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H-03 HYDRAULIC MOTORS

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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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Hydraulic Motors

1 Application

1.1 This guideline is applicable to the hydraulic motors (rated pressure $\leq 42\text{Mpa}$) intended to be installed on seagoing ships and offshore installations classed with CCS.

1.2 The hydraulic motors refer to in this Guideline mainly include:

- (1) Axial piston and radial piston hydraulic motors;
- (2) External involute gear motors;
- (3) Vane motors;
- (4) Hydraulic swing motors.

Reference to this chapter may be made for hydraulic motors of other types.

2 Normative references

CCS Rules for Classification of Sea-going Steel Ships

GB/T 13853-2009 General Specification for Hydraulic Pumps and Motors for Ships

JB/T 10829-2008 Hydraulic Motors

JB/T 8728-2010 Low Speed High Torque Hydraulic Motors

3 Terms and definitions

3.1 Definitions of the terms regarding product inspection, type approval, type test, test specimen, unit/path inspection are given in Chapter 3, PART ONE of CCS Rules for Classification of Sea-going Steel Ships.

3.2 Rated pressure: the maximum input pressure during continuous operation at the rated speed of revolution, which is capable of ensuring the designed service life.

3.3 No-load pressure: the input pressure when a hydraulic motor is operating under no load.

3.4 Maximum pressure: the input pressure peak allowing for short-period operation.

3.5 Nominal displacement: the nominal value of the geometric displacement of a hydraulic motor.

3.6 Theoretical flow rate: the flow rate required for the volume change of a hydraulic motor's enclosed chamber to reach the given speed in unit time.

3.7 Rated speed: the maximum speed during continuous operation under rated conditions, which is capable of ensuring the designed service life (note: the rated speed of variable motors may vary when they are operating at different rates of displacement, and therefore, the data of rated speed corresponding to different rates of displacement is to be provided).

3.8 Maximum speed: the peak speed allowing for short-period operation, which is to be no less than 110% of the rated speed.

3.9 Minimum speed: the minimum value of the speed required for stable operation of a motor under normal working conditions.

3.10 Rated condition: the operating condition at rated pressure and rated speed (at maximum rate of displacement for variable motors).

3.11 Input power: the input hydraulic power at the inlet of a hydraulic motor.

3.12 Output power: the hydraulic power output by the output shaft of a hydraulic motor.

3.13 Theoretical torque: the torque generated by the rotor of a hydraulic motor under the action of hydraulic pressure.

3.14 Actual torque: the torque output by the shaft of a hydraulic motor.

4 Drawings and documentation to be submitted

4.1 The following drawings and documentation to be submitted are to be submitted to CCS for approval:

(1) Main properties and specifications of products;

(2) General assembly drawing;

(3) Main parts diagram (motor body components, safety valve components, controller components, motor shaft, rotor (when applicable), piston (when applicable), cylinder (when applicable), piston ring (when applicable), transmission gears (when applicable), vane (when applicable), motor housing, cover, etc.);

(4) Design calculations;

(5) Summary table of the material mechanical and chemical properties of main parts;

(6) Manufacturer test program of products.

4.2 The following drawings and documentation to be submitted are to be submitted to CCS for review:

(1) Relevant main acceptance criteria;

(2) Instructions for use of products;

(3) Samples of product nameplate, product quality certificates, etc.

5 Materials and components

5.1 The main parts are different for different types of hydraulic motors.

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

5.3 Main parts include motor housing, cover, motor shaft, rotor (when applicable), piston (when applicable), cylinder (when applicable), piston ring (when applicable), transmission gears (when applicable), vane (when applicable), safety valve components, controller components and seals.

5.4 Where the main parts described in 5.3 are purchased or fabricated by an outside fabricator, a complete system to control the subcontractor's fabrication quality must be established by the applicant for the purpose of ensuring quality, and in addition, the material quality certificates must be provided.

6 Welding procedure qualification

6.1 Where the housing of hydraulic motors is constructed of welded structures or involves a welding repair process, the welding procedure qualification is to be performed in accordance with the relevant requirements in CCS Rules for Materials and Welding.

7 Design objectives

7.1 Performance requirements

The performance of hydraulic motors is to comply with the requirements of recognized standards accepted by CCS, and moreover, the marine environmental suitability test is to be carried out. In general, the performance requirements for hydraulic motors include:

7.1.1 Pressure resistance

The pressure chamber of a hydraulic motor is to be capable of withstanding 1.5 times of rated pressure continuously for 5min without leakage and without permanent deformation of any part.

7.1.2 Displacement

The no-load displacement of a hydraulic motor is to be within the range of 95%~110% of nominal displacement.

7.1.3 Volumetric efficiency and total efficiency

The volumetric efficiency and total efficiency of a hydraulic motor calculated in accordance with this regulation or equivalent standards are to be in compliance with the standards accepted by CCS.

The following steps are to be followed:

- (1) Regulate the inlet pressure of the motor to set the test pressure at 10%, 25%, 40%, 55%, 70%, 85% and 100% of the rated pressure respectively;
- (2) Regulate the motor speed to set it at 10%, 25%, 40%, 55%, 70%, 85% and 100% of the rated speed respectively;
- (3) Measure the pressure, flow rate and speed of the motor corresponding to each abovementioned operating condition. Plot the curves reflecting the changes of pressure and flow rate along with speed;
- (4) Calculate the volumetric efficiency and total efficiency of the motor by the formula below.

$$\eta_v = \frac{v_{1,i}}{v_{1,e}} = \frac{q_{v1,i} / n_i}{q_{v1,e} / n_e} \times 100\%$$

Volumetric efficiency:

$$= \frac{(q_{v2,i} + q_{vd,i}) / n_i}{(q_{v2,e} + q_{vd,e}) / n_e} \quad \text{-----} \quad (1)$$

Total efficiency:

$$\eta_t = \frac{2\pi m_e T_2}{1000(p_{1,e} q_{v1,e} - p_{2,e} q_{v2,e})} \times 100\%$$

$$= \frac{2\pi m_e T_2}{1000[p_{1,e}(q_{v2,e} + q_{vd,e}) - p_{2,e} q_{v2,e}]} \times 100\% \quad \text{-----} \quad (2)$$

Input hydraulic power:

$$p_{1,n} = \frac{p_{1,e} \times q_{v1,e}}{60} = \frac{p_{1,e}(q_{v2,e} + q_{vd,e})}{60} (KW) \quad \text{-----} \quad (3)$$

Output mechanical efficiency:

$$p_{2,m} = \frac{2\pi m_e T_2}{60000} (KW) \quad \text{-----} \quad (4)$$

Starting efficiency:

$$\eta_{hm} = \frac{2\pi T_2}{\Delta p v_{1,i}} \times 100\%$$

Where,

$v_{1,i}$ -----input displacement at no-load pressure, in ml/r;

$v_{1,e}$ -----input displacement at test pressure, in ml/r;

$q_{v1,i}$ -----input flow rate at no-load pressure, in L/min;

$q_{v1,e}$ -----input flow rate at test pressure, in L/min;

n_i -----speed at no-load pressure, in r/min;

n_e -----speed at test pressure, in r/min;

$q_{v2,i}$ -----output flow rate at no-load pressure, in L/min;

$q_{vd,i}$ -----leakage flow rate at no-load pressure, in L/min;

$q_{v2,e}$ -----output flow rate at test pressure, in L/min;

Δp -----difference between input test pressure and output test pressure, in MPa;

$q_{vd,e}$ -----leakage flow rate at test pressure, in L/min;

$p_{1,e}$ ----- input test pressure, being positive when higher than the atmospheric pressure and negative when lower than the atmospheric pressure, in MPa;

$P_{2,e}$ -----output test pressure (i.e. back pressure), in MPa;

T_2 -----output torque, in N.m.

7.1.4 Starting efficiency test

The minimum starting efficiency at rated pressure is to comply with the requirements of the standard acceptable to CCS.

7.1.5 Low-speed performance test

The minimum stable speed of a hydraulic motor at the maximum displacement, rated pressure and specified back pressure is to comply with the requirements of the standards acceptable to CCS.

7.1.6 Variable performance test (applicable to variable motors)

The corresponding data of different controlling variables and controlled variables is to be measured under the specified design conditions based on the variables control mode, and variable performance curves are to be plotted. The relevant requirements of applicable recognized standards are to be complied with.

7.1.7 Noise

The airborne noise level of hydraulic motors (A-weighted sound pressure level) under rated conditions is to comply with the standards acceptable to CCS. Noise measurement may be carried out with reference to CCS Guidelines for Noise Control and Testing for Ships and Products 2013.

7.1.8 Overspeed performance

Hydraulic motors, under rated pressure and no-load conditions, are to be capable of operating properly for more than 15min at 125% of the rated speed or at the maximum design speed (whichever is greater) without any anomaly.

7.1.9 Overload performance

Hydraulic motors are to be capable of operating continuously and properly for 20h at the maximum pressure or 125% of the rated pressure and rated speed without any anomaly.

7.1.10 Durability

The reduction in the volumetric efficiency of a hydraulic motor after durability test is to be:

(1) $\leq 3\%$ for vane motors and piston motors;

(2) $\leq 4\%$ for gear motors.

The durability of motors may be tested in accordance with the standards acceptable to CCS or any one of the following programs:

(1) The hydraulic motor is to be shock tested with not less than 100 thousands of continuous hydraulic pulses (the high and low amplitude values of the hydraulic pulses are to be the rated pressure and no-load pressure of the motor respectively, and the duration of high amplitude pulses is to be no less than 33% of the entire test duration) at a frequency of 10~15 times per minute and the operating conditions of the motor are to be observed.

(2) The hydraulic motor is to be tested with not less than 50 thousands of continuous forward-reverse direction changeover shocks at a frequency of five times per minute and the operating conditions of the motor are to be observed.

(3) The hydraulic motor is to operate continuously for 3000h during the full load test and its operating conditions are to be observed.

(4) The hydraulic motor is to operate continuously for 200h during the overload test (at 125% of the rated pressure of the motor) and its operating conditions are to be observed.

7.1.11 Environmental suitability

(1) Low temperature performance

Hydraulic motors are to be capable of operating properly without leakage or loosening of the fasteners when the ambient temperature and hydraulic oil temperature are at -25°C and -15°C respectively;

(2) High temperature performance

Hydraulic motors are to be capable of operating properly without leakage or loosening of the fasteners when the ambient temperature and hydraulic oil temperature are at 55°C and 65°C respectively;

(3) Inclining and swaying: $\pm 7.5^{\circ}$ (pitch, the period being 3s, 5s and 7s respectively); $\pm 22.5^{\circ}$ (roll, the period being 3s, 5s and 7s respectively);

(4) Vibration: when the vibration frequency is within the range of 2Hz~10Hz, the value of displacement amplitude is $\pm 1\text{mm}$; and the vibration frequency is within the range of 10Hz~80Hz, the value of acceleration is $\pm 7\text{m/s}^2$;

(5) Shock: the value of acceleration 100m/s^2 , duration of acceleration wave-form 6ms;

(6) Alternate humid-heat: temperature: $25^{\circ}\text{C} \pm 3^{\circ}\text{C} \sim 40^{\circ}\text{C} \pm 2^{\circ}\text{C}$, relative humidity: 90%~96%;

(7) Fungus: temperature: $28^{\circ}\text{C} \sim 38^{\circ}\text{C}$, relative humidity: 90%~98%, degree of fungus growth: level 1;

(8) Salt fog: temperature: $35^{\circ}\text{C} \pm 2^{\circ}\text{C}$, PH value: 6.5~7.2

7.1.12 Sealing performance

(1) Static seal: all static seals are to be free from oil leakage under normal working conditions;

(2) Dynamic seal: all dynamic seals are to be free from oil dripping within 4h under normal working conditions.

7.2 Assembly requirements

7.2.1 Elements are to be assembled using parts and purchased parts qualified through inspection in accordance with the requirements of relevant product standards or technical documents. Any deformed, damaged and rusted parts and purchased parts are not to be used for assembly; the parts are to be thoroughly cleaned and free from any pollutants prior to assembly (e.g. iron scale, burr, fiber impurity, etc.); cotton, paper and other materials which may release fibers are not to be used to wipe the inner cavity of the housing, part fitting surface and the inflow and outflow paths during assembly, and seals with defects or beyond shelf life are not to be used; the exposed non-machined surface of elements is to be evenly coated in consistent color and the putty is not to be applied prior to coating.

7.2.2 Internal cleanness of hydraulic motors is to be in compliance with the requirements of the standard adopted by the manufacturers.

7.2.3 After motor assembly is completed, all the oil ports are to be sealed and 0.16MPa gas pressure is to be applied inside the enclosed housing. The housing is to be free from gas leakage (when applicable).

7.2.4 After assembly, the motor safety valves and controllers are to be function tested (when applicable).

7.3 Appearance quality and machining quality

The appearance of the products and parts are to comply with the following requirements:

- (1) The motor housing is to be heat treated to eliminate the internal stress. The non-machined surfaces of castings such as motor housing are to be free from defects such as ridge, flow mark, air void, pinhole, etc.;
- (2) The non-machined internal surfaces of cast parts and the fasteners used are to be provided with effective means of corrosion protection;
- (3) The coating is to be applied in accordance with the requirements of relevant general standards.

7.4 Identification

7.4.1 Name plates are to be attached to hydraulic motors at easily visible locations. The name plates and relevant identification marks must be in English or Chinese/English language; and the name plate is to show the following information:

- Product name, type, manufacturer code, manufacturer serial number;
- Main technical parameters;
- Name of manufacturer;
- Date of manufacture.

7.4.2 For hydraulic elements subject to direction requirements (e.g. rotating direction of hydraulic pumps, etc.), the required direction is to be indicated with an arrow or equivalent marks at easily visible location on the elements.

7.5 Material requirements

7.5.1 The materials selected for the main parts of hydraulic motors are to be suitable for the conditions of the working medium, such as type, temperature, pressure, etc.; The shaft, shell and main cast are to be purchased from the factories manufacturer approved by CCS, the material mechanical tests of the main cast of others types hydraulic motor reinspected in factory is accepted.

7.5.2 The materials selected for the main pressure parts, such as motor housing and controller, are to have certain ductility and comply with the requirements of CCS Rules for Classification of Sea-going Steel Ships or other standards acceptable to CCS. Where grey iron is used as the material of the pressure parts such as motor housing, its safety margin is to be assessed and where necessary, verification test (e.g. bust test) is to be carried out by appropriate methods.

7.5.3 The motor shaft is generally made of carbon steel or alloy steel forging or round bar, which usually requires carburizing, quenching and high temperature tempering treatment. The material of critical parts bearing alternate loads, such as motor shaft, needs to be heat treated and the heat treatment process is to comply with the requirements for material heat treatment specified in the standards acceptable to CCS.

7.5.4 The material of motor safety valves (if any) is to comply with the requirements specified in the standards acceptable to CCS. The material is to have a strength sufficient to withstand the maximum operating pressure of the hydraulic motor without being damaged.

7.5.5 All pressure parts are to be hydraulically tested to 1.5 times design pressure for a period not less than 5min prior to assembly.

7.5.6 It is strictly prohibited for non-metallic materials used in motors to contain any asbestos.

7.6 Strength requirements

7.6.1 The strength of the hydraulic motor housing and controller housing may be calculated and checked in accordance with the relevant requirements of CCS Rules for Classification of Sea-going Steel Ships or other standards acceptable to CCS.

7.6.2 The hydraulic motor shaft is to have a strength sufficient to withstand the torque on the output end; the connection between the rotor and drive shaft is to have a strength sufficient to withstand the transmitted torque.

7.7 The designed service life of motor bearings is to be calculated according to the equivalent dynamic load borne by the selected type of bearing in the real application.

7.8 Safety valve

7.8.1 Hydraulic motors are generally to be provided with safety valves, so that when the system pressure exceeds the design pressure, the safety valves will be automatically opened to allow for pressure relief, thus performing the function of safety protection;

7.8.2 The opening pressure of safety valves of hydraulic motors is generally to be set at a value not less than 1.25 times of the rated pressure of the motors;

7.8.3 The adjustment opening pressure of a safety valve and its flow rate corresponding to the maximum set flow rate of the motor are to be tested. For safety valves of motors of the same type, the flow test may be waived provided that the flow test of such valves has already been carried out.

8 Type test

8.1 Selection of typical test specimens

8.1.1 Where type approval of the products of a single specification is being applied for by the applicant, one motor is to be selected at random as the specimen for type test;

8.1.2 Where type approval of serial products of different types and specifications is being applied for by the applicant, one motor of large, medium and small specifications respectively is to be taken from each type series to cover the most representative products or the products with the largest specifications of each type, as the specimens for type test.

8.2 Prototype test items and methods

8.2.1 See Annex 1 for testing apparatus.

8.2.2 Test conditions

Unless otherwise specified, the working medium used for test is to meet the following requirements:

(1) The temperature of the working medium is to be 50 ± 2 °C for prototype test and 50 ± 4 °C for manufacturer test;

(2) The kinematic viscosity of the working medium is to be within the range of $1.7 \times 10^{-5} \text{ m}^2/\text{s} \sim 5 \times 10^{-5} \text{ m}^2/\text{s}$;

(3) The solid particle contamination level of the working medium is to be no less than -/19/16 as specified by GB/T14039-2002;

(4) The precision levels of measuring instruments is to be no less than level B listed in Table 2.

8.2.3 Prior to the tests, the function test and running-in test of the motors are to be carried out following the manufacturer's internal procedure.

8.2.4 Prototype test items and methods are given in Table 3.

9 Unit/path inspection

9.1 Inspection and test items

(1) The inspection of hydraulic motors after approval includes document review, inspections during manufacturing and manufacturer tests;

(2) Inspections during manufacturing mainly include material test, NDT of critical parts (if required), inspection of the parts' manufacture and assembly quality;

(3) Main castings and forgings such as motor shaft, motor housing, etc. are to be comply with 7.5.1 requirements 9.2 Records or reports to be submitted by the manufacturer include at least the following items:

(1) Material quality certificates and/or mechanical and chemical retest reports for main parts fabricated by the manufacturer;

(2) Conformity certificate and other relevant certificates of main purchased parts or main parts fabricated by an outsourcing fabricator;

(3) Manufacturer's inspection, measurement and test conditions, list of testing equipment, copies of valid calibration certificates. Precision levels of measuring instruments and the test itself are given in Table 1 and Table 2 respectively

Table 1 Precision Levels of Measuring Instruments

Parameters	Precision level		
	A	B	C
Speed /%	±0.5	±1.0	±2.0
Torque/%			
Volumetric flow rate (displacement) /%		±1.5	±2.5
Pressure/%			
Temperature/ °C		±1.0	±2.0

Table 2 Precision Levels of Testing

Parameters	Precision level
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	A	B	C
Speed /%	±0.5	±1.0	±2.0
Torque/%			
Volumetric flow rate (displacement) /%		±1.5	±2.5
Pressure/%			
Temperature/ °C	±1.0	±2.0	±4.0
Note: ranking of precision level: level A higher than level B, level B higher than level C.			

4) The test reports. submitted by the manufacturer. The test reports are to cover the type, specifications and number of the products or test specimens, date of test, test environment, test items, various test data, issues found during the test and inspection, description of the disposals, test conclusions.

9.3 The items and methods of manufacturer tests of hydraulic motors are given in Table 4.

Table 3 Hydraulic Motor Test Items and Methods

No.	Test item	Type test	Factory Manufacturer test	Test method	Remark
1	Appearance quality	X	X	The surface of the motor parts is to be free from burrs and other foreign matters. Forgings are to be free from defects such as cracking, air void, porosity, etc., and the paths and holding chambers are to be free from any slag inclusion or residues.	

2	Material and assembly quality	X	X	1. Inspection of the material certificates for the main parts of hydraulic motors; 2. Mechanical tests of critical parts (e.g. motor shaft) must be carried out under the witness of the surveyor; when the parts are produced in batches, it is acceptable that the test specimens be sampled by the heat/batch number of the materials and the test carried out under witness; 3. All the pressure parts are to be hydraulically tested to 1.5 times of the design pressure for a period not less than 5min prior to assembly.	
3	Tightness test	X	X	Rated pressure is to be applied to the motor and held for 5min, at this point, the motor seals are to be free from any leakage. Use of equivalent means is to be specially considered.	

Continued Table 3

4	Internal cleanness	X	X	Internal cleanness of motors is to be determined by the method specified by JB/T7858-2006 and the results are to comply with the requirements of 5.6 or the standards acceptable to CCS.	
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5	Safety valve operation test (when applicable)	X	X	The motor is to be started and its operating pressure ramped up. The safety valve is to be opened when the pressure is increased to 1.25 times of the rated pressure.	
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Continued Table 3

No.	Test item		Type test	Factory Manufacturer test	Test method	Remark
6	Safety valve displacement test		X	—	The adjustment opening pressure of the safety valve and its flow rate corresponding to the maximum set flow rate of the motor are to be tested (except the safety valves of motors of the same type for which the flow test has already been carried out).	
7	Performance test	Pressure resistance test	X	X	A hydraulic pressure equal to 1.5 times of the motor's rated pressure is to be applied to the pressure chamber of the motor at an increment rate of 0.1 times of the rated pressure per second and held for 5min. The motor seals are to be free from any leakage and the parts are to be free from any permanent deformation.	
8		Displacement verification test	X	X	The motor is to be tested by the method specified by GB/T7936. The resultant no-load displacement of the motor is to be within the range of 95%~110% of its nominal displacement.	
9		Volumetric efficiency and total efficiency	X	—	The volumetric efficiency and total efficiency are to be calculated by the method described in 3.7.1.3 and the results are to comply with the requirements of the standards acceptable to CCS.	

Continued Table 3

10		Starting efficiency test		—	The motor is to be started at a constant torsional moment or a constant pressure. The different phase angles of the motor's output shaft and the starting pressure or torsional moment in the forward and reverse directions at 25%, 75% and 100% of the rated pressure and at the specified back pressure are to be measured respectively, with different values of constant torsional moment or constant pressure under the maximum displacement condition. Then the starting efficiency is calculated.	
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Continued Table 3

No.	Test item		Type test	Factory Manufacturer test	Test method	Remark
11		Low speed performance test	X	—	1. The minimum stable speed in the forward and reverse directions without creeping is to be measured repeatedly by means of gradual deceleration and acceleration respectively at the maximum displacement, rated pressure and specified back pressure. 2. The minimum stable speed is to be measured by the abovementioned method at four evenly divided pressure points within the range from 50% of the rated pressure to the rated pressure. 3. Tests at various pressure points in the forward and reverse directions of revolution are to be carried out for more than five times.	
12		Variable performance test			The corresponding data of different controlling variables and controlled variables is to be measured under the specified design conditions according to the variables control mode, and variable performance curves are to be plotted.	

Continued Table 3

13		Noise level	X	○	10 evenly distributed measuring points are to be set on the approximate spherical surface at 1m radius from the motor housing, with the motor being under rated operating conditions. The airborne noise levels (A-weighted sound pressure levels) at these measuring points are to be measured respectively and the root mean square is to be taken. The results are to comply with the requirements of the standards acceptable to CCS.	
14		Overspeed performance test	X	X	The motor is to be adjusted to be at its maximum displacement and its speed is to be increased to 125% of the rated speed when the motor is operating at its rated pressure and no-load pressure respectively. Allow the motor to operate continuously for 15min. The motor is to operate stably without any anomaly.	

Continued Table 3

No.	Test item		Type test	Factory Manufacturer test	Test method	Remark
15		Overload performance test	X	X	The motor is to be adjusted to be at its rated speed and the pressure is to be increased to 125% of the rated pressure. Allow the motor to operate continuously for 20h (note: no less 1 min operation for manufacturer; 20h operation is not required for manufacturer test.). The motor is to operate stably without any anomaly. The reduction of its volumetric efficiency after the test is to meet the requirements of 7.1.10.	
16		Shock test	X	—	The motor speed is to be adjusted at the maximum displacement and rated pressure, until the shock pressure peak reaches 120%~125% of the rated pressure in the forward and reverse directions of revolution. The motor is to be shock tested in the forward and reverse directions of revolution (one changeover of direction is considered as one shock) at a frequency of 10~30 times per minute according to the specifications of 3.7.1.9. The shock waveform is to comply with the requirements of recognized standards. The reduction of its volumetric efficiency upon completion of the test is to meet the requirements of 7.1.10.	

Continued Table 3

17		Full load test	X	X	The motor is to be allowed to operate continuously no less than 1min at the rated speed and rated pressure. The actual speed, input pressure, output pressure, input flow rate, output flow rate and oil temperature of the motor are to be measured and compared to the design parameters. The reduction of its volumetric efficiency upon completion of the test is to meet the requirements of 7.1.10.	
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Continued Table 3

No.	Test item		Type test	Factory Manufacturer test	Test method	Remark
18	Environmental suitability test	Low temperature performance	X	—	The ambient temperature and hydraulic oil temperature are to be adjusted to -25 ℃ and -15 ℃ respectively and maintained for 1h. The displacement of the motor is to be adjusted to its maximum and the pressure is to be set at no-load pressure. Then the motor is to be consecutively started for three times and operate continuously for 10min under the rated conditions. The hydraulic motor is to be capable of operating properly without any leakage and loosening of fasteners.	
19		High temperature performance	X	—	The ambient temperature and hydraulic oil temperature are to be adjusted to 55 ℃ and 65 ℃ respectively. Then the motor is to be operating continuously for 1h under the rated conditions. The hydraulic motor is to be capable of operating properly without any leakage and loosening of fasteners.	

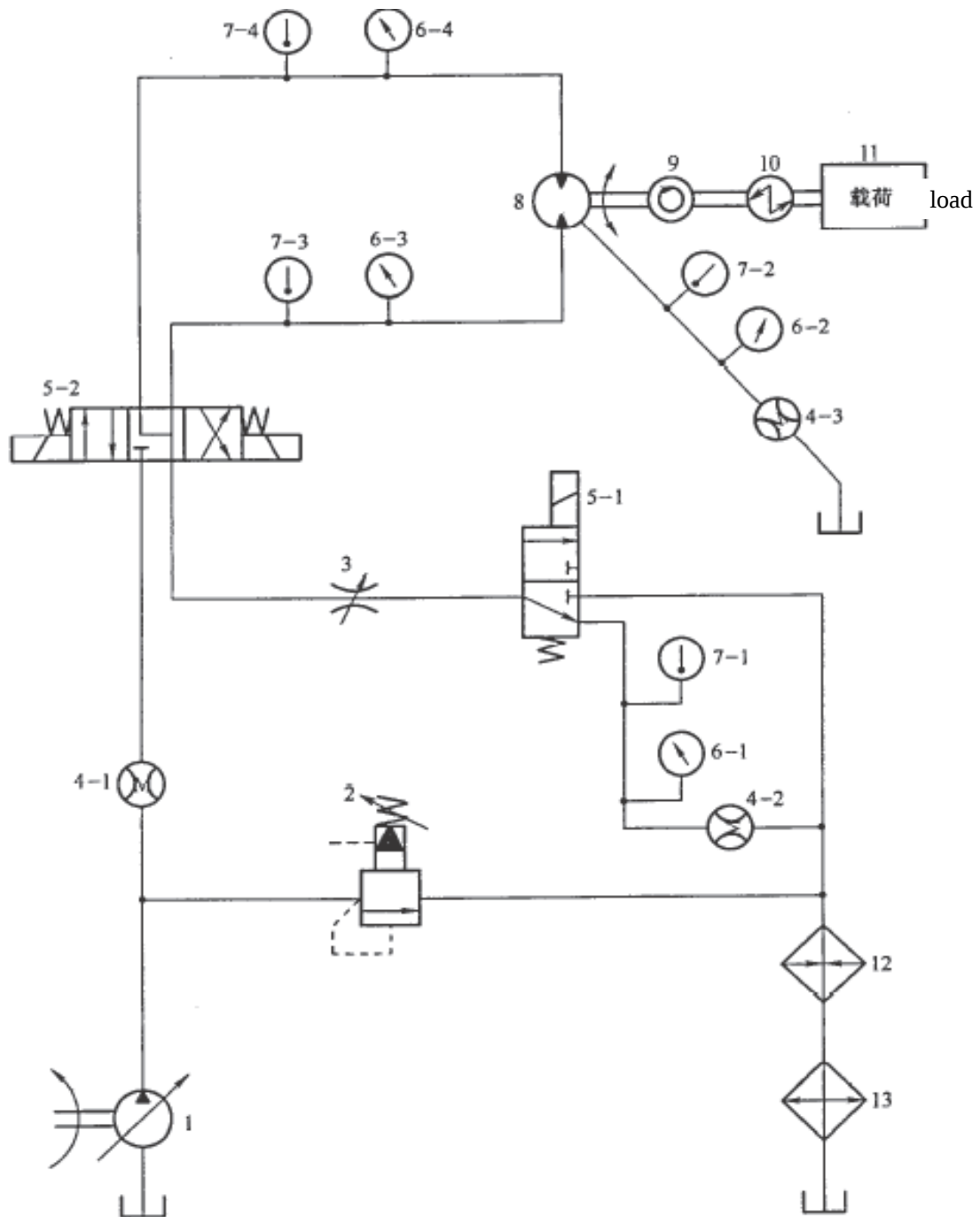
Continued Table 3

20		Inclining and swaying test	X	—	The motor is to be mounted onto the swaying test bench. The test bench is to be started according to the six single parameters specified in 3.7.1.8 c) and the motor is to be started at the same time and adjusted to be at its rated speed and rated pressure. The duration of the test for each item is to be no less than 30min. The operating conditions of the motor are to be observed and the results comply with the requirements of 3.7.1.8 c).	
21		Vibration test	X	—	The motor is to be mounted onto the vibration test bench and adjusted to be under its rated conditions. The test is to be carried out by the method specified in CB1146.9-1996 according to the parameters specified in 3.7.1.8 d) for a total duration not less than 2h. The operating conditions of the motor are to be observed and the results comply with the requirements of 3.7.1.8 d).	

Continued Table 3

No.	Test item		Type test	Factory Manufacturer test	Test method	Remark
22		Environmental impact test	X	—	The motor is to be mounted onto the impact test bench and adjusted to be under its rated conditions. The motor is to be impact tested by applying impact for three times along six mutually vertical directions by the method specified in CB1146.9-1996 according to the parameters specified in 3.7.1.8 e). The operating conditions of the motor are to be observed and the results comply with the requirements of 3.7.1.8 e).	
23		Sealing performance inspection	X	X	The tested motor is to be wiped clean. Where some parts cannot be wiped clean at one time and any pseudo leakage occurs after operation, re-cleaning is allowed. Upon completion of above tests, the leakage of the motor is to comply with the requirements below:	The operating time during manufacture test may be determined as per manufacturer specifications.
Note: X means “required”,○ means “optional” and — means “not required”.						

Annex 1 Hydraulic Motor Test Loop Diagram



1-hydraulic pump; 2-relief valve; 3-throttle valve; 4-1~4-3-flow meters; 5-1, 5-2-directional valves; 6-1~6-4-pressure gauges; 7-1~7-4-thermometers; 8-tested motor; 9-tachometer; 10-torque meter; 11-load; 12-heater; 13-cooler