MICRODYN NADIR

ADVANCED SEPARATION TECHNOLOGIES

MOLSEP®

Hollow Fibre Module

General Instructions and Technical Information for the Use of

FS10-FS-FUST653

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Contents

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1. Introduction

This general instructions and technical information are for the use of MOLSEP® hollow fiber module, Type: FS10-FS-FUST653, which is specially designed to produce bacteria and pyrogen free water in pharmaceutical, Semi-conductor, food, bio and other processing.

Please read the following contents carefully before handling, design and operation of the modules and their filtration plants. Incorrect handling or operation may lead to decline the performance or even to module damage. In case of questions or problem, please contact us at:

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NOTE:

The information is based on our latest state of knowledge and is intended to provide only general notes on MOLSEP® Modules. At any time we reserve the right to make modifications due to new developments. Any existing property rights must be observed. MOLSEP® Modules are devices which are intended for use by specially trained personnel only. We do not accept liability for any injury or damaged to persons, equipment or products caused directly or indirectly by the use of the modules offered herein. Any warranty for module delivered in a defective state is limited to replacement of said module only.

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The superior features of the module, FS10-FS-FUST653, are introduced as follows.

- **High Water Productivity**
  Fairly low membrane resistance of the hollow fiber and quite large membrane aria, 7.8 m^2 in the module, succeed in producing enough permeate quantity even under lower pressure operation.
- **High Thermo Durability**
  In order to apply hot water sterilization, the hollow fiber in the module is made of heat resistant plastic, Polyethersulfone, and all other module components are also selected from highly heat resistant materials.
  The module is proved by passing the heavy trial test which loaded the module severe thermal stress by rapid heating and cooling repetition between 2°C and 98°C.
- **Very Low Effluent**
  The material of the module components are selected on the view point of effluent free and the module itself is confirmed to pass in the keen elution standard, “Test method of Plastic Bag for Infusion “ in The 10th Japanese Pharmacopoeia.
- **Excellent Chemical Resistance**
  Because the hollow fiber is made of an excellent plastic, Polyethersulfone, it can be applied over the wide pH range from 1 to 13 and to many kinds of chemicals. Furthermore the efficiency of the membrane can be easily recovered by using of a strong detergent.

- **Distinguished and Sharp Separation Characteristics**
  The hollow fiber membrane has its molecular cut-off at 6,000 Dalton so that it can reject not only bacteria and fine particles but also endotoxins completely in feed water. So pyrogen free water can be confidently produced by MOPSEP® hollow fiber modules.

Please read the module specification attached before handling, design and operation of the modules and their filtration plants.

2. Handling and Storage

2.1. Condition as Shipping

Unopened, sealed in the original packaging, MOPSEP® hollow fiber modules are filled inside with 2% formalin as a standard preservative in order to prevent troubles by drying membrane and microorganism contamination before the customer's use.

NOTE :

Preservatives react as the disinfectant. Avoid it to contact on skin and eyes by use of protection gears. Oral taking it and inhalation of its vapor also should be avoided.

2.2. Storage

- Storage temperature must be maintained between 5°C and 35°C.
- Humidity must not exceed 70%.
- Exposure to direct sunlight or ultraviolet ray from such sources as germicidal lamps, even in doors may deteriorate components of the module. Module should be stored in the dark.
- For a long storage after opening the original package or using it, fill the preservative like 2% formalin in the module to prevent contamination of microorganism.

NOTE :

Avoid storage of modules at temperatures below 5°C to prevent freezing trouble.

2.3. Keep Wet

Keep the hollow fiber wet to avoid irreversible damage. Seal the open ports of the module to prevent membrane dry and contamination in case of detached module storage.

2.4. Careful Handling

The hollow fiber modules are essentially plastic products, so please take care not to shock them by dropping or hitting in transportation and handling. Strong shocks may cause the module broken.

3. Planning the Filtration Plant

3.1. Plant Design

In comparison to pumps and piping the membrane is sensitive to rapid or radical load fluctuations, such as

- shock pressures

- jumps and drops of temperature
- rapid increase of solid matter content respectively viscosity
- rapid changes of feed flow rate

Please consider these useful hints while planning and operating the filtration plant.

NOTE :

Vibrations of the plant may damage the module.

3.2. Piping and Mounting of the module

- Ensure a strainless connection of the modules and the pipes.
- It is recommended to use some pipes flexible, when relatively large change on operating pressure or temperature is expected regarding to vibration or stretching parts.
- Set air release valves in piping to prevent air accumulation in it, if it is possible.

4. Installation of Module

- In prior to install the modules, flush the system with warm water to remove any residual dirt from system fabrication. To protect modules from high solid matter content (e.g. threads) ensure that prefiltration works correctly.
- Open the package and take the module out. In case of any visible damage to the module, please notify MICRODYN-NADIR immediately.
- Open both permeate ports and drain the preservative from shell side first. Then open feed and concentrate ports and drain next.
- Fixing the module direction to the arrow on the label, which indicates feed direction, and to each piping connection with module ports, mount the module on the module platform.
- Taking care not to slip sealing matter, joint the feed port first and the concentrate port next with clamps. Then joint the permeate ports last. Cleaned sealing matter should be used.
- Ensure the condition of the joints and tighten all clamps reciprocally enough to operate the plant.

NOTE :

- Excess force to tighten the joints causes a break of the module ports.
- Avoid unnecessary force at connections by some strain or mismatch of connector’s positions.

5. Start-up, Operation and Shut-down Procedure

Before plant operation, please read the module specification sheet and confirm operating conditions not to operate the plant out of applicable range.

5.1. Initial Start-up

For test operation of the filtration plant, quality of feed water must be higher than tap water revel. The hollow fiber membrane, as supplied is preserved by 1% benzoic acid. At initial start-up the module

should be flushed for ca. 15 min to remove the benzoic acid. All concentrate and permeate should be drained during the flushing period. This flushing also works degassing in the system. So please confirm that no remained air is in the system after the flushing.

Rinsing data of benzoic acid is shown in the attached data sheet, please see it.

Then start the test operation of the plant through flow rate and pressure are increased gradually until reaching a normal operation condition. Check the plant whether any water leak or not, and shut the plant down to fix it if some leakage is found. No trouble in the plant is found then test operation is completed.

5.2. Operation

Please increase flow rate and pressure gradually even for start-up of normal operation.

5.3. Shut-down

Switch off the feed pump then close the necessary valves in order to keep no remained pressure in the system.

In the case of long standstill of the plant, a preservative has to be added to prevent microorganism contamination after module cleaning.

NOTE :

- For the limit of feed inlet or trans-membrane pressures and temperature, please see the module specification. Exceeding of the limits may cause damage to the module.
- Rapid opening of valves will cause shock pressure, water hammer, and overshoot pressure beyond the limit and may cause damage to the modules.
- Permeate pressure should be kept lower than concentrate pressure otherwise back filtration happen at module outlet and decline the water productivity.
- Do not run the module in dead-end filtration to keep permeate quality even when quality of raw water is good.

6. Thermal Sterilization

The hollow fiber module, FS10-FS-FUST653, can be applied to hot water sterilization up to 98°C. Please see the result of rapid heat shock test, which is shown in the attached technical information sheets, “Thermal Durability of the Module”. The module is proved by passing the heavy trial test which loaded it thermal stress by rapid heating and cooling repetition between 2°C and 98°C

However potting resin, Epoxy, is affected by higher temperature to soften and decrease its pressure durability. Thus the applicable inlet pressure during sterilization is lower than 0.6 MPa, which is maximum inlet pressure under room temperature, and the applicable pressure is listed in the Table below.

Operating Temperature Range (°C)	0 ~ 50	50 ~ 80	80 ~ 98
Maximum Trans-Membrane Pressure (MPa)	0.3	0.2	0.1
Maximum Feed Inlet Pressure (MPa)	0.6	0.4	0.2
Maximum Shell Side (Permeate) Pressure (MPa)	0.4	0.3	0.15

Table 1: Applicable Pressure Limits for Different Operating Temperature

The rate of heating up and cooling down for the module must keep less than 10°C per one minute. Because fast changing speed of module temperature gives them strong mechanical stress, it may break the module or fatigue by its repetition leads hollow fibers and other parts to be weaker and damaged.

NOTE :

- Exceeded operating pressure at higher temperature must make the damage to the module and cause the module broken.
- Heat shocks, such rapid heating or cooling, may damage the module.

Our recommended hot water sterilization is carried out by circulation of 85°C hot water, which is a temperature as permeate, in the system for half an hour.

7. Module Cleaning

Judging by experience water productivity of the module decreases gradually during filtration. Most of soiling on the membrane surface can be removed by chemical cleaning. After chemical cleaning the water productivity of the module will be restored on a high level again.

There is no general cleaning procedure available for all applications and raw water qualities. Optimum cleaning procedures depend on membrane type, application and raw water quality.

In case of good raw water quality like tap water, we recommend 50-200 ppm Sodium Hypochlorite aq. solution as a cleaning chemical and that the cleaning solution will be circulated in the system for 1-2 hours a week under room temperature. Most cases of the cleaning with Sodium Hypochlorite are carried out to combine with the aim of chemical sterilization.

The chemical resistances of the module should be ensured when the cleaning agents and conditions are decided. Please see the attached “Table 1. Chemical Durability of the Module”.

NOTE :

Strong chemicals or conditions over the applicable range in the Table 1 must make the module lifetime much shorter and may cause the module broken.

8. Module lifetime

Module lifetime ends, when chemical cleaning no longer restores membrane performance, which means not only productivity but also separation characteristics, to acceptable levels, or when mechanical strength of hollow fiber is not enough to stand under normal operating conditions by aging and accumulation of chemical damage at the cleaning. Please contact us for replacement.

9. Technical Information of the Module

Technical Information of the module is shown in attached data sheet. Please see them and contact us if you need other information which is not in them.

10. Appendix

Challenge Test of Bacterial Elimination

1. Test Module

FS10-FS-FUS T653 (Effective Membrane Area : 7.8 m^2)

2. Test Procedure

1) Bacteria

   Serratia marcescens IFO 12648

2) Procedure

   50L bacteria liquid was prepared by the addition of incubated rich medium to water. This liquid was fed to FS10 module and the cross-flow filtration was carried out. Retentate and permeate were backed to a feed tank and recycled. After 1 min. running, feed liquid and permeate were collected. Then the number of living bacteria in the samples was counted by the conventional membrane-filter method [1)].

The test apparatus is shown in Fig. 1.

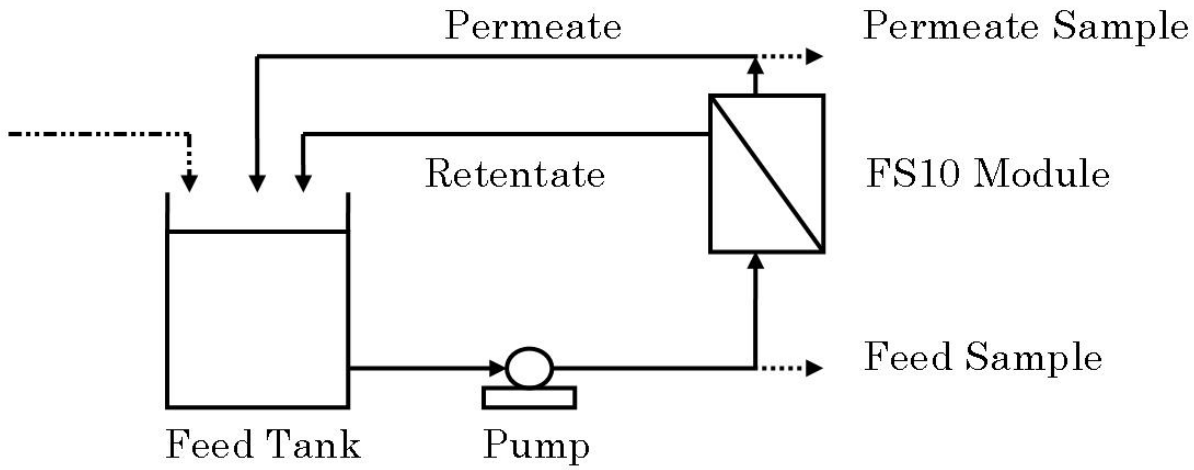

Fig. 1 Schematic Flow Diagram of Test Apparatus

3) Filtration Conditions

Feed Flow Rate	: 2.0 m^3/hr	Feed Recovery	: 90%
Feed Inlet Pressure	: 0.21 MPa	Temperature	: 20

3. Results

The results of challenge test, which are listed in Table 1., show no bacteria detection in the permeate of FS10-FS-FUST653 module.

Sampling Time, min	Feed, CFU / ml	Permeate, CFU / 100 ml
1	1.32×10^7	0
10	8.2×10^4	0
60	2.5×10^4	0
180	1.7×10^4	0

Unit : CFU / ml

Table 1. Number of Bacteria in Feed and Permeate

4. References (Japanese Standards)

1) JIS K 3823: Testing methods for determining bacterial rejection of ultrafiltration modules.

Challenge Test of Endotoxin Elimination

1. Test Module

FS10-FS-FUST653 (Effective Membrane Area : 7.8 m^2)

2. Test Procedure

1) Endotoxin

A. Heavy Load Test

Endotoxin: E. Coli 0111B4

Concentration: 2,000 ng/ml

B. Multiple Source Test

Endotoxin Source: E. Coli 026B6, E. Coli 055b5, E.Coli 0127B8,
E. Coli 0128B12, S. abortus equi, S. typhimurium
S. typhosa 0901, S. enteritidis, S. marcescens

Concentration: 500 ng/ml for each toxins and 4,500ng/ml as a total after mixed-up.

2) Procedure

50L test liquid was fed to FS10 module and the cross-flow filtration was carried out. Retentate and permeate were backed to a feed tank and recycled. After 1 min. running, feed liquid and permeate were collected. Then the concentration of endotoxin in samples was determined by “Limulus HS Test Wako”, of which detection limit was 0.01ng/ml.

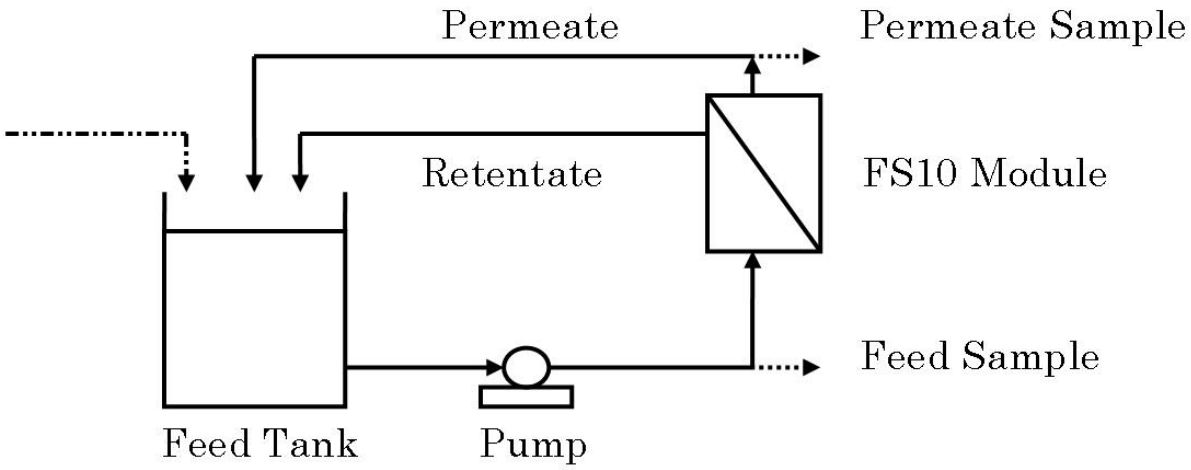

Fig. 2 Schematic Flow Diagram of Test Apparatus

3) Filtration Conditions

Volume of Test Liquid : 50 L Temperature : 20ºC
Feed Flow Rate : 2.0 m^3/hr Feed Recovery : 90%
Feed Inlet Pressure : 0.21 MPa

3. Results

The results of challenge test, which are listed in Table 2.and 3., show no detected endotoxin in the permeate of FS10-FS-FUST653 module.

Sampling Time, min	Feed	Permeate
1	2,000	< 0.01
10	20	< 0.01
60	1	< 0.01
180	1	< 0.01

Unit : ng / ml

Table 2. Result of Heavy Load Challenge Test by "A" Liquid

Sampling Time, min	Feed	Permeate
1	4,500	< 0.01
10	10	< 0.01
60	0.1	< 0.01
120	4,500 (reloaded)	< 0.01
130	10	< 0.01
180	1	< 0.01

Unit : ng / ml

Table 3. Result of Multiple Challenge Test by "B" Liquid

Elution Test of Module

1. Test Module

FS10-FS-FUST653 (Effective Membrane Area : 7.8m^2)

2. Test Procedure [1)]

Elusion test of the module was carried out according to modified Japanese standard for medical plastic products.

In the first of test, 80ºC hot pure water was fed into the module until inside temperature reached at 80ºC. Then the module was sealed and soaked in water bath to keep inside temperature 80ºC for 1 hour. After that, an effluent sample was obtained from module inside and analyzed.

3. Results

The results of elution test are listed in Table 4. The module, FS10-FS-FUST653, passed all test Items.

Test Items	Standard	Results
Color	Colorless	Pass
Bubbling	Disappear within 3 min	Pass
pH	Difference from Blank within 1.5	Pass
Sodium Salts	Less than 2.5 µg/ml	Pass
Sulfate Salts	Less than 4.8 µg/ml	Pass
Phosphate Salts	Less than 0.15 µg/ml	Pass
Ammonium Compounds	Less than 0.5 µg/ml	Pass
COD_{Mn}, mg/L	Difference from Blank within 1.0 mg/L	Pass
Evaporated Residuals	Less than 1.0 mg/L	Pass
UV Absorbance, 200-241 nm	Less than 0.08 Abs.	Pass
UV Absorbance, 241-350 nm	Less than 0.05 Abs	Pass

Table 4. Results of Elution Test

4. References (Japanese Standard)

[1)] 10th Japanese Pharmacopoeia, “Test Method of Plastic Bag for Infusion”

Elution Test of Module Material

1. Test Module

FS10-FS-FUST653 (Effective Membrane Area : 7.8m^2)

2. Test Procedure [1)]

Elusion test of the module was carried out according to Japanese standard for medical plastic products.

Eluants	: Pure Water 200ml (Specific Conductivity > 18 MΩcm)
Surface Area of Samples	: 600 cm^2
Temperature	: 121ºC
Elution Time	: 1 hour

3. Results

The results of elution test are listed in Table 5. All components of the module, FS10-FS-FUST653, passed all test Items.

Test Items	Standard	Hollow Fiber	Potting Resin	Case	O-Ring
Color	Colorless	Pass	Pass	Pass	Pass
Bubbling	Disappear within 3 min	Pass	Pass	Pass	Pass
pH	Difference from Blank within 1.5	Pass	Pass	Pass	Pass
Sodium Salts	Less than 2.5 µg/ml	Pass	Pass	Pass	Pass
Sulfate Salts	Less than 4.8 µg/ml	Pass	Pass	Pass	Pass
Phosphate Salts	Less than 0.15 µg/ml	Pass	Pass	Pass	Pass
Ammonium Compounds	Less than 0.5 µg/ml	Pass	Pass	Pass	Pass
COD_{Mn}, mg/L	Difference from Blank within 1.0 mg/L	Pass	Pass*	Pass	Pass
Evaporated Residuals	Less than1.0 mg/L	Pass	Pass	Pass	Pass
UV Absorbance, 200-241 nm	Less than 0.08 Abs.	Pass	Pass	Pass	Pass*
UV Absorbance, 241-350 nm	Less than 0.05 Abs.	Pass	Pass	Pass	Pass*

* These results were not passed at 121ºC but passed at 100 ºC

Table 5. Results of Elution Test

4. References (Japanese Standard)

1) 10th Japanese Pharmacopoeia, “Test Method of Plastic Bag for Infusion”

Elution Test of Module Material for Inorganic Matter

1. Test Module

FS10-FS-FUST653 (Effective Membrane Area : 7.8m^2)

2. Test Procedure

Elusion test of the module was carried out as Follows.

Each samples of the module components was soaked in pure water at 100ºC for 1 hour, then effluents were analyzed.

Eluants	: Pure Water 600ml (Specific Conductivity > 18 MΩcm)
Sample Weight	: 30 g
Temperature	: 100ºC
Elution Time	: 1 hour

3. Results

The results of elution test for inorganic matter is listed in Table 6. All components of the module, FS10-FS-FUST653, showed very low elution for inorganic matter.

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Elements	Analysis Method	Detection Limits	Blank	Hollow Fiber	Potting Resin	Case	O-Ring
Na	Flame Atomic Absorption	10	ND	ND	ND	ND	22
K	Flame Atomic Absorption	10	ND	ND	ND	ND	ND
Mg	Flame Atomic Absorption	1	ND	ND	ND	ND	5.5
Ca	Flameless Atomic Absorption	1	ND	ND	ND	ND	20
Al	Flameless Atomic Absorption	1	ND	ND	ND	ND	ND
Si	Flameless Atomic Absorption	10	ND	ND	ND	ND	ND
Zn	Flameless Atomic Absorption	0.5	ND	ND	ND	ND	0.6
Fe	Flameless Atomic Absorption	1	ND	ND	ND	ND	ND
Cu	Flameless Atomic Absorption	2	ND	ND	ND	ND	ND
Sn	Flameless Atomic Absorption	20	ND	ND	ND	ND	ND
Pb	Flameless Atomic Absorption	2	ND	ND	ND	ND	ND
Cl^-	Ion Chromatography	10	ND	ND	ND	15	20
F^-	Ion Chromatography	50	ND	ND	ND	ND	ND
SO_4^{2-}	Ion Chromatography	20	ND	ND	ND	ND	ND
NO_3^-	Ion Chromatography	30	ND	ND	ND	ND	ND
PO_4^{3-}	Ion Chromatography	30	ND	ND	ND	ND	ND
Total Surface Area of 30g sample (cm^2)				4500	200	600	160
Equivalent module number as sample				0.056	0.076	3.3	2.9

Units : ppb ND : No Detected

Table 6. Results of Elution Test for Inorganic Matter

Chemical Durability of Module

Test Module: FS10-FS-FUST653 (Effective Membrane Area : 7.8m^2)

Chemicals	Concentration	Temperature	Time	Judgment
Hydrochloric Acid	0.1N	80ºC	30 Days	○
	0.5N	80ºC	30 Days	×
Sulfuric Acid	0.1N	60ºC	30 Days	○
Nitric Acid	0.1N	60ºC	30 Days	○
Citric Acid	1N	60ºC	30 Days	○
Sodium Hypochlorite	1%	25ºC	30 Days	○
	1%	60ºC	30 Days	□
Formalin	3%	80ºC	30 Days	○
	35%	25ºC	30 Days	○
	35%	80ºC	30 Days	×
Ethanol	100%	25ºC	30 Days	○
	70%	25ºC	30 Days	○
	70%	25ºC	30 Days	×
Sodium Hydroxide	1N	60ºC	30 Days	○

Judgment : ○ ; No Influenced □ ; Slightly Influenced × ; Damaged

Table 1. Chemical Durability of FS10-FS-FUS T653 Module

Thermal Durability of Module

1. Sample Module

Test Module: FS10-FS-FUST653 (Effective Membrane Area : 7.8m^2)

2. Heat Shock Test

Heat shock test of module was carried out by feeding hot and cold water alternately into the module in short period. After 100 times repetition of heat shocks the module was examined by air leak test, which is a method of module perfection.

3. Conditions

1) Operation

Feed Water	: UF treated pure water
Feed Pressure	: 0.1 MPa
Feed Flow Rate	: 0.5 – 1.2 m^3/hr
Permeation Rate	: 0.3 – 1.0 m^3/hr

2) Thermal Conditions

Hot Water	: 98 –99ºC
Cold Water	: 2 – 5ºC
Heating and Cooling speed	: ≻50ºC/min
Repetition	: 100 Times

4. Result

No leakage and damage were observed the module, especially both on fibers and potting resin.

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