FOR SMARTER, GREENER WORLD
HOLLOW FIBER / FLAT SHEET MEMBRANE
WATER TREATMENT MEMBRANE PRODUCTS
The G-Brane is a new brand of LG water treatment membrane that provides the best water solution based on three principles, high permeability, high stability, and high durability. Based on its 60 years of achievement in electronics, chemical, and telecommunications, LG is leaping forward to become a great company that lasts for centuries. Since its 1999 Environmental Declaration, LG has been active in environmentally-friendly businesses.

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In order to lead the green industry growth, LG has selected three major green initiatives, and is driving forward the water treatment business as a part of the green new business among the three initiatives.

LG TOTAL WATER SOLUTION

Membrane Filtration Engineering
Membrane Filtration Operation Technology
Membrane Filtration Process Technology
Membrane Material Innovation

LG GREEN INITIATIVES

Green New Business
Green Production
Green Products

The G-Brane is a new brand of LG water treatment membrane that provides the best water solution based on three principles, high permeability, high stability, and high durability.
The Core Competence of LG G-Brane

- **Membrane Technology Based on Convergence**
  Based on the convergence of membrane material, application and IT technologies, LG Electronics delivers a differentiated treatment process and state-of-the-art engineering through a collective work with laboratories and academic researchers.

- **Total Membrane Solution**
  With its diverse membrane products such as flat sheet and hollow fiber, LG Electronics provides a systematic solution in all aspects of water membrane treatment including engineering, construction, and operations and management.

- **Stable Product Supply**
  Based on the world’s largest production capacity, LG Electronics is able to supply membrane products anytime and anywhere, supported by the highest-level customer service.

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LG’s Membrane Solutions
Opening the Door to a Smarter, Greener World

**Saleforce Coverage**
LG Electronics product sales and service coverage reaches about 150 countries in North America, Europe, Middle East, Africa, Asia, and the CIS.

**Global R&D Network**
LG Electronics is building a membrane business network in North America and Europe in addition to its existing business headquarter and laboratories in Korea and China.

**Quality Control**
With its quality control process, the Six Sigma, LG Electronics is strict in quality control through all processes covering procurement, testing, shipment and transportation. The credibility tests are conducted in the field, adding to the perfection of the membrane products.
Hollow Fiber Membrane

LG delivers high-performance, environmentally-friendly products to the membrane customers based on its cutting-edge materials and manufacturing technologies.

Hollow Fiber Membrane Materials

The Porous Membrane of Inner/Outer Surface Asymmetry in Hollow Fiber Material

The LG hollow fiber membrane has an asymmetrical structure in which the size of the pore decreases from the inner to the outer surface of the fiber, which helps the formation of an even and thick membrane, increases permeability and an efficient elimination of turbidity.

- On the outer surface, the pore size is evenly 0.1 μm, enhancing the elimination of floating matters, while a few μm of inner surface pore size maximizes permeability.
- Uniform 250 μm-thick separation membrane layers are formed, offering strong product stability against external shocks.

Even Flux by Model and Enhanced Process Stability

LG’s hollow fiber manufacturing process is under thorough quality management utilizing the Six Sigma process across all processes from fiber production to module assembly. The deviation of flux among membrane modules is minimized, providing stability and reducing uneven membrane fouling and flow distribution in actual sites.

- Deviation limited to 5% through Six Sigma quality management

Non-Effluent Environmentally-Friendly Membrane

The LG hollow fiber is produced with non-effluent, environmentally-friendly material by parts, and received water membrane module standard certification, proving the product’s stability.

- TIPS : Thermal Induced Phase Separation

High PVDF Content, High Strength Membrane

The LG hollow fiber membrane, manufactured with the TIPS process, contains high-intensity PVDF material that is resistant to oxidation, alkali, and acid chemicals, providing excellent durability and chemical resistance under the conditions of frequent cleaning.

- Superior mechanical strength to competitors’ PVDF membrane due to a PVDF content-doubling technology
- Hollow fiber recovers quickly from outer impact with an optimal engineering of strength and elasticity

Membrane’s Chemical Resistance

\[
\text{Membrane's Chemical Resistance} \quad (\text{NaCl} 0.500 \text{ g/L} \quad \text{NaOH} 0.5 \text{ g/L})
\]

Configuration of Hollow Fiber Membrane Module

Water Membrane Certification

- NSF Certification (NSF/ANSI 61)
- NSC (KWWA-12-003)
Hollow Fiber Membrane

The LG hollow fiber membrane module has two categories, pressurized and submerged. The pressurized module is suitable for industrial and drinking water treatment with its hydraulic baffle separator designed to increase permeability and stability. The submerged module is suitable for large-capacity sewage and wastewater treatment with its hydraulic design and dual aeration structure, strengthening packing density and chemical resistance.

Pressurized Hollow Fiber Module (G-Brane P Series)

- Strengthened Permeability and Stability with Hydraulic Structure

As a result of proprietary module housing design, LG’s pressurized membrane module is resistant to impact from sudden influx of water even though it has high packing density. It everts out influx of water to increase permeability and stability.

- The baffle of beehive design resolves the water hammer effect that comes from the influx of water, and prevents membrane fouling often caused by drifts.
- The separator improves fluid flow within the hollow fiber module of high packing density and realizes an even filtration performance.

Maximized Packing Density with Pressure Loss-Minimizing Design

The LG pressurized membrane module minimizes pressure loss while maximizing packing density, realizing a high-efficiency, high-density product and strengthening the housing against pressure from outer impact.

- Optimal design of inner and outer pressure loss and of packing density
- Module stability is enhanced to resist *10 kgf/cm², five times the maximum operating inner pressure

Submerged Hollow Fiber Module (G-Brane S Series)

- Suitable for Large-Capacity Sewage and Wastewater Treatment with High Resistance Against Fouling and High Packing Density

The LG submerged membrane module has high packing density and fouling resistance, being suitable for MBR, sewage discharge water reuse, and large-capacity sewage and wastewater treatment.

- Strengthened fouling resistance with the dual aeration structure
- *10 kgf/cm², five times the maximum operating inner pressure
- Minimized installation space with high density enabled by an 8-inch module of 35m² membrane area

Dual Aeration Structure

The LG submerged membrane module is differentiated from existing products since its dual aeration structure minimizes cleaning chemicals and aeration flow rate, reducing the cost of maintenance.

- Even physical cleaning performance with an optimal dual aeration structure in the middle and lower parts of the module
- Strengthened cleaning performance with an optimal arrangement of aeration structure, reducing the air usage by 30% per membrane area
LG is collaboratively deploying its global resources, striving to be the Water-industry leader. World-class membrane performance and customer focused excellence.

Flat Sheet Membrane

The LG flat sheet membrane is made of PES permeable material and has a double-layer structure of even pore size distribution enabled by the Six Sigma process. It provides excellent permeability, fouling resistance, stability and elimination effectiveness.

Flat Sheet Membrane Material

Highly Permeable Membrane with Hydrophilic Material

The LG flat sheet membrane is composed of a permeable polymer material, PES (Polyethersulfone), differentiated from other materials such as PTFE and PP. It provides exceptional fouling resistance and permeability under conditions of sewage and wastewater treatment process and high concentration active sludge.

- Highly hydrophilic, showing selective permeation under high concentration sludge condition.
- Highly resistant to fouling under high concentration condition, as organic matters such as protein and microorganisms do not easily adhere
- More convenient to handle, as the pre-treatment process of increasing permeability is skipped.

Stable Membrane with Uniform Pore Size Distribution

The LG flat sheet membrane is manufactured using the NIPS (Non-Solvent Induced Phase Separation) process which is divided into the casting process, evaporation process, immersion process, and drying process. Each process plays a role in determining the shape, distribution, characteristics, and performance of the membrane pore. What enhances the LG flat sheet significantly is the optimization technology of solvent and non-solvent combination and the Six Sigma process.

Stable Membrane with 3-Layer Structure

The LG flat sheet is structured with 3 layers—membrane layer, supportive layer, and membrane layer again. Therefore it has 2 membrane layers. It double prevents membrane damage by foreign objects flowing in from sewage and wastewater processes.

- Stable treatment quality secured by increased durability with 3-layer membrane.
- The triple-layer filtration structure provides additional turbidity removal performance.

High Adhesiveness of The Flat Sheet and Panel

The LG flat sheet module is produced with a facility that is specialized for membrane sheet ABS panel, providing high durability and adhesiveness and therefore usable even in bad conditions.

- Adhesiveness stronger by 25% compared to competitor

Flat Sheet Membrane Material

<table>
<thead>
<tr>
<th>Category</th>
<th>Contact Angle</th>
<th>Pure Permeability</th>
</tr>
</thead>
<tbody>
<tr>
<td>LG Flat Sheet Membrane</td>
<td>58.3°</td>
<td>4,375 LMH</td>
</tr>
<tr>
<td>Hydrophilic Membrane</td>
<td>64.9°</td>
<td>3,844 LMH</td>
</tr>
</tbody>
</table>

* Evaluation condition : Absorption pressure – 0.5kgf/cm²
* LMH = ℓ/㎡.hr

Comparison of Flat Sheet Structure

Membrane Surface Scanned by Electronics Microscope (FE-SEM 10KV, X5000)
Flat Sheet Membrane

The LG flat sheet unit is composed of module and rack. The module shows an even distribution of suction pressure with fluid interpretation design, and the rack comes in various types in order to meet different user environments.

Flat Sheet Module / Rack (G-Brane F Series)

Optimal Design of Flat Sheet Structure

Water treated with solid-liquid separation by the flat membrane sheet is tested by a hydraulic simulation (CFD). Realizes a suction pressure distribution even with the effective fluid flow within the module panel of a vertical structure.

Structure of The Flat Sheet Unit

The LG flat sheet unit is composed of the membrane block that has the module, and the aeration block for air scouring. It comes in 3 types, standard, slim and strong, being able to provide customized flat sheet unit according to different raw water characteristics.

- The G-Brane FN, the standard type, is suitable for general sewage treatment.
- The G-Brane FS, the slim type, is suitable for factories and urban facility as it occupies as much as 34% less installation space than the standard type.
- The G-Brane FT, the strong type, is suitable for high concentration influent.

Flat Sheet Unit Specification

<table>
<thead>
<tr>
<th>Type</th>
<th>Standard</th>
<th>Slim</th>
<th>Strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separation G-Brane FN</td>
<td>G-Brane FS</td>
<td>G-Brane FT</td>
<td></td>
</tr>
<tr>
<td>Dimension (mm)</td>
<td>788x1,645x1,746</td>
<td>788x3,080x1,746</td>
<td>753x1,291x1,908</td>
</tr>
<tr>
<td>Membrane area (m²)</td>
<td>100</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>Treatment capacity (m³/day)</td>
<td>40-60</td>
<td>80-120</td>
<td>40-60</td>
</tr>
</tbody>
</table>

*About 30 models of LG flat sheet unit are for different separations.

Result of Flat Sheet Operation (for 8 months)

<table>
<thead>
<tr>
<th>Year</th>
<th>TMP (cmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>10-14</td>
</tr>
<tr>
<td>2009</td>
<td>12-3</td>
</tr>
<tr>
<td>2010</td>
<td>1-22</td>
</tr>
<tr>
<td>2010</td>
<td>3-13</td>
</tr>
<tr>
<td>2010</td>
<td>5-2</td>
</tr>
<tr>
<td>2010</td>
<td>6-21</td>
</tr>
</tbody>
</table>

Timing of chemical cleaning

- October 2009: 10-14
- October 2009: 12-3
- December 2009: 1-22
- December 2009: 3-13
- February 2010: 5-2
- February 2010: 6-21

The Double-Deck Unit Efficiency

The LG flat sheet double-deck unit is for a small space in an urban area. The high density unit is economical since it requires less space and less capacity of facilities such as blower.

- Saving of electricity cost due to less blower capacity
- Each deck can be separately hoisted and this downsizes the blower facilities. Ultimately, it reduces the initial investment cost.

<table>
<thead>
<tr>
<th>Separation</th>
<th>G-Brane FN</th>
<th>G-Brane FS</th>
<th>G-Brane FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension (mm)</td>
<td>788x1,080x3,477</td>
<td>753x2,805x3,665</td>
<td>802x3,130x2,650</td>
</tr>
<tr>
<td>Membrane area (m²)</td>
<td>400</td>
<td>500</td>
<td>320</td>
</tr>
<tr>
<td>Treatment capacity (m³/day)</td>
<td>160-240</td>
<td>200-300</td>
<td>120-200</td>
</tr>
</tbody>
</table>

FOR SMARTER, GREENER WORLD
G-MBR Water Treatment Process
Korea New Excellent Technology Certification No. 322, Verification No. 145

The G-MBR process uses LG High-Flux, hydrophilic slim sheet membranes, and adopts the G-Filter system for removing phosphorous (T-P) more. The process, meets the recently reinforced requirements for “Water discharged from public sewage treatment facilities” under the Sewage regulation. Notably, the process can meet the requirement for a total phosphorous (T-P) amount of under 0.2 mg/l, becoming the country’s first advanced sewage treatment process to earn the new environmental technology certification and verification. Also, the G-MBR process allows compact installation space, and offers outstanding cost-efficiency and convenience of maintenance, operation and installation.

Application of Slim Flat Sheet Membranes
LG G-MBR process involving slim flat sheet membranes can retain the MLSS with diverse and high load changes (5,110~15,250 mg/l, AVG 10,694 mg/l). The process offers flexible processes to external environments such as 10.7~24.1°C temperatures, providing stable treated water quality.

G-MBR Process’s Verification Results
- The integrated phosphorous-removal system (G-Filter) strongly resists shock load, and is the country’s first verification process to meet the 2012 reinforced T-P 0.2 mg/l or under.
- An integrated phosphorous removal system wherein mixture, agitation, coagulation, and filtration simultaneously occur; minimizing the required area compared with the existing phosphorous removal process.

T-P Treatment Results

* For more information, please refer to our official website.
The In-Line Coagulation System

Korea New Excellent Technology Certification No. 422

The In-Line coagulation system is a stable water treatment technology that can reduce membrane fouling by minimizing floc breaking of feed water. Unlike the existing process of reducing TMP and foulants by reducing the diameter of the pore, the In-Line coagulation system decreases TMP by enlarging the floc of foulant with the same pore diameter.

Also, when applying the In-Line coagulation system, capital and maintenance cost are reduced compared to existing technologies because the mixing and coagulation periods can be skipped.

Application of The In-Line Coagulation System

- The In-Line coagulation system is a technology that can reduce membrane fouling by minimizing floc breaking of feed water.
- The increase of TMP is down by 20% in the case of normal turbidity and by 24.5% in the case of low temperature compared to the existing mixing/coagulating processes.
- The pre-treatment coagulation process is simplified by skipping the mixing and coagulating periods, reducing the costs of facility and maintenance.

Membrane Filtration Process

- Remove suspended solids and microbes
- Keep turbidity of processed water less than 0.1 NTU

The Result of Korea New Excellent Technology Certification of The In-Line Coagulation System

- The pre-treatment coagulation process is simplified by skipping the mixing and coagulating periods, reducing the costs of facility and maintenance.
- The In-Line coagulation system increases the efficiency of dissolving organic matter and turbidity removal.

Average DOC of raw water and treated water comparison between the existing and new technologies.
### Product Specifications of The Pressurized Hollow Fiber Membrane

<table>
<thead>
<tr>
<th>ITEM</th>
<th>G-Brane F5</th>
<th>G-Brane F7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module Model</td>
<td>MR-MF20A</td>
<td>MR-MF20F</td>
</tr>
<tr>
<td>Effective Area</td>
<td>1m²/module</td>
<td>1m²/module</td>
</tr>
<tr>
<td>Dimension</td>
<td>Ø465 x 1,187 x 4 mm</td>
<td>Ø500 x 1,230 x 2.9 mm</td>
</tr>
<tr>
<td>Materials</td>
<td>PES, ABS</td>
<td>PES, ABS</td>
</tr>
<tr>
<td>Membrane Type</td>
<td>Submerged Suction</td>
<td>Submerged Suction</td>
</tr>
<tr>
<td>Operation Pressure</td>
<td>&lt; -0.47 kgf/cm²</td>
<td>&lt; -0.47 kgf/cm²</td>
</tr>
<tr>
<td>Operation Temp</td>
<td>40°C</td>
<td>40°C</td>
</tr>
<tr>
<td>pH</td>
<td>1 - 12</td>
<td>1 - 12</td>
</tr>
<tr>
<td>Weight</td>
<td>1.7 kg</td>
<td>1.5 kg</td>
</tr>
<tr>
<td>Membrane Material</td>
<td>PES, ABS</td>
<td>PES, ABS</td>
</tr>
<tr>
<td>Membrane Type</td>
<td>Hollow Fiber</td>
<td>Hollow Fiber</td>
</tr>
<tr>
<td>Fiber Diameter</td>
<td>Ø0.1 x 0.15 / Ø 0.7mm</td>
<td>Ø0.1 x 0.15 / Ø 0.7mm</td>
</tr>
<tr>
<td>Flow Configuration</td>
<td>Outside-in</td>
<td>Outside-in</td>
</tr>
<tr>
<td>Chemical Cleaning</td>
<td>~ 5,000mg/L (as NaOCl)</td>
<td>~ 5,000mg/L (as NaOCl)</td>
</tr>
</tbody>
</table>

### Product Specifications of The Flat Sheet Membrane

<table>
<thead>
<tr>
<th>ITEM</th>
<th>G-Brane F7 (Standard)</th>
<th>G-Brane F5 (Skin)</th>
<th>G-Brane F7 (Strong)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module Model</td>
<td>MR-MF20A</td>
<td>MR-MF20F</td>
<td>MR-MF20G</td>
</tr>
<tr>
<td>Effective Area</td>
<td>1m²/module</td>
<td>1m²/module</td>
<td>0.8m²/module</td>
</tr>
<tr>
<td>Dimension</td>
<td>Ø216 x L 1,731 mm</td>
<td>Ø234 x L 1,968 mm</td>
<td>Ø216 x L 2,152 mm</td>
</tr>
<tr>
<td>Materials</td>
<td>PVC, PU</td>
<td>PVC, ABS</td>
<td>PVC, ABS</td>
</tr>
<tr>
<td>Membrane Type</td>
<td>Submerged Suction</td>
<td>Submerged Suction</td>
<td>Submerged Suction</td>
</tr>
<tr>
<td>Operation Pressure</td>
<td>&lt; -0.47 kgf/cm²</td>
<td>&lt; -0.47 kgf/cm²</td>
<td>&lt; -0.47 kgf/cm²</td>
</tr>
<tr>
<td>Weight</td>
<td>40 kg</td>
<td>20 kg</td>
<td>40 kg</td>
</tr>
<tr>
<td>Membrane Material</td>
<td>PVDF (Polyvinylidene Fluoride)</td>
<td>PVDF (Polyvinylidene Fluoride)</td>
<td>PVDF (Polyvinylidene Fluoride)</td>
</tr>
<tr>
<td>Membrane Type</td>
<td>Hollow Fiber</td>
<td>Hollow Fiber</td>
<td>Hollow Fiber</td>
</tr>
<tr>
<td>Fiber Diameter</td>
<td>Ø0.1 x 0.15 / Ø 0.7mm</td>
<td>Ø0.1 x 0.15 / Ø 0.7mm</td>
<td>Ø0.1 x 0.15 / Ø 0.7mm</td>
</tr>
<tr>
<td>Flow Configuration</td>
<td>Outside-in</td>
<td>Outside-in</td>
<td>Outside-in</td>
</tr>
<tr>
<td>Chemical Cleaning</td>
<td>~ 5,000mg/L (as NaOCl)</td>
<td>~ 5,000mg/L (as NaOCl)</td>
<td>~ 5,000mg/L (as NaOCl)</td>
</tr>
</tbody>
</table>

### Product Specifications of The Submerged Hollow Fiber Membrane

<table>
<thead>
<tr>
<th>ITEM</th>
<th>G-Brane S2</th>
</tr>
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<tbody>
<tr>
<td>Module Model</td>
<td>MR-MHS03A</td>
</tr>
<tr>
<td>Effective Area</td>
<td>0.8m²/module</td>
</tr>
<tr>
<td>Dimension (mm)</td>
<td>Ø490 x L 1,000 x 6 mm</td>
</tr>
<tr>
<td>Materials</td>
<td>PVC, PU</td>
</tr>
<tr>
<td>Membrane Type</td>
<td>Hollow Fiber</td>
</tr>
<tr>
<td>Operation Pressure</td>
<td>&lt; -0.47 kgf/cm²</td>
</tr>
<tr>
<td>Operation Temp</td>
<td>40°C</td>
</tr>
<tr>
<td>Operation Flux</td>
<td>15 - 65 LMH</td>
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<tr>
<td>pH</td>
<td>1 - 12</td>
</tr>
<tr>
<td>Weight</td>
<td>32 kg</td>
</tr>
<tr>
<td>Membrane Material</td>
<td>PVDF (Polyvinylidene Fluoride)</td>
</tr>
<tr>
<td>Membrane Type</td>
<td>Hollow Fiber</td>
</tr>
<tr>
<td>Fiber Diameter</td>
<td>Ø0.1 x 0.15 / Ø 0.7mm</td>
</tr>
<tr>
<td>Flow Configuration</td>
<td>Outside-in</td>
</tr>
<tr>
<td>Chemical Cleaning</td>
<td>~ 5,000mg/L (as NaOCl)</td>
</tr>
</tbody>
</table>
Intellectual Property

Through a consistent technological development and maintaining of superior product performance, LG is acquiring certifications from Korea and abroad.

**Patent Applications**
- Slim type membrane separation device
- Pressurized module housing inclusive of the fan-shaped baffle
- Membrane module and the concerning submerged membrane separation device
- Submerged membrane separation device and operation process
- Submerged membrane separation device
- Maintenance cleaning process of filtration membrane and the concerning water treatment system
- Water treatment device equipped with water re-feed waterway
- Pressurized hollow fiber module
- Slim type membrane package module and the concerning submerged membrane separation device

**Patent Registration**
- Advanced sewage treatment system inclusive of internal filtration screen
- Phosphorous removal device for advanced sewage water treatment
- Submerged membrane separation device and its operating process
- Water treatment device equipped with circulating waterway and the concerning treatment process
- Phosphorous removal device for advanced sewage water treatment
- Advanced sewage treatment system inclusive of internal filtration screen
- Membrane module and the concerning submerged membrane separation device
- Submerged membrane separation device
- Membrane module, assembled membrane module and the concerning submerged separation membrane device

**Trademark Registration**
- G-MBR trademark application (December 2009)
- G-Brane trademark application (February 2014)

**Certifications**
- Certification from Korea Water and Wastewater Works Association (50/75m² hollow fiber membrane)
- Korea New Excellent Technology Certificate No. 422 (G-MBR Process)
- Korea New Excellent Technology Verification No. 145 (G-ABIR Process)
- NSF Certification (NSF/ANSI 61)
- Patent Certificate (Phosphorous removal system for use in the advanced sewage treatment system)
- Patent Certificate (Membrane filtration water treatment technology that improves floc formulation efficiency with in-pipe coagulation)

FOR SMARTER, GREENER WORLD
Based on the hollow fiber membrane application know-how, product development and pilot operation, LG is ramping up its efforts to secure references in water treatment and water reuse projects.

Since developed in 2009, LG flat sheet membrane product is proving its performance in various areas such as plant operation, and sewage and wastewater treatment plants.