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JAPANESE INDUSTRIAL STANDARD

Testing Methods for Solute Rejection and Water Flux of Reverse Osmosis Membrane Element and Module using Aqueous Solution of Various Solutes

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Testing Methods for Solute Rejection
and Water Flux of Reverse Osmosis
Membrane Element and Module using
Aqueous Solution of Various Solutes

K 3805-1990

1. Scope

This Japanese Industrial Standard specifies testing methods for solute rejection and water flux of reverse osmosis membrane element and module using aqueous solution of three types of sodium chloride, magnesium sulfate and isopropanol (isopropyl alcohol) (hereafter referred to as the "aqueous solution").

Remark: In this Standard the units and numerical values shown in { } are in accordance with the traditional units and are Standard values.

Applicable Standards:

JIS B 7413-Etched-Stem Mercury-in-Glass Thermometer (Partial Immersion Type)

JIS B 7505-Bourdon Tube Pressure Gauges

JIS B 7551-Variable Area Flowmeters

JIS G 4304-Hot Rolled Stainless Steel Plates and Sheets

JIS G 4305-Cold Rolled Stainless Steel Plates and Sheets

JIS K 0101-Testing Method for Industrial Water

JIS K 0114-General Rules for Analytical Method in Gas Chromatography

JIS K 0552-Testing Methods for Electric Conductivity of Highly Purified Water

JIS K 0805-Continuous Total Organic Carbon Analyzer

JIS K 1522-Isopropyl Alcohol (Isopropanol)

JIS K 3802-Technical Terms for Membranes and Membrane Processes

JIS K 8150-Sodium Chloride

JIS K 8995-Magnesium Sulfate

JIS Z 8802-Methods for Determination of pH of Aqueous Solutions

2. Definitions

For the purposes of this Standard main definitions are in accordance with JIS K 3802 and further the following definition applies:

Brine seal ⁽¹⁾ The seal member to separate feed water and concentrated water, which is used when the spiral type membrane element and pleated type membrane element are tested.

Note ⁽¹⁾ The brine seal is also called U packing.

3. Testing Conditions

3.1 Concentration and Operating Pressure The concentration ⁽²⁾ and operating pressure of aqueous solution used for test shall be of the values described in the instruction manual of manufacturer. An example is shown in (1) to (3).

Note ⁽²⁾ The concentration of aqueous solution is to be $\pm 5\%$ of designated concentration.

(1) In the Case of Sodium Chloride Aqueous Solution

Table 1. Type of Each Module and Concentration and Operating Pressure of Sodium Chloride Aqueous Solution (An Example)

Type of module	Concentration of sodium chloride aqueous solution (mg/l)	Operating pressure (kPa {kgf/cm ² })	Remark
High pressure type	30000 to 35000	5000 to 6000 {50 to 60}	It is used for desalination of sea water.
Medium pressure type	500 to 2000	2000 to 4500 {20 to 45}	These are used for brackish-water treatment and ultrapure-water manufacturing.
Low pressure type		1000 to 2000 {10 to 20}	
Ultralow pressure type		to 1000 { to 10}	It is used for ultrapure-water manufacturing.

(2) In the Case of Magnesium Sulfate Aqueous Solution

Table 2. Type of Each Module and Concentration and Operating Pressure of Magnesium Sulfate Aqueous Solution (An Example)

Type of module	Concentration of magnesium sulfate aqueous solution (mg/l)	Operating pressure (kPa {kgf/cm ² })	Remark
Medium pressure type	-	-	These are used for brackish-water treatment and ultrapure-water manufacturing.
Low pressure type	500 to 2000	1000 to 2000 {10 to 20}	
Ultralow pressure type		to 1000 { to 10}	It is used for ultrapure-water manufacturing.

(3) In the Case of Isopropanol (Isopropyl Alcohol) Aqueous Solution

Table 3. Type of Each Module and Concentration and Operating Pressure of Isopropanol (Isopropyl Alcohol) Aqueous Solution (An Example)

Type of module	Concentration of isopropanol (isopropyl alcohol) aqueous solution (mg/l)	Operating pressure (kPa {kgf/cm ² })	Remark
Medium pressure type	100 to 1500	2000 to 4500 {20 to 45}	These are used for brackish-water treatment and ultrapure-water manufacturing.
Low pressure type		1000 to 2000 {10 to 20}	
Ultralow pressure type		to 1000 { to 10}	It is used for ultrapure-water manufacturing.

3.2 Temperature and pH Value of Feed Water The temperature and pH value of feed water shall be as follows.

- (1) Temperature An arbitrary temperature at 10 to 40°C, and the variation of temperature during test is $\pm 1^\circ\text{C}$.
- (2) pH Value The pH value is pH described in instruction manual of manufacturer and is to be kept at constant during testing period ⁽³⁾.

Note ⁽³⁾ Generally, in many cases pH value of 6.5 ± 0.5 is used.

3.3 Concentrated Water Flow Rate or Recovery The concentrated water flow rate ⁽⁴⁾ or recovery for each type of module shall be the value described in instruction manual of manufacturer. An example of concentrated water flow rate is shown in Table 4 and an example of recovery, in Table 5.

Note ⁽⁴⁾ The concentrated water flow rate is to be $\pm 5\%$ of designated flow rate.

Table 4. Concentrated Water Flow Rate for Each Type of Module (An Example)

Unit: mm

Type of module	Concentrated water flow rate (l/min)		
	Module nominal dimensions Diameter x length		
	65 x 1000	100 x 1000	200 x 1000
High pressure type	5	10	40
Medium pressure type			
Low pressure type	10	20	80
Ultralow pressure type			

Remark: The module nominal dimensions, in the case of inch marking, 65 x 1000 is 2.5 x 40, 100 x 1000 is 4 x 40, 200 x 1000 is 8 x 40.

Table 5. Recovery for Each Type of Module (An Example)

Type of module	Recovery ⁽⁵⁾ (%)
High pressure type	10 to 35
Medium pressure type	10 to 75
Low pressure type	
Ultralow pressure type	

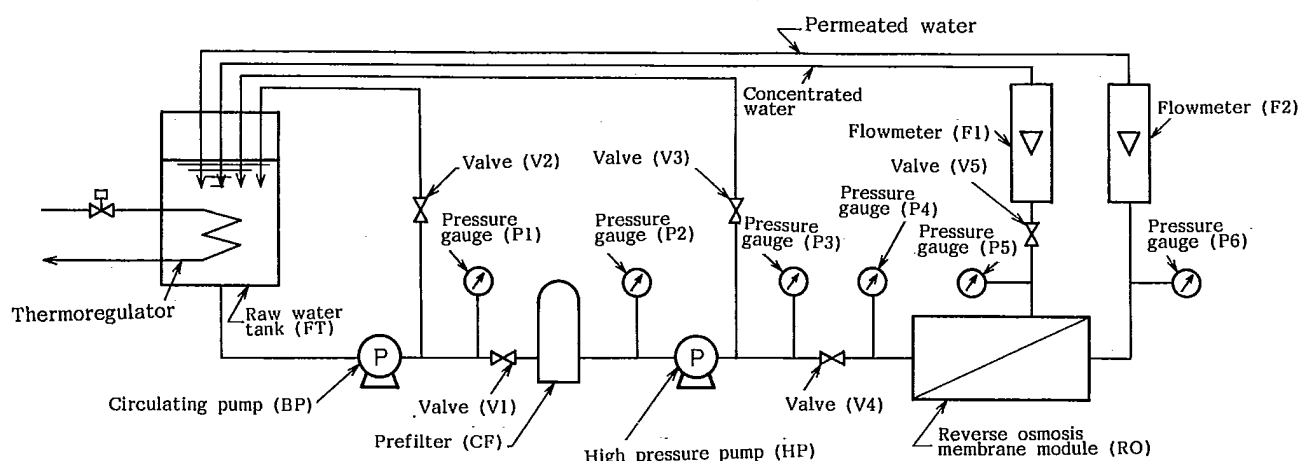
Note ⁽⁵⁾ The recovery is different according to type of module.

4. Apparatus

The apparatus shall be as follows:

4.1 Performance Tester The performance tester (hereafter referred to as the "tester") consists of pipings, valves, raw water tank, pump, prefilter, reverse osmosis module, flowmeter, pressure gauge, thermoregulator, etc. A construction example is shown in Figure.

Figure. Tester for Solute Rejection Performance (An Example)



- (1) Pipings Pipings, generally, shall be made of stainless such as SUS 316 specified in JIS G 4304 or JIS G 4305 or plastics, free from corrosion, generation of rust, etc. and, endurable to operating pressure.
- (2) Valves Valves shall be the diaphragm valve, ball valve, three-way valve, etc. and, endurable to corrosion.
- (3) Raw-Water Tank The raw-water tank is to prepare the aqueous solution to be used for test, to store the raw-water to supply to module, able to endure corrosion, and shall be provided with a stirrer or of such structure that the transmitted water and the concentrated water are mixed sufficiently in tank.
- (4) Pump The pump is to press feed the raw-water to supply to module and shall endure the corrosion.
- (5) Prefilter The prefilter is to remove suspensoid in raw-water to supply to module, at upstream of high-pressure pump.
- (6) Flowmeter Out of the flowmeters specified in JIS B 7551, the flowmeter of which the minimum graduation is 5 to 10 % of measuring flow rate and the maximum graduation shall be able to measure the degree of 1.5 to 2 times the measuring flow rate.

- (7) Pressure Gauge The pressure gauge shall be that having accuracy equivalent or superior to the same grade as Bourdon tube pressure gauge specified in JIS B 7505 and of which the maximum pressure shall be able to measure the degree of 1.5 to 2 times the measuring pressure. The accuracy grade shall be 1.5 grade or superior ⁽⁶⁾.

Note ⁽⁶⁾ There are cases where errors are generated in indicated values due to pressure vibration or the like, and therefore it is preferable to carry out the periodic calibration according to standard pressure gauge by using a pressure gauge attached with vibration control mechanism.

- (8) Thermoregulator The automatic thermoregulator containing heating and cooling apparatuses.

4.2 Appliances

- (1) Thermometer A glass stem thermometer of 100 P specified in JIS B 7413, digital thermometer according to semiconductor sensor system and the thermometer according to other system which is preliminarily calibrated by standard thermometer.

- (2) pH-meter A pH-meter of model II specified in 4.2 of JIS Z 8802 ⁽⁷⁾.

Note ⁽⁷⁾ It is to be calibrated preliminarily according to the method specified in 11. (4) of JIS K 0101.

- (3) Electric Conductivity Meter An electric conductivity meter specified in 12. of JIS K 0101 ⁽⁸⁾.

Note ⁽⁸⁾ For every measuring cell to be used, by using the standard solution of solute prepared according to mass method, preliminarily examine the relation between the solute concentration and the electric conductivity.

Further, in the case where the electric conductivity of material is not more than 10 $\mu\text{S}/\text{cm}$, when the electric conductivity meter specified in 5. of JIS K 0552 is used, the error becomes less.

- (4) Continuous Total Organic Carbon (TOC) Analyzer An analyzer for general use specified in JIS K 0805.

- (5) Gas Chromatograph The gas chromatograph specified in JIS K 0114.

5. Reagents

Main reagents to be used in this Standard shall be as follows:

- (1) Sodium Chloride The sodium chloride specified in JIS K 8150.
- (2) Magnesium Sulfate The magnesium sulfate specified in JIS K 8995.
- (3) Isopropanol (Isopropyl Alcohol) The isopropanol (isopropyl alcohol) specified in JIS K 1522.
- (4) Pure Water According to the type of solute the pure water of Table 6 shall be used.

Table 6. Types of Solute and Classes of Pure Water

Type of solute	Class of pure water
Sodium chloride	Those of electric conductivity of not more than 10 $\mu\text{S}/\text{cm}$
Isopropanol (isopropyl alcohol)	
Magnesium sulfate	The city water or industrial water, after dechlorination treatment, performed with water purification treatment ⁽⁹⁾ , which contains metallic ion not more than 1 mg/l.

Note ⁽⁹⁾ As to the methods of water purification treatment, there are ion exchange method, distillation method, reverse osmosis method, etc.

6. Preparatory Operation

The preparatory operation for solute rejection test shall be as follows:

- (1) Cleaning of Apparatus The cleaning of apparatus before attaching module shall be carried out as follows ⁽¹⁰⁾.

Note ⁽¹⁰⁾ In the case where the stain of apparatus is less, this may be abbreviated.

- (a) Put pure water into a raw-water tank ⁽¹¹⁾.

Note ⁽¹¹⁾ Corresponding to stains and material quality of apparatus, acid, alkalic for washing, surface active agent or fungicide may be used.

- (b) By using a circulating pump (BP), wash the stains in all piping.

- (c) Exhaust the washings after washing for a definite time, then by using pure water newly wash with rinsing the apparatus.

- (2) Attaching and Washing of Module The attaching and washing ⁽¹²⁾ of module shall be carried out as follows:

Note ⁽¹²⁾ In the case where the stain of module is less, this may be abbreviated.

- (a) Carry out the attaching of module according to the instruction manual of manufacturer.

- (b) Put pure water into a raw-water tank.