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MACHINERY INDUSTRY STANDARD OF
THE PEOPLE'S REPUBLIC OF CHINA

ICS 23.080

J 76

Record number: 53647-2016

JB/T 9076-2016

Replacing JB/T 9076-1999

Reciprocating cryogenic liquid pumps - Specification

往复式低温液体泵 技术条件

Issued on: January 15, 2016

Implemented on: June 01, 2016

**Issued by: Ministry of Industry and Information Technology of the People's
Republic of China**

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Reciprocating cryogenic liquid pumps - Specification

1 Scope

This Standard specifies the technical requirements, test methods, inspection rules, nameplate, packaging, transportation, storage and scope of supply of reciprocating cryogenic liquid pumps for air separation plant (hereinafter referred to as reciprocating pumps).

This Standard applies to reciprocating pumps whose conveying medium is liquid oxygen, liquid nitrogen, liquid argon or other non-corrosive liquefied gases, design temperature is $-196\text{ }^{\circ}\text{C} \sim -101\text{ }^{\circ}\text{C}$, and discharge pressure is not higher than 36 MPa.

Note: The pressure in this Standard is gauge pressure unless otherwise specified.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the dated version applies to this document. For undated references, the latest edition (including all amendments) applies to this document.

GB 150 (all parts), Pressure vessels

GB/T 1220, Stainless steel bars

GB/T 5231, Designation and chemical composition of wrought copper and copper alloys

GB/T 6075 (all parts), Mechanical vibration - Evaluation of machine vibration by measurements on non-rotating parts

GB/T 9069, Determination of sound power level for noise emitted by reciprocating pump - Engineering method

JB/T 6896, Surface clearness of air separation plant

NB/T 47013 (all parts), Nondestructive testing of pressure equipment

ASTM B865, Standard Specification for Precipitation Hardening Nickel-Copper-Aluminum Alloy (UNS N05500) Bar, Rod, Wire, Forgings, and Forging Stock

3 Technical requirements

3.1 General

3.1.1 The reciprocating pump shall comply with the provisions of this Standard, and shall be manufactured according to the drawings and technical documents approved by the prescribed procedures, or as required by the contract.

3.1.2 Motors and electrical devices shall meet the regional level requirements stipulated in the contract.

3.1.3 The connection between the pump head of the reciprocating pump and the pipeline, and the connection between the base and the foundation shall be able to avoid deformation affecting the use due to changes in temperature and pressure.

3.1.4 During the operation of the reciprocating pump and during the termination of pumping, the cold end part and the transmission case shall be polluted by moisture, dust and foreign matter as little as possible.

3.1.5 All pipeline installations and support settings, etc., shall be able to withstand the total load of temperature stress caused by repeated changes in medium temperature and additional stress caused by connecting pipelines for a long time.

3.1.6 In the structure of the reciprocating pump, there shall be no dead angles that are prone to air blockage, and the outlet of the reciprocating pump shall not be arranged downward.

3.1.7 Spare parts and consumable parts of reciprocating pumps shall have good interchangeability and shall meet the requirements of this Standard.

3.2 Performance requirements

3.2.1 The reciprocating pump shall work normally according to the performance parameters specified in the drawings. Under rated operating conditions, the performance indicators shall meet the requirements in Table 1.

3.2.2 When liquid compressibility is considered, the volumetric efficiency shall be reduced, and the user shall provide the compressibility data of the medium.

3.2.3 The reciprocating pump shall work normally and operate reliably when the discharge pressure deviation increases to 105% of the rated discharge pressure value.

3.3.2 The calculated stress of the material of the pressure-bearing parts of the reciprocating pump shall not exceed the maximum allowable stress at the maximum operating temperature of the material.

3.4 Non-destructive testing

Non-destructive testing shall comply with the provisions of NB/T 47013. Materials for forged pressure-bearing parts (including shafts) shall be subjected to ultrasonic testing, which shall not be lower than the requirements of level II in NB/T 47013.3. The pressure-bearing butt welds shall be subjected to radiographic testing, which shall not be lower than the requirements of level II in NB/T 47013.2; the fillet welds shall be subjected to penetrant testing, which shall not be lower than the requirements of level II in NB/T 47013.5.

4 Test methods and inspection rules

4.1 Test methods

4.1.1 Water is prohibited in the performance tests of reciprocating pumps, and cryogenic media such as liquid nitrogen shall be used for performance tests; liquid oxygen should not be used as the test medium.

4.1.2 Flow measurement:

Use the flow meter method, inflation bottle measurement method or other equivalent methods, such as the gas flow meter detection and conversion method after the on-site vaporizer. Test flow deviation shall meet the requirements of 3.2.1. The specific method is as follows:

a) Flow meter method

- 1) Applicable to the performance test device equipped with a flow meter.
- 2) After the reciprocating pump is in normal operation and reaches the set speed, collect the flow data, and take the average value of the three sets of data as the actually measured flow of the reciprocating pump.

- b) Inflation bottle measurement method: After the discharge pressure of the reciprocating pump is stabilized, completely vaporize the cryogenic liquid in the vaporizer, and fill it into the metering container; record the inflation time t , and measure the pressure p_1 , p_2 and temperature T_1 , T_2 in the container before and after inflation; calculate the flow rate of the reciprocating pump according to Formula (1).

$$q = 9\,699.48 \frac{V}{t\phi} \left(\frac{p_2 + 0.1}{T_2} - \frac{p_1 + 0.1}{T_1} \right) \dots\dots\dots (1)$$

Where:

q – flow rate of the pump, in liters per hour (L/h):

V – capacity of the inflation bottle, in liters (L);

t – total time of measurement, in seconds (s):

ϕ – coefficient, the volume occupied by each liter of cryogenic liquid vaporized into gas at 0 °C and 0.101 325 MPa (absolute), in cubic meters (m³);

p_2 – final pressure of the inflation bottle, in megapascals (MPa);

T_2 – final temperature of the inflation bottle, in Kelvins (K):

P_1 – initial pressure of the inflation bottle, in megapascals (MPa);

T_1 – initial temperature of the inflation bottle, in Kelvins (K).

4.1.3 Outlet pressure test:

After the reciprocating pump works normally and runs to the specified speed, close the outlet valve, observe the pressure gauge of the outlet pipeline of the reciprocating pump, and test whether it reaches the specified outlet pressure value and runs stably. Be careful not to shut down the valve.

4.1.4 When the reciprocating pump reaches the specified outlet pressure and flow rate, use a dynamometer or the current and voltage calculation method to test the shaft power.

4.1.5 Required net positive suction head test for reciprocating pumps:

When the reciprocating pump reaches the specified rated speed and rated pressure, while maintaining the differential pressure not lower than the rated differential pressure, gradually reduce the suction pressure of the pump until the flow rate is 5% ~ 10% lower than the normal flow rate; test at not less than 5 points. When the reciprocating pump is close to cavitation, the interval between test points shall be appropriately reduced. At each suction pressure test point, the values of medium temperature, flow rate of

hours. When the factory does not have low temperature operation conditions, it is allowed to be carried out at the user's site. Type inspection items are as follows:

- 1) performance (flow rate, discharge pressure, suction pressure, shaft power, number of reciprocations, net positive suction head of the pump, etc.) determination;
- 2) vibration measurement;
- 3) noise measurement;
- 4) wear measurement of piston ring and guide ring.

4.2.3 The ex-factory inspection rules are as follows:

- a) Each reciprocating pump shall be subjected to the ex-factory inspection;
- b) Conduct routine inspections according to product drawings and technical documents;
- c) The transmission part of the reciprocating pump must be subjected to a no-load loading test for 4 hours, requiring stable operation and no abnormal sound;
- d) The cryogenic performance test of the reciprocating pump is carried out by sampling one out of every 4 (or at least 4) machines. Run the reciprocating pump with cryogenic medium for 2 h ~ 4 h, and measure the flow rate, discharge pressure, suction pressure, number of reciprocations, etc. at the same time; do a 5% overpressure test, and there shall be no abnormal phenomenon after running for 10 minutes.

5 Nameplate, packaging, transportation and storage

5.1 Each reciprocating pump shall have the product nameplate fixed at an obvious position. The nameplate shall indicate the following contents:

- a) model and name.
- b) name of the manufacturer.
- c) working medium.
- d) design temperature.
- e) performance parameters:
 - flow, in liters per hour (L/h);
 - suction pressure, in megapascals (MPa):

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