm 15^{o}$ heel, or $\pm 22.5^{o}$ roll, or $\pm 5^{o}$ trim or $\pm 7.5^{o}$ pitch;

(2) ambient temperature is under 0～55℃;

⑶ relative humidity is ≤ 90%;

⑷ the sewage treatment plant is at angles of inclination of 22.5 ° in any plane from the normal operating position.

6.2 As using for the ship with flag of China, designed hydraulic loading should not be less than 70 L/day per person, and designed organic loading should not be less than 35 g/day per person.

6.3 temperature of environment and influent quality should be specified by manufacture, that can refer to Federal regulations of the United States 33CFR159.119 quoted by USCG: the temperature of influent quality is 2℃～32℃, when environmental temperature is 5℃; the temperature of influent quality is 2℃～32℃, when environmental temperature is 50℃.

6.4 For the purpose of regulation 1.2.2 of Resolution MEPC.227(64) (sewage treatment plants installed on or after 1 January 2016 on: ships (other than passenger ships) in all areas; and passenger ships outside MARPOL Annex IV special areas.), a sewage treatment plant should meet the following effluent standards when tested for its Certificate of Type Approval by the Administration:

⑴ 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.

⑵ Total Suspended Solids (TSS) Standard (see 4.1.2 of Resolution MEPC.227(64) for detail test method):

① Where the sewage treatment plant is tested ashore, the geometric mean of the total suspended solids content of the samples of effluent taken during the test period should not exceed 35 Qi/Qe mg/l.

② Where the sewage treatment plant is tested on board 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 should 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 should the maximum allowed TSS be greater than (35 plus x) Qi/Qe mg/l.

⑶ Biochemical oxygen demand without nitrification and chemical oxygen demand Administrations should ensure 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 without nitrification (BOD5 without nitrification) of the samples of effluent taken during the test period does not exceed 25 Qi/Qe mg/l and the chemical oxygen demand (COD) does not exceed 125 Qi/Qe mg/l. The test method standard should be ISO 5815 1:2003 for BOD5 without nitrification and ISO 15705:2002 for COD, or other internationally accepted equivalent test standards.

⑷ 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 without nitrification 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.

⑸ pH : the pH of the samples of effluent taken during the test period should be between 6 and 8.5.

⑹ Residual chlorine: when chloric chemicals is used as a disinfectant, the residual chlorine in the samples of effluent taken during the test period is to be below 0.5 mg/*l*.

6.5 For the purpose of regulation 1.2.3 of Resolution MEPC.227(64) (sewage treatment plants installed on: new passenger ships when operating in a MARPOL Annex IV special area and intending to discharge treated sewage effluent into the sea on or after 1 January 2016; and existing passenger ships when operating in a MARPOL Annex IV special area and intending to discharge treated sewage effluent into the sea on or after 1 January 2018.), a sewage treatment plant installed on a passenger ship intending to discharge sewage effluent in special areas should additionally meet the following effluent standards when tested for its Certificate of Type Approval by the Administration:

⑴ Nitrogen and phosphorus removal standard (note 1):

The geometric mean of the total nitrogen and phosphorus content of the samples of effluent taken during the test period should not exceed:

① total nitrogen: 20 Qi/Qe mg/l or at least 70 per cent reduction [(1)] (Total nitrogen means the

sum of total Kjeldahl nitrogen (organic and ammoniacal nitrogen) nitrate-nitrogen and nitrite-nitrogen.);

② total phosphorus: 1.0 Q_i/Q_e mg/l or at least 80 per cent reduction [(2)].

(2) Method of testing should be: ISO 29441:2010 for total nitrogen; and ISO 6878:2004 for total phosphorus; or other internationally accepted equivalent test standard.

Note (1): Regulation 4.4 of Resolution MEPC.227(64) refer to a review of the Nitrogen and Phosphorus removal standard which should have been undertaken by the Committee at its sixty-seventh session. But in the sixty-seventh and the sixty-eighth session, the Committee did not make it to the final determination. Before the IMO MEPC determine to revise the removal standard, CCS will temporarily implement the requirements.

Note (2): Related to the reduction of influent loading.

6.6 Requirements for designed structure and attachments:

(1) Proper holes of sewage box are to be fitted for the purpose of draining, cleaning, inspection and maintenance;

(2) Venting pipe connection of sewage box led to atmosphere is to be fitted. For the sewage treatment plant probably generating explosive gas, a spark arrestor is to be fitted at the end of the venting pipe (For the sewage treatment plants with aerobic process, it could be installed simple protecting facilities to prevent foreign matter from entering into);

(3) Emergency overflow hole is to be fitted on sewage box, normally in disinfection room, and above the high alarm level.

(4) Plant or equipment is to be so arranged that it easily to take samples of influent and effluent of sewage.

(5) Plant or equipment is to be arranged with effective means of corrosion prevention, etc.

(6) Discharge of treated water: the design of electrical control should meet that it could send out sound and light alarm when the main treatment equipment such as ultra-violet sterilizer, ozone generator and electrolyzer, etc., is out of order or out of power. Suggest to specify effluent water pressure head when sewage treatment plants are working, in order to design the effluent pipe.

6.7 In meeting the effluent standards, an approved sewage treatment plant should not rely solely on dilution of wastewater. Where amounts of dilution are deemed essential to a treatment process, the effluent standards having concentration limits (mg/l) should be adjusted proportionally using dilution compensation factor Q_i/Q_e to take account of dilution Q_d. In addition, for effluent standards having a percentage reduction, the geometric mean of the daily percentage reduction values should be calculated using the accumulated flow Q_i and Q_e over each 24-hour test day, in terms of l/day, multiplied by the geometric mean of the corresponding concentration C_i and C_e for the same 24-hour test day, in terms of mg/l.

The overall percentage reduction over the entire test period n is:

$$PR = \sqrt[n]{PR_1 \cdot PR_2 \cdots PR_n} \cdot 100$$

,where PR_n is the daily removal value:

$$PR_n = \frac{\left(\frac{(Q_i)_n \cdot \sqrt[s]{(C_i)_1 \cdot (C_i)_2 \cdots (C_i)_s}}{1000}\right)_n - \left(\frac{(Q_e)_n \cdot \sqrt[s]{(C_e)_1 \cdot (C_e)_2 \cdots (C_e)_s}}{1000}\right)_n}{\left(\frac{(Q_i)_n \cdot \sqrt[s]{(C_i)_1 \cdot (C_i)_2 \cdots (C_i)_s}}{1000}\right)_n}$$

where: n represents the test day number; and

s represents the sample number collected on test day n

6.8 Electric control box: should be subjected to type approval test to verify its meeting part 3 of the annex to the Revised Guidelines and Specifications for Pollution Prevention Equipment for Machinery Space Bilges of Ships (resolution MEPC.107(49)) and Chapter 2 and 3, Part Four of China Classification Society Rules for Classification of Sea-going Steel Ships. Electric control equipment such as PLC controller should be comply with Section 6, Chapter 2, Part seven of China Classification Society Rules for Classification of Sea-going Steel Ships.

6.9 cleaning device and drain valve should be installed for ultra-violet sterilizer.

7 Type test

7.1 The type test may be performed ashore in the simulation shipboard condition or onboard with ship actual operating condition.

7.2 Selection of typical samples

⑴ The test sample is to be full-scale sewage treatment plant.

⑵ It can be confirmed according to calculations that the plants with various treatment capability are the same series (the same series means the plants have the same sewage treatment principle and manufacturing technique, as Biochemical method device their sewage retaining time and unit BOD air-supply amount are basically consistent). The types with the worst designed conditions (factors such as inclination conditions, structural stability of large products under swaying motion conditions are to be considered) are to be selected (scaling is to be fully taken into account) from the series as the test sample to represent the whole series of sewage treatment plant by the unit conducting type approval of CCS according to the specific situations. The potential restrictions on the performance of sewage treatment plant due to the increasing and reducing of its size are to be fully considered. Sewage treatment plants with very large or very small size or with specific conditions may be approved by prototype test. If it is impossible to provide calculations to determine whether the sewage treatment plants with various specifications and types are the same series products, type test is to be carried out for each specification.

7.3 Type test items and requirements

⑴ Inspection of appearance, size, welding and assembly quality

① To inspect the appearance, size, quality of welding and inner and outer wall anticorrosive coatings of sewage treatment plant for confirming compliance with design requirements.

② To inspect the installation of pump, disinfectant equipment and components, pipeline valves, electrical control box and instruments for confirming compliance with design requirements.

⑵ Water tightness test: each tank is subject to hydraulic test by a water column with 2.1 m pressure and it is to be confirmed that no leakage or deformation is to be found between the tanks or in the whole tank.

⑶ Performance test:

① Raw sewage quality: For equipment 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 grey water 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. For equipment 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 is not to be less than 500 mg/l. The BOD5 index of the influent is to be measured and recorded. During the type test, calculation is to be carried out based on the average BOD concentration of influent (raw sewage) and effluent (treated water) and the average hydraulic loading so as to determine the capacity. The test result is not to be lower than the design requirements. For adding of grey water and vacuum collecting of sewage, refer to the corresponding standards.

For the sewage treatment plant mentioned in Regulation 1.2.3 of IMO MEPC 227(64), total nitrogen and total phosphorus of raw sewage shall be measured (total nitrogen and total phosphorus of gray water shall be measured, if influent and dilution have gray water.); For the sewage treatment plant its influent have gray water, test shall use mixed water, mixed ratio of black water and gray water could refer to Regulation 4.3 of ISO 15749-1(2004). Gray water preparation requirements are as follows: detergent 10g/100L, washing powder 20g/100L, shampoo 5g/100L, edible oil 25g/100L, barber's hair 1g/100L.

② Duration of test: The duration of the test period is to be 10 days after steady-state conditions have been reached by the equipment under test. A minimum of 40 effluent samples after treatment are to be collected.

③ Loading factors: During the test period, the sewage treatment plant is to be tested under conditions of minimum, average and maximum volumetric loadings. For loading factors and sampling timings, refer to Figure 2. For different requirements for testing ashore and testing onboard, see 5.4 of MEPC.227(64) for detail.

④ Sampling methods and frequency: An influent sample is to be taken and analyzed for every effluent sample taken and the results recorded. If possible, additional influent and effluent samples are to be taken to allow for a margin of error. See 5.5 of MEPC.227(64) for detail.

⑤ Salinity and temperature: Tests are to be carried out within the range of temperature (including environmental temperature, influent temperature, flushing and back flushing medium temperature), and salinity specified by the manufacturer, salinity of sea water shall not be less than 35g/L, range of temperature shall refer to 4.2(1)② of this Guideline. The duration of the test period should be a minimum of 2 days.

⑥ Inclination test (included in the 10-day type test): When the sewage treatment plant is tested ashore, it can operate under conditions of tilt consistent up to 22.5° in any plane from the normal operating position, and the test takes at least two days. The inclination direction of the sample plant is to be determined according to the most unfavorable condition such as fluid level control reliability, electrical reliability and intact stability of equipment.

⑦ Analysis and test of effluent: For sewage treatment plant, consideration is to be given to recording of other indexes in addition to those required for thermotolerant coliforms, total suspended solids, COD, BOD5, pH and residual chlorine. Indexes which might be considered include turbidity, total phosphorus. It is encouraged that the use of ozone, ultra-violet irradiation or any other disinfectant, which minimizes the adverse environmental effects. When chloric chemicals is used as a disinfectant, the disinfectant residual in the effluent is to be below 0.5 mg/*l*. The test standards for effluent are to be in compliance with the requirements of IMO MEPC.277(64).

⑧ Zero load test: For biochemical sewage treatment plant, a zero load test is to be carried out. The plant is to re-operated after a 2-day operation stop and the plant is to be expected to return to a normal operation within one or two days after restart. The zero load test may be arranged after completion of the above mentioned test items.

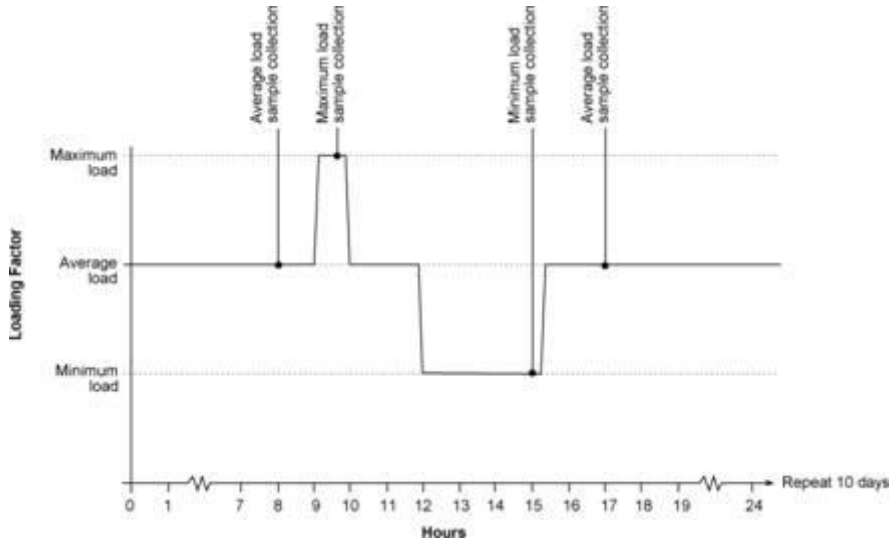

Figure 2: Suggested hydraulic loading factors and sampling frequency for testing sewage treatment plants. May be modified as necessary to take account of characteristics of individual sewage treatment plants

(4) electrical control system shall send out sound and light alarm when the main treatment equipment such as ultra-violet sterilizer, ozone generator and electrolyzer, etc., is out of order or out of power.(5) Stripping: After type test, the sample plant is to be stripped, internal corrosion, spray painting quality, etc. are to comply with the design requirements.

7.4 Unit for testing sample water is accepted by CCS and nationally approved authoritative organization with the appropriate qualification.

8 Routine inspection

8.1 Inspection items

(1) check of CCS Marine Product Certificate and qualification certificates issued by the manufacturer;

(2) check of records or reports and conditions for inspection and tests: including the check of quality certificates and/or reports of physical and chemical properties of materials of main parts processed at the manufacturer; the check of inspection, measurement and test conditions of the manufacturer, together with a list of test and inspection equipment used and valid calibration certificates; the check of test report of the manufacturer, covering sample type, specification, serial number, test place and date, test environment, test items, test data, conclusions of inspection and test, etc. as well as the check of issues found during

test and handling measures, etc.

8.2 The test items for unit/batch inspection after approval:

(1) inspection of appearance, size, welding and assembly quality;

(2) box water tightness test (by a water column with 2.1 m pressure);

(3) operation test of equipment: to check whether the operation tests of equipment such as air pump, discharge pump, comminuting pump, dosing pump, ozone generator, ultra-violet sterilizer and electrolyzer are in normal order;

(4) fresh water operation test: tested with fresh water flushing to inspect all components and parts are working normally;

(5) backflow performance test (applicable to biochemical sewage treatment plant): open the return valves for lifting backflow sludge and scumming to check it is in normal condition.

(6) electrical control system shall send out sound and light alarm when the main treatment equipment such as ultra-violet sterilizer, ozone generator and electrolyzer, etc., is out of order or out of power.

8.3 Attention is to be paid to the change of Regulation 4.2.1 of Resolution MEPC.227(64) “Nitrogen and phosphorus removal standard of the sewage treatment plant installed on a passenger ship intending to discharge sewage effluent in special areas” (the Nitrogen and Phosphorus removal standard which should have been undertaken by the Committee at its sixty-seventh and sixty-eighth session wasn’t made to the final determination by the Committee.)