

PFAS Removal by CSM NF/RO Membranes

Per- and polyfluoroalkyl substances (PFAS) are a group of synthetic chemicals with strong carbon-fluorine bonds that make them resistant to degradation, leading to widespread environmental contamination. PFAS are found in water sources globally, and their persistence in the environment has raised significant health concerns due to their potential toxicity, including developmental, immunological, and carcinogenic effects.

Given the challenges in removing PFAS from water, advanced treatment methods like reverse osmosis (RO) and nanofiltration (NF) membranes have gained attention. RO membranes, with their tighter pore structure, offer high rejection rates for both long- and short-chain PFAS, while NF membranes, being slightly more permeable, may offer lower energy consumption but might be less effective for smaller PFAS molecules.

This study evaluates and confirms the PFAS removal performance of CSM RO and CSM NF membranes. Based on the findings, it aims to provide actionable insights to support informed decision-making in the design of water treatment systems.

■ NSF/ANSI 58-2024 Reverse Osmosis Drinking Water Treatment System

PFAS removal rate criteria are not yet formally established under NSF/ANSI 61; therefore, the testing conditions and performance requirements in NSF/ANSI 58 serve as a reference only.

	Influent challenge concentration (mg/L)	Maximum permissible product water concentration (mg/L)	Minimum Removal Rate (%)
Total PFAS	0.00216	0.00002	≥ 99.07
PFHpA	0.00004	0.00002	≥ 50.00
PFHxS	0.0003	0.00002	≥ 93.33
PFNA	0.00005	0.000006	≥ 88.00
PFOA	0.0015	0.00002	≥ 98.67
PFOS	0.0015	0.00002	≥ 98.67

※ Reference: Testing conditions based on NSF/ANSI 58-2024

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PFAS	RO Removal Rate (%)	NF Removal Rate (%)
	FEn, BE	NE90
PFHpA	99.63	99.35
PFHxS	99.13	99.45
PFNA	99.83	99.60
PFOA	99.81	99.30
PFOS	99.15	99.46

※ The PFAS removal rates presented are based on the test conditions outlined in the appendix.

※ The PFAS removal rates differs according to test parameters such as pressure, pH, and membrane type, as well as the molecular structure and chain length of individual PFAS compounds.

■ Product

Membrane	Product	Flux	Rejection
RO	RE8040-FEN	11,000 GPD	99.7 % (NaCl)
	RE8040-BE	11,000 GPD	99.7 % (NaCl)
NF	*NE8040-90	8,000 GPD	90~97% (NaCl)
	NE8040-ARM	5,400 GPD	99.0% (MgSO ₄)
	NE8040-70	9,000 GPD	99.0% (MgSO ₄)
	NE8040-40	12,000 GPD	99.0% (MgSO ₄)
	NE8040-SRM	8,500 GPD	99.5% (MgSO ₄)

※ RO Test condition: 2,000 ppm NaCl at 225 psi, Rec.15%, pH 6.5~7.0, 25 °C

※ NF Test Condition: 2,000 ppm MgSO₄ at 75 psi, Rec.15%, pH 6.5~7.0, 25 °C

※ *NE8040-90 Test Condition: 2,000 ppm NaCl at 75 psi, Rec.15%, pH 6.5~7.0, 25 °C

Toray Advanced Materials Korea Inc.

6F, 7, Magokdong-ro 10-gil, Gangseo-gu, Seoul, 07790, Republic of Korea

Tel: +82-2-3279-7365, Fax: +82-2-3279-7399

www.csmfilter.com

(Appendix 1)
PFAS Removal by CSM RO Membranes

Materials	Structural formula	MW (g/mol)	CAS NO.	RO
				FEN
PFBA	C ₄ H ₁ F ₇ O ₂	214.03	375-22-4	≥99.77 ²⁾
PFPeA	C ₅ H ₁ F ₉ O ₂	264.04	2706-90-3	≥99.81 ²⁾
PFBS	C ₄ H ₁ F ₉ O ₃ S	300.1	375-73-5	≥99.92 ¹⁾
PFPA	C ₆ F ₁₀ O ₃	310.04	422-64-0	≥99.87 ³⁾
PFHxA	C ₆ H ₁ F ₁₁ O ₂	314.05	307-24-4	≥99.69 ²⁾
4:2 FTS	C ₆ H ₅ F ₉ O ₃ S	338.15	757124-72-4	≥99.91 ¹⁾
PFHpA	C ₇ H ₁ F ₁₃ O ₂	364.06	375-85-9	≥99.63 ²⁾
PFHxS	C ₆ H ₁ F ₁₃ O ₃ S	400.11	355-46-4	≥99.13 ³⁾
PFOA	C ₈ H ₁ F ₁₅ O ₂	414.07	335-67-1	≥99.81 ²⁾
6:2 FTS	C ₈ H ₅ F ₁₃ O ₃ S	428.15	27619-97-2	≥99.90 ¹⁾
PFHpS	C ₇ H ₁ F ₁₅ O ₃ S	450.1	375-92-8	≥99.92 ¹⁾
PFNA	C ₉ H ₁ F ₁₇ O ₂	464.07	375-95-1	≥99.83 ²⁾
PFOS	C ₈ H ₁ F ₁₇ O ₃ S	500.13	1763-23-1	≥99.15 ³⁾
PFDA	C ₁₀ H ₁ F ₁₉ O ₂	514.08	335-76-2	≥99.42 ³⁾
8:2 FTS	C ₁₀ H ₅ F ₁₇ O ₃ S	528.15	39108-34-4	≥99.95 ¹⁾
PFUnA	C ₁₁ H ₁ F ₂₁ O ₂	564.09	2058-94-8	≥99.91 ¹⁾
NEtFOSAA	C ₁₀ H ₈ F ₁₇ NO ₄ S	570.22	2991-50-6	≥99.93 ¹⁾
PFDoA	C ₁₂ H ₁ F ₂₃ O ₂	614.1	307-55-1	≥99.73 ²⁾

¹⁾ 10~20 ppb PFAS, 33 ppm IPA 2,000ppm NaCl at 30LMH, recovery 15%, 25°C, pH 7.0²⁾ 10~40 ppb PFAS, 2,000ppm NaCl at 225 psi, recovery 15%, 25°C, pH 6.5~7³⁾ Total PFAS 600 ppt, water purification plant condition at 12bar, 16LMH

(Appendix 2)
PFAS Removal by CSM NF Membranes

Materials	Structural formula	MW (g/mol)	CAS NO.	NF				
				NE90	ARM	NE70	NE40	SRM
PFBA	C ₄ H ₁ F ₇ O ₂	214.03	375-22-4	≥99.50 ²⁾	≥99.40 ²⁾	≥94.94 ²⁾	≥81.59 ²⁾	≥95.28 ²⁾
PFPeA	C ₅ H ₁ F ₉ O ₂	264.04	2706-90-3	≥99.58 ²⁾	≥99.63 ²⁾	≥96.49 ²⁾	≥85.72 ²⁾	≥97.20 ²⁾
PFBS	C ₄ H ₁ F ₉ O ₃ S	300.1	375-73-5	≥99.47 ¹⁾			≥74.75 ¹⁾	
PFPA	C ₆ F ₁₀ O ₃	310.04	422-64-0	≥99.32 ³⁾				
PFHxA	C ₆ H ₁ F ₁₁ O ₂	314.05	307-24-4	≥99.56 ¹⁾			≥91.83 ¹⁾	
4:2 FTS	C ₆ H ₅ F ₉ O ₃ S	338.15	757124-72-4	≥99.47 ¹⁾			≥92.06 ¹⁾	
PFPeS	C ₅ HF ₁₁ O ₃ S	350.09	2706-91-4	≥99.43 ¹⁾			≥77.55 ¹⁾	
PFHpA	C ₇ H ₁ F ₁₃ O ₂	364.06	375-85-9	≥99.35 ¹⁾	≥99.72 ²⁾	≥94.23 ²⁾	≥89.18 ²⁾	≥96.33 ²⁾
PFHxS	C ₆ H ₁ F ₁₃ O ₃ S	400.11	355-46-4	≥99.45 ¹⁾			≥84.28 ¹⁾	
PFOA	C ₈ H ₁ F ₁₅ O ₂	414.07	335-67-1	≥99.30 ²⁾	≥99.78 ²⁾	≥94.09 ²⁾	≥87.80 ²⁾	≥98.04 ²⁾
6:2 FTS	C ₈ H ₅ F ₁₃ O ₃ S	428.15	27619-97-2	≥99.50 ¹⁾			≥94.37 ¹⁾	
PFHpS	C ₇ H ₁ F ₁₅ O ₃ S	450.1	375-92-8	≥99.59 ¹⁾			≥88.08 ¹⁾	
PFNA	C ₉ H ₁ F ₁₇ O ₂	464.07	375-95-1	≥99.60 ²⁾	≥99.88 ²⁾	≥96.59 ²⁾	≥85.96 ²⁾	≥89.72 ²⁾
PFOS	C ₈ H ₁ F ₁₇ O ₃ S	500.13	1763-23-1	≥99.46 ³⁾				
PFDA	C ₁₀ H ₁ F ₁₉ O ₂	514.08	335-76-2	≥99.82 ²⁾	≥99.79 ²⁾	≥99.69 ²⁾	≥89.29 ²⁾	≥99.93 ²⁾
8:2 FTS	C ₁₀ H ₅ F ₁₇ O ₃ S	528.15	39108-34-4	≥99.94 ¹⁾			≥99.80 ¹⁾	
PFUnA	C ₁₁ H ₁ F ₂₁ O ₂	564.09	2058-94-8	≥99.93 ¹⁾			≥99.84 ¹⁾	
NEtFOSAA	C ₁₀ H ₈ F ₁₇ NO ₄ S	570.22	2991-50-6	≥99.96 ¹⁾			≥99.94 ¹⁾	
PFDoA	C ₁₂ H ₁ F ₂₃ O ₂	614.1	307-55-1	≥99.26 ¹⁾			≥99.86 ¹⁾	

¹⁾ 10~20 ppb PFAS, 33 ppm IPA 2,000ppm NaCl at 30LMH, recovery 15%, 25°C, pH 7.0²⁾ 10~40 ppb PFAS, 2,000ppm MgSO₄ at 75 psi, recovery 15%, 25°C, pH 6.5~7³⁾ Total PFAS 600 ppt, water purification plant condition at 6 bar, 16LMH

Sungpyo Hong



Team Leader

Filter Technical Support Team, Filter Division

Toray Advanced Materials Korea Inc.

6F, 7, Magokdong-ro 10-gil, Gangseo-gu, Seoul, 07790, Republic of Korea

Tel: +82-2-3279-7365, Fax: +82-2-3279-7399

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