Guideline No.M-19 (201510)

M-19

OIL SEPARATOR

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Foreword

CCS Product Inspection and Testing Guideline (hereinafter referred to as this Guideline) contains the technical requirements, inspection and testing criteria related to classification and statutory survey of marine products to be applied for CCS approval/inspection.

This Guideline frees the users to adopt other test methods and requirements which are equivalent to or are stricter than this Guideline.

This Guideline is published and updated by CCS, and is released at http://www.ccs.org.cn. Your comments or suggestions are welcomed and may be sent to our email addressed mp@ccs.org.cn.

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OIL SEPARATOR

1 Application

1.1 This Guideline applies to design, manufacture and acceptance of oil separator (also known as marine disc separator) which removes water and mechanical impurities in mineral oil (fuel oil and lubricating oil) on board. It may be taken as a reference for other types of oil separator.

2 Basis for approval and inspection

Chapter 1, Part Three of *CCS Rules for Classification of Sea-Going Steel Ships*

Chapter 5 and Chapter 7, Part One of *CCS Rules for Materials and Welding*

Standards accepted by CCS (e.g. GB/T 5745 Marine Disc Separator).

3 Definitions

3.1The terms and definitions in Chapter 3, Part One of CCS *Rules for Classification of Sea-going Steel Ships* are applicable to this Guideline.

3.2 The terms involved in this Guideline are as follows:

(1) Rated conditions: The operation condition where oil separator, at rated speed and under the specified clean oil discharge pressure in the design, separates oil without emulsification tendency and at a separation temperature of not more than 60 ℃ and a viscosity of not more than 24 mm^2/s (40 ℃).

(2) Rated speed: Design revolutions per minute for oil separator bowls.

(3) Rated capacity: Oil separator's capacity per hour under rated conditions.

(4) Actual capacity: Oil separator's capacity for oils of different viscosity at rated speed under corresponding separation conditions.

4 Plans and documents

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

(1) Main product performance specification table (it may not be provided separately if defined in general plan or other documents);

(2) General assembly plan;

(3) Plans of main parts/components (bowl body, bowl hood, main lock ring, main shafts, housing, clutch, transmission unit);

(4) Main system schematic diagram and safety alarm device (where applicable)

(5) Calculation book (if applicable);

(6) Factory inspection/ test program.

(7) Type test program (if applicable – only required for product type approval and the program approval procedures are to be fulfilled in accordance with the workflow requirements for type approval of CCS)

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

(1) Product Instructions;

(2) List of physicochemical properties of main parts and components (it may not be provided separately if defined in general plan or other documents);

(3) Main relevant acceptance standards (if applicable);

(4) Supplier's list of important parts/components (if applicable — only required for product type approval and the program approval procedures are to be fulfilled in accordance with the workflow requirements for type approval of CCS).

5 Materials and components

5.1 The materials and components of the product are to be controlled according to relevant requirements of the CCS Rules currently in effect;

5.2 For raw materials of the following parts (if applicable) in oil separator, the manufacturer's quality documents are to be provided:

Main shafts (vertical shaft and horizontal shaft), bowl (bowl body, bowl hood, main lock ring), housing.

6 Design and technical requirements

6.1 Service condition

The oil separator is to function properly under the following marine environmental conditions:

(1) For separators with horizontal shafting, the vertical shaft is mounted perpendicular to the horizontal plane with the horizontal shafting axis of the oil separator parallel to the ship midline;

Heel ±15°; trim ±5°;

Roll ±22.5°; period 10 s ~ 12 s;

Pitch ±7.5°, period 10 s ~ 12 s;

(2) When belt or direct connection is adopted for separators without horizontal shafting,

Heel ±15°, trim ±15°;

Roll ±22.5°, period 10 s ~ 12 s;

Pitch ±22.5°, period 10 s ~ 12 s;

(3) The relative humidity of service environment is not more than 95%;

(4) The temperature of service environment is not more than 50℃;

(5) Moulds and salt mist exist in service environment.

6.2 Basic parameters

(1)The basic parameters (type, model, speed, rated capacity, etc.) of oil separator are to comply with the design requirements.

(2) Appendix A may be referred to for separation conditions and actual capacity for different types of mineral oil.

(3) The oil feed pump (gear pump or screw pump) may be attached to or independent of the oil separator, with the main parameters to be in accordance with the requirements in Table 6.2.

Main parameters of oil feed pump **Table 6.2**

Parameters	Gear pump or screw pump
Degree of suction vacuum, in MPa	≥ 0.04
Discharge pressure, in MPa	≥ 0.20
Capacity, in L/h	To be greater than the actual capacity for oil in Appendix A

6.3 Performance

(1) When the volume percentage of water content (V/V) in oil is not more than 2% and the mass percentage of mechanical impurity content (m/m) is not more than 0.1% under rated condition, after primary separation by the purifier bowl, they are to be decreased to 0.3% and 0.03% respectively.

(2) When the oil separator runs under rated condition, the highest oil temperature of the lubrication box is to be not more than 85℃, and the temperature rise is not more than 50℃.

(3) When the oil separator runs under rated conditions, the bowl speed is to be not lower than 97% of the rated speed.

(4) When the oil separator runs under rated condition, the vibration intensity is to be not more than 4.5 mm/s.

(5) Under the condition of 115% rated speed, parts of oil separator such as bowl body, bowl hood, main lock ring are to be free from defects and residual deformation such as cracks.

(6) The startup current and the maximum current value are to meet the design requirements.

6.4 Safety

(1) Rotation direction marks are to be set or painted at visible places of the associated motor and independent oil pump of separators.

(2) The lubrication box of oil separator is to be equipped with oil level observation device or indicator.

(3) The tightening direction of connecting threads of the loaded parts in oil separator bowl is to be opposite to the rotation direction of the bowl.

(4) The oil separator is to be equipped with brake arrangement.

(5) The rotary parts and stationary parts are not allowed to be rubbed during the oil separator operation process (including startup and stop).

(6) The associated motor of oil separator is to be in accordance with the provisions of relevant standards and CCS Rules.

(7) The associated electric control equipment of separator is to be in accordance with the provisions of GB standards and CCS Rules.

(8) The associated motor and electric control equipment of oil separator are to be provided with reliable grounding devices.

(9) The exposed transmission parts or mechanism of oil separator are to be provided with shielding arrangements.

(10) The oil separator is to prevent the separated liquid or water permeating into the lubrication box.

(11) Other safety requirements of oil separator are to be in accordance with the relevant provisions of general industry standards.

(12) The bowl body, bowl hood, main lock ring and vertical shaft are to be subject to strength calculation and over-speed test for check.

(13) The oil separator is to be equipped with slings for lifting.

(14) The products which are installed in risky areas are to comply with the explosion-proof requirements for ships.

6.5 Appearance

(1) Defects such as wrinkle, flow mark, air bubble and pinhole are not permitted on the external non-machined surface of relevant casting parts of oil separator.

(2) Effective corrosion protection measures are to be taken for the internal non-machined surface of relevant casting parts of oil separator and the fasteners used.

(3) Obvious bump defects are not permitted on the compression-formed stainless steel housing of oil separators.

(4) Other coating requirements are to be in accordance with the provisions of relevant general standards.

6.6 Materials

(1) The mechanical properties and chemical compositions of main parts of oil separator such as bowl body, bowl hood, main lock ring and vertical shaft are to be in accordance with standards accepted by CCS (such as GB/T1220 or CB/T773) or other materials with properties not inferior to the standard stipulated below and with the manufacturer's material quality certificates.

(2) The materials of other parts of oil separator are to be in accordance with the following provisions or other materials with properties inferior to the standard stipulated below:

① Gray iron castings are to be in accordance with the provisions of standards (such as GB/T9439) accepted by CCS;

② Nodular cast iron parts are to be in accordance with the provisions of standards (such as GB/T1348) accepted by CCS;

③ Aluminum castings are to be in accordance with the provisions of standards (such as GB/T1173) accepted by CCS;

④ Copper castings are to be in accordance with the provisions of standards (such as GB/T1176) accepted by CCS;

⑤ Stainless steel castings are to be in accordance with the provisions of standards (such as GB/T2100) accepted by CCS;

⑥ Structural steels and stainless steels are to be in accordance with the provisions of standards (such as GB/T699 or GB/T3077, GB/T1220) accepted by CCS;

⑦ Important springs are to be in accordance with the provisions of standards (such as GB/T5218) accepted by CCS;

6.7 Process

(1) Main parts such as bowl body, bowl hood, main lock ring and vertical shaft must be subject to nondestructive test, and are to be in accordance with standards (such as JB/T9095 and JB/T10411) accepted by CCS or to use equivalent accepted non-destructive test methods and quality judgment, and defects are not permitted to be repaired by welding.

(2) The mechanical properties of main parts such as bowl body, bowl hood, main lock ring and vertical shaft after final heat treatment are to be in accordance with design requirements.

(3) When circular fixation mode of conical surface are used to connect the bowl body and vertical shaft, the area contacting with measure gauge for their matching cone are to be more than 80% respectively.

(4) The bowl parts of oil separator are to be subject to the check of dynamic balance with an accuracy of level G6.3 and the permissible degree of unbalance of dynamic balance is determined according to Appendix B.

(5) The maximum balance amount of dynamic balance of bowl parts (total amount of weight removed or added) is to be in accordance with the following provisions:

① For bowl parts with total mass less than or equal to 100 kg, the maximum balance amount of dynamic balance is to be not more than 1/800 of total mass of the bowl;

② For bowl parts with total mass more than 100 kg but less than 300 kg, the maximum balance amount of dynamic balance is to be not more than 1/1000 of total mass of the bowl;

③ For bowl parts with total mass more than 300 kg but less than 600 kg, the maximum balance amount of dynamic balance is to be not more than 1/1500 of total mass of the bowl;

④ For bowl parts with total mass more than 600 kg, the maximum balance amount of dynamic balance is to be not more than 1/2000 of total mass of the bowl. Relevant bowl parts are to be checked and corrected if the maximum balance amount exceeds the above provisions.

(6) De-weighting or weighting method is used to correct the value of unbalance of dynamic balance of bowl parts, and more than two positions to be de-weighted or weighted are not permitted. The de-weighted positions are to be smooth without sharp edges.

7 Type test

7.1 Selection of typical samples

Oil separators of each mode/specification are to be subject to type test.

7.2 The type test items are to include the following:

(1) Safety, appearance, material, process, dimensional inspection;

(2) Start-stop test;

(3) Operation test;

(4) Vibration measurement;

(5) Over-speed test;

(6) Inclination test;

(7) Sway test;

(8) Separation performance test;

(9) Continuous operation test;

(10) Teardown inspection.

7.3 Requirements for type test equipment/instruments:

(1) If manufacturer's laboratory/test bench is taken as the test site of approval test, it is to be examined and confirmed approvingly by the CCS Surveyor according to requirements of 7.3(2), (3) and (4); otherwise, all tests are to be conducted in the certification and test organizations accepted by CCS.

(2) The measuring instrument must be qualified by metrological service and within the specified validity period, and the accuracy is to comply with the test accuracy requirements. For details of accuracy of test instruments, see Table 7.3(1):

Accuracy requirements of test instruments **Table 7.3(1)**

Measured parameters	Measurement instruments	
	Name	Accuracy grade ≤
Time	Stopwatch	1
Speed	Tachometer	1.5
Pressure	Vacuum gauge, pressure gauge	1.5

Continued Table 7.3(1)

Temperature	Thermometer	1.5
Flow	Flowmeter	2.5
Current	Amperemeter	1.5
Voltage	Voltmeter	2.5
Vibration intensity	Vibrometer	5% of readings

(3) The oil for test is to be the lubricating oil in accordance with standards (such as 0# light diesel specified in GB 252) accepted by CCS and Table 7.3(2), or other fuel oil according to design requirements, and the clean fresh water is the test medium for over-speed test, inclination test and sway test.

Lubricating oil parameter **Table 7.3(2)**

Kinematic viscosity (mm^2/s)(100 ℃)	Visual inspection	Viscosity index	Carbon residue %
9.3 ~ 16.3	Transparent	≥ 75	≤ 0.15

The test additives are clean fresh water and activated carbon sieved by No. 200 sieve or equivalent particle additives.

(4) Refer to Fig. C in Appendix C for test system.

(5) The test parameters measured include: flow, pressure, current, voltage, bowl speed, temperature of separated oil, and temperature of lubricating oil.

① Measurement of flow: The flow is to be measured in accordance with requirements of recognized standards and may be measured with turbine flowmeter, tube flowmeter and electromagnetic flowmeter.

② Measurement of pressure: The pressure may be measured with liquid-column gauge or other types of manometer in accordance with requirements of accepted standard.

7.4 The following inspections are to be carried out before type test:

(1) Physicochemical property test of main raw materials and check of certificates of main materials:

① Scope: The physicochemical property test of raw materials is to be fulfilled if the casting and forging are self-made by manufacturer; for out-sourced parts, they are to be purchased from factories approved or accepted by CCS and the test specimens heat-treated with workpieces are to be subject to physicochemical property test.

② Sampling: The specimen of casting/forging is to be sampled and sealed on site according to CCS Rules for Materials and Welding.

③ Relevant chapters of CCS Rules for Materials and Welding are to be referred to for test method and technical requirements.

(2) Nondestructive test of bowl body, bowl hood, main lock ring and vertical shaft

(3) Dynamic balance inspection of bowl parts

(4) Disc quantity confirmation

(5) Visual and dimensional inspection

7.5 Test method and requirements

(1) Start-stop test

The oil separator is started under no-load condition to observe the startup process, and the time required for oil separator to reach rated speed from startup and the maximum current value in this process are measured and recorded. The working condition of start-up process is to be in accordance with the requirements of 6.4(5) and the time required for start-up and the maximum current value are to be in accordance with the design requirements.

When the oil separator reaches the rated speed, cut the power supply without use of brake and the free shutdown process is to comply with the requirements of 6.4(5).

(2) Operation test

① The test oil is in accordance with standards accepted by CCS (such as 0# light diesel of GB 252) or equivalent oil, and the test is conducted at normal temperature.

② The test is conducted under rated condition. The continuous test period is to be not less than 2 h, and the purifying/clarifying bowl is to be subject to clarification test for 0.5 h. The automatic discharging oil separator discharges every 0.5 h.

③ The voltage, current, bowl speed (or r.p.m of velometer), discharge pressure, capacity, oil temperature for separation, oil temperature of lubrication box and ambient temperature are measured and recorded one hour after stable operation in the test, and one measurement of partial ejection amount is to be measured for partial-ejection oil separator. The result is to be in accordance with the requirements of 6.3(2), 6.3(3) and design performance parameters.

④ The oil separators equipped with automatic control system are to be jointly debugged according to design requirements. The result is to be in accordance with the design requirements.

(3) Measurement of vibration

The vibration of oil separator is to be measured in accordance with standards (such as GB/T 10895) accepted by CCS one hour after stable operation in the test and the result is to be in accordance with the provisions of 6.3(4).

(4) Over-speed

① The over-speed test is to be conducted on the site with reliable safety measures.

② The test is conducted at 115% of rated speed with the bowl filled with clean water and the test duration is not less than 10 min。

③ The parts such as bowl body, bowl cover and main lock ring are to be subject to nondestructive test and dimension measurement before test, and two groups of actual dimensions are to be measured for each tested part and the measuring positions are to be marked clearly. After test, the above tested parts are to be subject to nondestructive test and dimension measurement at the original measuring points again. Defects and residual deformation such as cracks are not permitted.

(5) Inclination

The inclination test is conducted at rated speed with a certain amount of clean fresh water introduced and the test duration for all conditions is not less than 15 min. The result is to be in accordance with the provisions of 6.1(1) or 6.1(2) and 6.4(5).

(6) Sway

The sway test is conducted at rated speed with a certain amount of clean fresh water introduced and the test duration for all conditions is not less than 15 min. The result is to be in accordance with the provisions of 6.1(1) or 6.1(2) and 6.4(5).

(7) Separation performance

① The purifier bowl is used in separation performance test of oil separator, and the following conditions are to be complied with when tested at rated speed.

(a) Test oil: lubricating oil in accordance with 7.3(3) or fuel oil according to design requirements;

(b) Proportion of test additives: The volume fraction of water content is 1.8% ~ 2.2% and the mass fraction of mechanical impurities is 0.08% ~ 0.12%; for fuel oil, additives is not added in principle or according to design requirements;

(c) Capacity: according to Table A.1 of Appendix A or design requirements;

(d) Separation temperature: 85 ℃ ~ 95 ℃ or according to design requirements;

(e) Clean oil discharge pressure: design pressure;

② The viscosity, density, water content and impurity content of test oil are to be measured and recorded respectively according to the standards (such as GB/T265, GB/T1884, GB/T260 and GB/T511) accepted by CCS or equivalent recognized standards before test.

③ Add clean fresh water and mechanical impurities into the test oil according to the proportion as specified in 7.5.(7) ①(b); use an agitator to mix them thoroughly, and heat the test oil is to the required separation temperature.

④ Take the first group of contrast oil sample at the sampling position of oil inlet and clean oil discharge of oil separator 15 min after the oil separator operation parameter meets the requirements of 7.5.(7) ①(c), 7.5.(7) ①(e), followed by taking one group of sample in every 10 min. A total of three groups of sample are required.

⑤The water content and mechanical content of contrast oil sample are measured according to the standards (such as GB/T260 and GB/T511) accepted by CCS.

⑥ The capacity of oil separator is measured by a calibrated flowmeter with the measurement time not less than 1 min.

⑦ The result of separation performance test is to be in accordance with provisions of 6.3(1).

(8) Continuous operation

① The test is conducted according to the method specified in 7.5(2) for a cumulative time of 300 h and the data are measured every two hours according to 7.5(2) ③. The oil separator discharges every 2 h for automatic total-ejection type and every 0.5 h for automatic partial-ejection type.

② The oil separator is to function properly during the test, and the data measured according to 7.5(2) ③ are to comply with the requirements of 6.3(2) ~ 6.3(6) and design parameters. The test is considered invalid if any of the following situations happens:

(a) Bearing is damaged;

(b) Abnormal vibration or the vibration intensity is more than 4.5 mm/s all the time;

(c) The oil temperature of lubrication box exceeds 85℃ or temperature rise exceeds 50℃.

(d) The gear is damaged or the belt is fractured.

(e) Sealing and sludge discharging failure of automatic discharging oil separator.

③ If other malfunctions except the situations specified above occur during the test, the test is

allowed to be continued after the malfunction is eliminated and the running time elapsed is valid.

(9) Teardown

The teardown inspection is to be conducted after completion of all tests to check the integrity of the following parts:

① The wastage of spiral gear or the intactness of belts;

② The normal functioning of bearings of vertical shafting and horizontal shafting;

③ The normal lubrication situations of lubricating points in transmission system;

④ The intactness of important springs without fracture;

⑤ No shear, deformation and aging signs on the rubber seals.

8 Unit/batch inspection

8.1 The unit/batch inspection where a CCS marine product certificate is to be issued is to be conducted only when those products have been qualified as deliverable in the factory inspection/test.

8.2 For manufacturer obtained the type approval by CCS, the following inspection items of unit/batch inspection are to be performed:

(1) The inspection items to be witnessed are to be performed according to the approved product inspection plan, but usually is to include at least:

① Safety, appearance, material, process, dimensional inspection;

② Start-stop test;

③ Operation test;

④ Vibration measurement.

(2) When applying for unit/batch inspection, the applicants are to submit the following documents to the Surveyor for approval:

① Quality certificate of raw materials or physicochemical properties re-test report of important parts and components — bowl body, bowl hood, main lock ring and vertical shaft;

② Nondestructive test report;

③ Dynamic balance report of bowl;

④ Factory performance inspection/test report or records of finished products;

⑤ Product certificate of accessories;

⑥ Copies of calibration certificate of test instruments used in inspection, or list of verification conditions.

(3) The Surveyor is to randomly take at least 5% (min. 1 unit) products per batch/specification for re-test of the above tests.

(4) The test report is to include product or sample model, specification, number, test site and test date, test environment, test items and all test data, descriptions of problems found in the test and inspection and the solution, conclusion of the test.

Appendix A (Informative)

Separation Conditions and Actual Capacity for Different Types of Mineral Oil

A.1 For oil separator conditions and actual capacity for different types of mineral oil, see Table A.1.

Separation conditions and actual capacity for different types of mineral oil **Table A.1**

Oils	Fuel oil									Lubricating oil	
	Distillate fuel oil		Residual fuel oil							Marine lubricating oil	Steam turbine oil
Kinematic viscosity mm^2/s	1.9 ~ 5.5	5.5 ~ 24	60	80	120	180	380	460	600	9.3 ~16.3 (40 ℃)	612~748 (40 ℃)
	40 ℃		50 ℃							100 ℃	40 ℃
Density kg/m^3(20 ℃) ℃)	< 900		900 ~991							880 ~900	< 900
Separation temperature ℃	20	40	75	80	90	98				85-95	75
Ratio of actual capacity to rated capacity %	130	100	70 ∫ 75	60 ∫ 65	55 ∫ 60	45 ∫ 50	35 ∫ 40	25 ∫ 30	20 ∫ 25	30 ∫ 60	80 ∫ 85
Note: The percentage of actual capacity and rated capacity is the ratio obtained with the rated capacity of 100%.											

Appendix B (Informative)

Permissible Degree of Unbalance of Dynamic Balance for Bowl Parts and Components of Oil Separator

B.1 The permissible degree of unbalance of dynamic balance for bowl parts and components of oil separator is expressed in mass-radius product, which is determined according to formula (B.1).

$$M = \frac{G \bullet e}{10} \qquad \text{……(B.1)}$$

Where:

M – the permissible mass-radius product value, in g ⋅cm;

G – the mass value of parts (or components), in kg;

e – the permissible offset of centre of mass of parts (or components), in μm.

The permissible offset of centre of mass is calculated according to formula (B.2) or determined according to Fig. B.1(1).

$$e = \frac{1000T}{\omega} = \frac{6300}{\omega} \qquad \text{……(B.2)}$$

Where:

T – the accuracy of dynamic balance for bowl parts and components, taking the value of 6.3 mm/s ;

ω – the rate of turning of parts (or components), in rad/s.

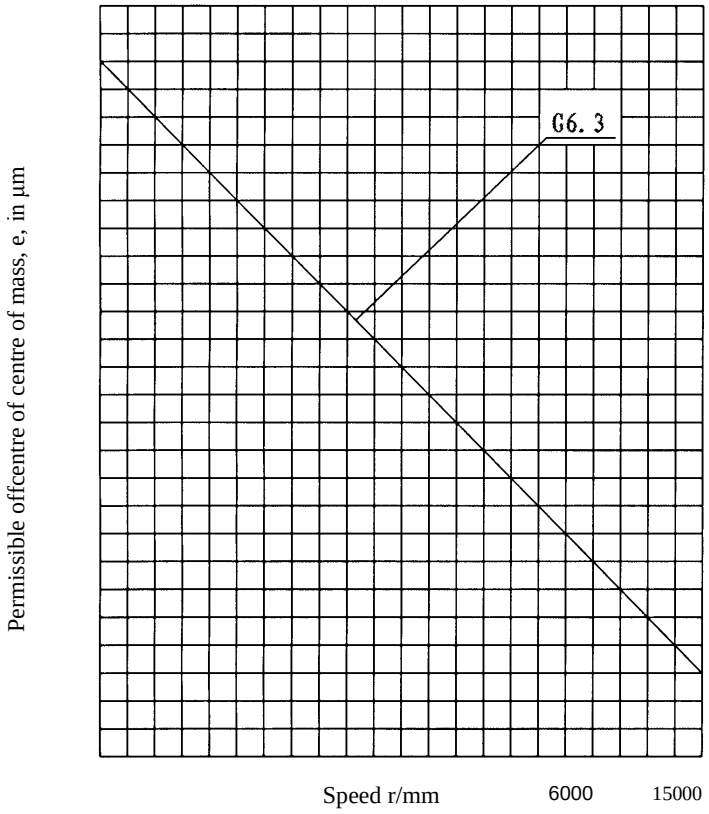

Fig. B.1(1) Permissible off-centre of centre of mass

The permissible mass-radius product (M) of dynamic balance calculated by formula (B.1) is the total permissible mass-radius product at the centre of mass of parts and components and it is to be divided into two parts when applied to actual balance process. The permissible mass-radius product of the corrected planes I and II (see Fig. B.1(2)) are to be calculated respectively according to formula (B.3) and formula (B.4).

$$M_1 = M \frac{b}{a+b} \quad \text{.....(B.3)}$$

$$M_2 = M \frac{a}{a+b} \quad \text{.....(B.4)}$$

Where:

M_1 - the permissible mass-radius product value on the corrected plane I, in g ċm;

M_2 - the permissible mass-radius product value on the corrected plane II, in g ċm;

M - the total permissible mass-radius product value at the centre of mass of parts and components, in g ċm;

a - the distance value from the centre of mass of parts and components to the corrected plane I, in cm;

b - the distance value from the centre of mass of parts and components to the corrected plane II, in cm;

Note: The corrected planes I and II are to be as far away from each other as possible with no effect on the strength and working performance of the balancing part.

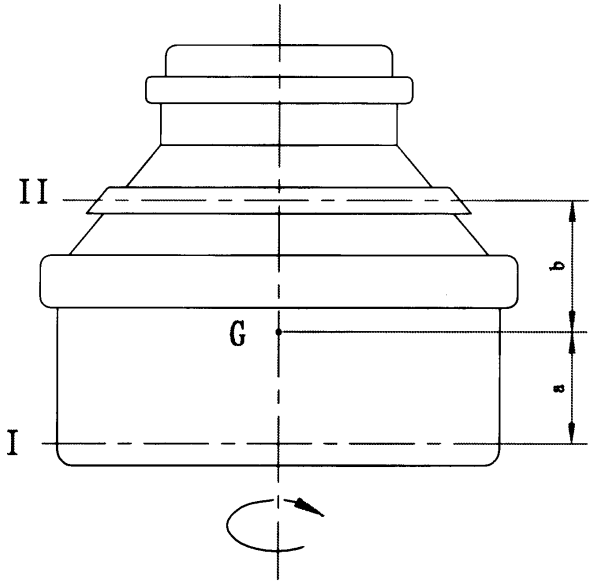

Fig. B.1 (2) Selection of corrected plane

Appendix C (Informative)

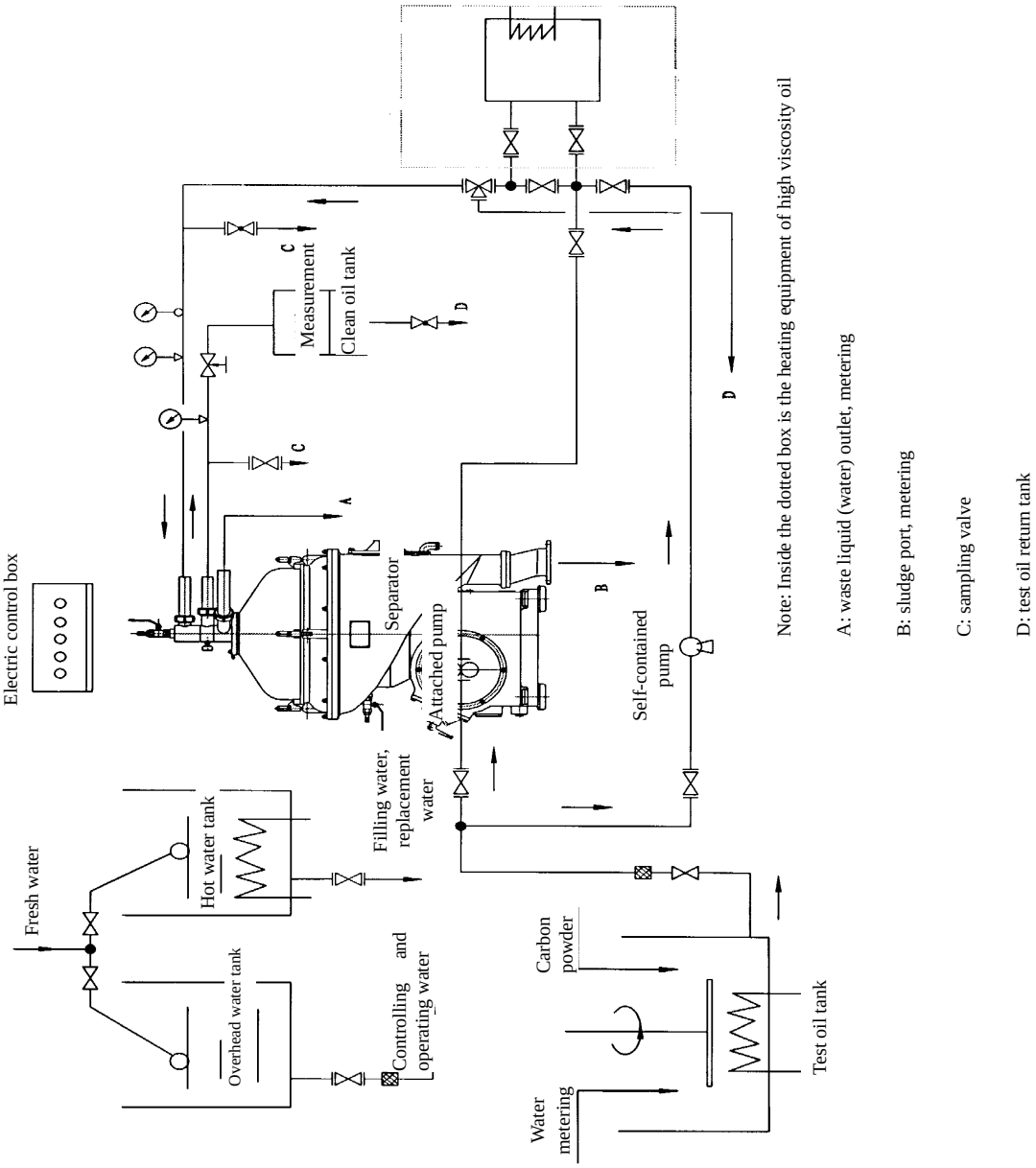

Fig. C Schematic diagram of test bench arrangement