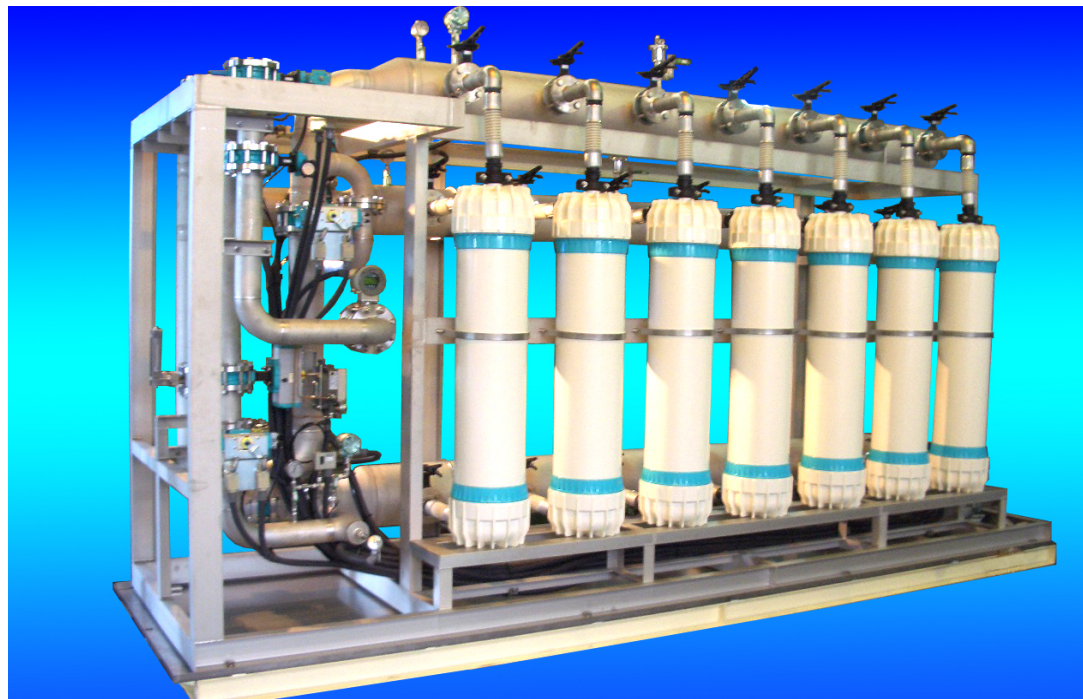


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Application of Ultrafiltration Membrane System to Water Recycle System for the Oil Industry



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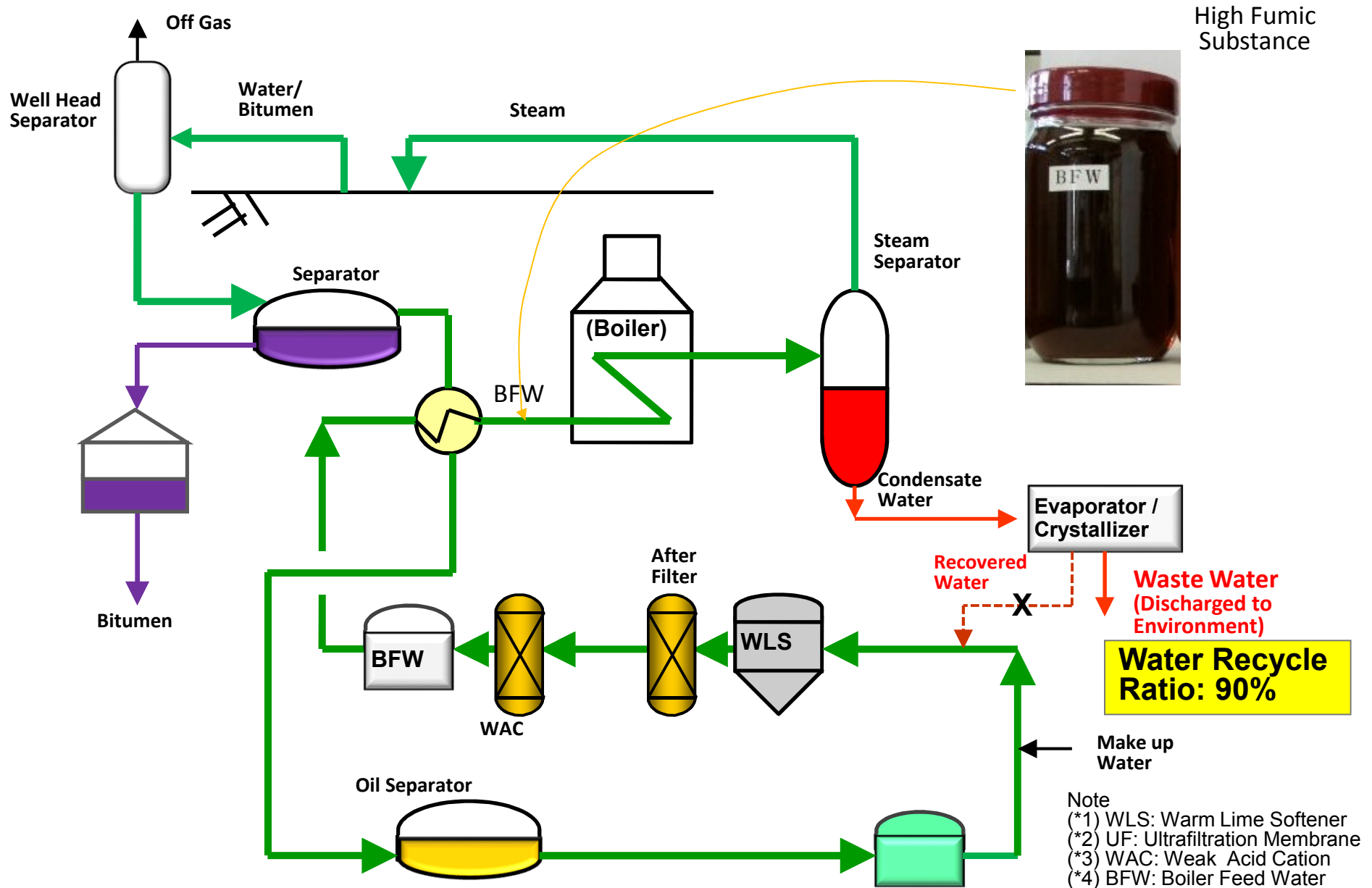
Application of Ultrafiltration Membrane System to Water Recycle System for the Oil Industry

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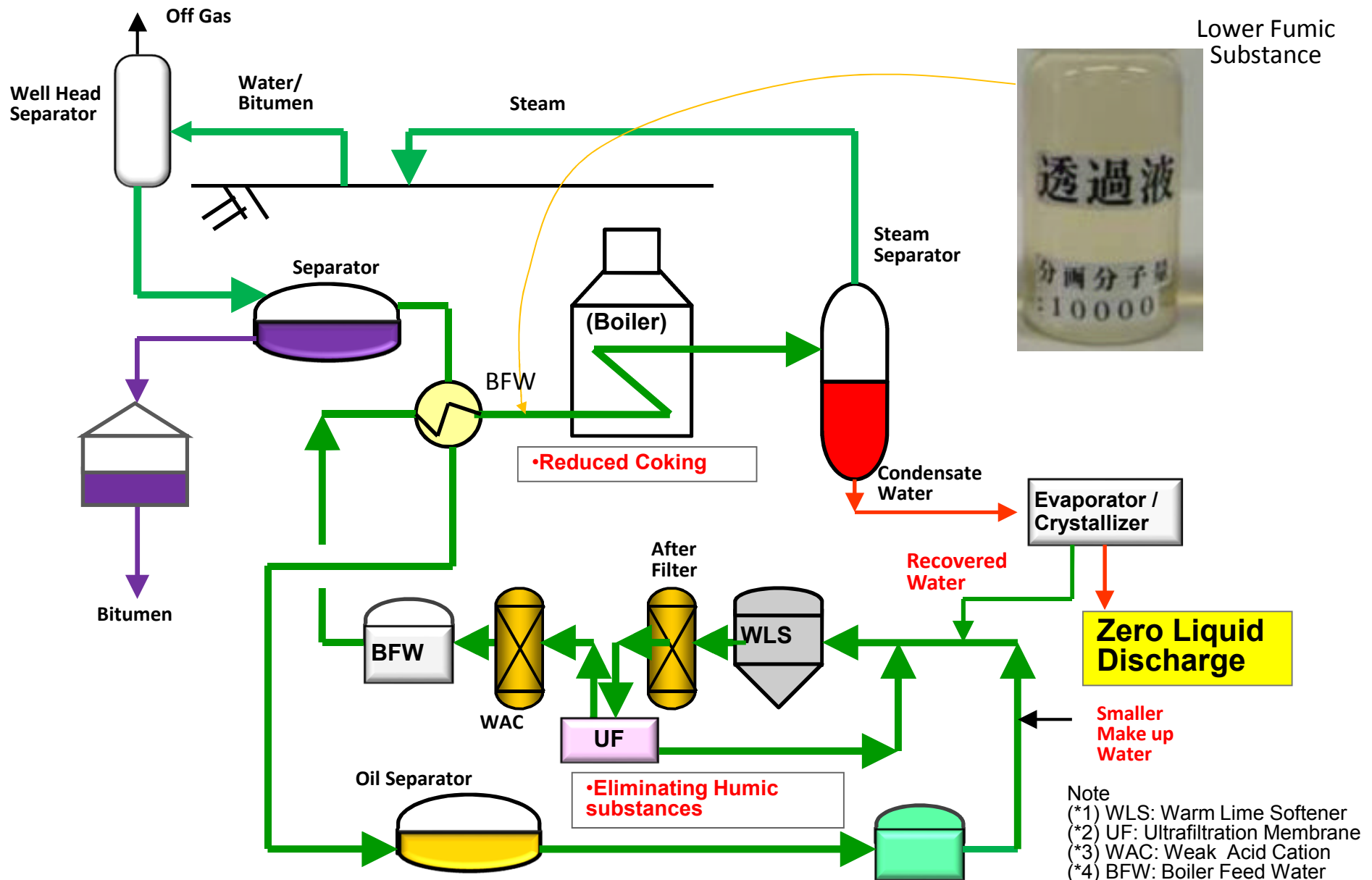
1. Integration UF^(*) Membrane System with SAGD
2. UF membrane Bench Test Performance
3. Application to Water Recycle System
4. Summary

(*) UF: Ultrafiltration

Water Treating System for SAGD



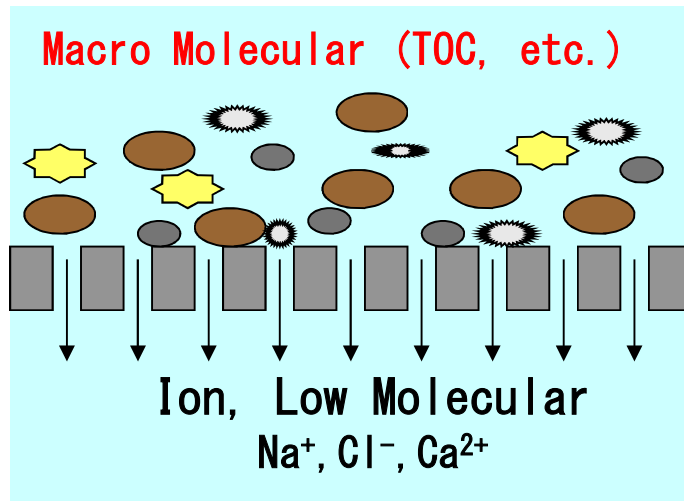
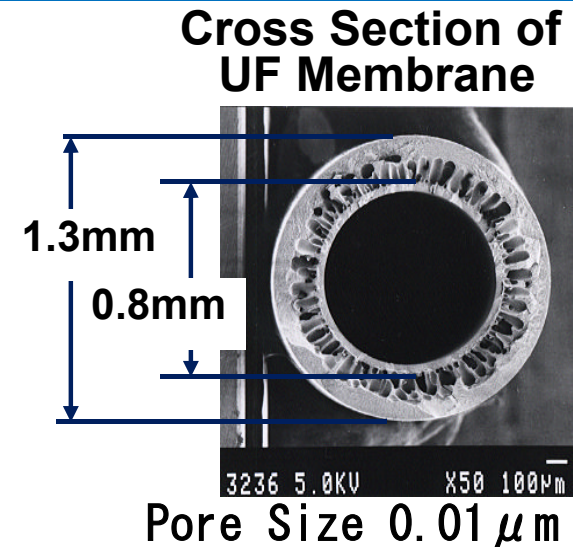
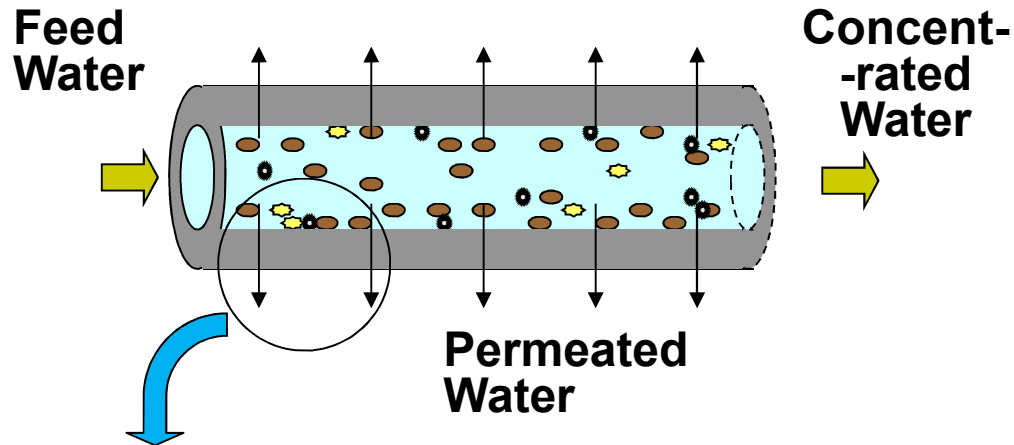
Water Treating System for SAGD (UF Membrane)



Contents

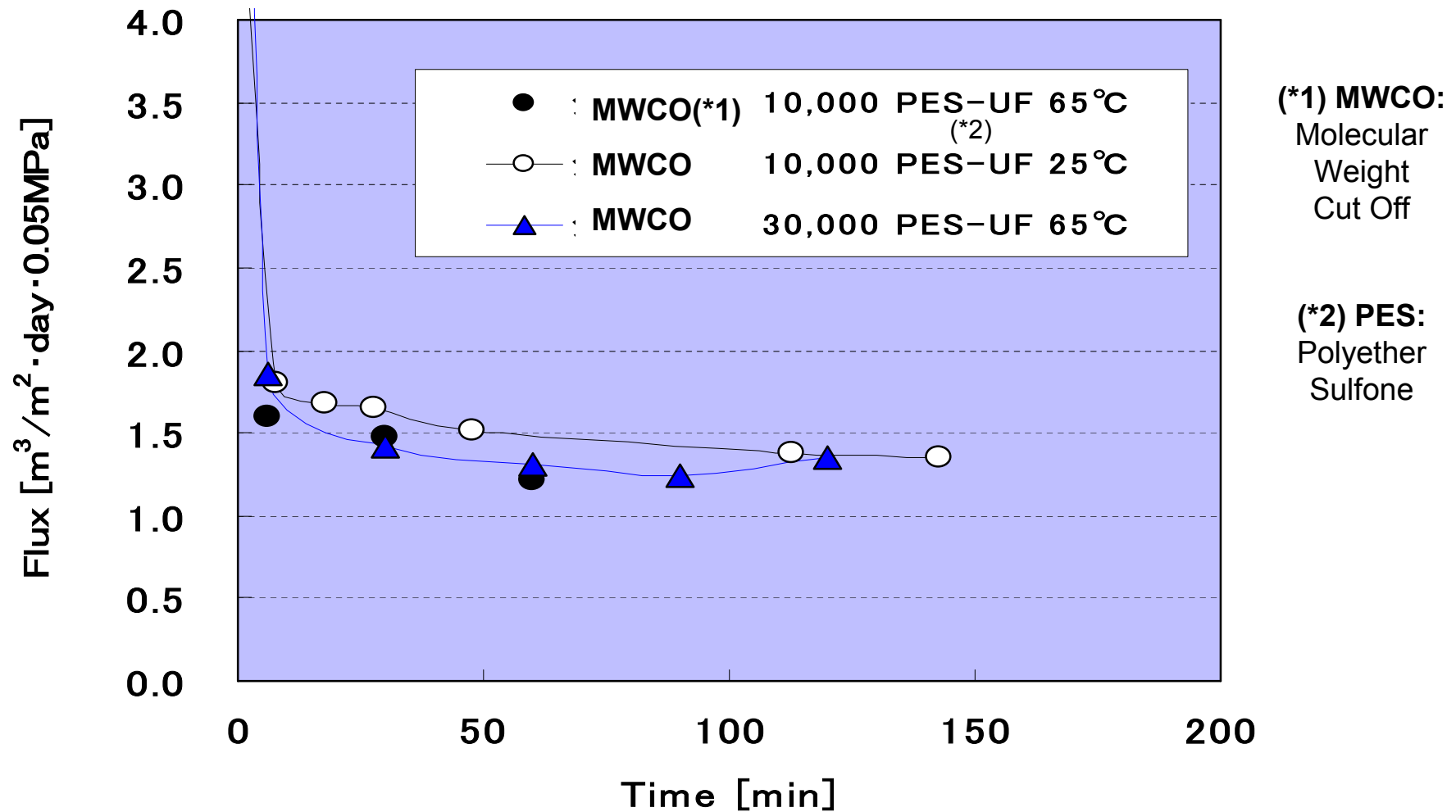
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UF Membrane for Removing Macro Molecular



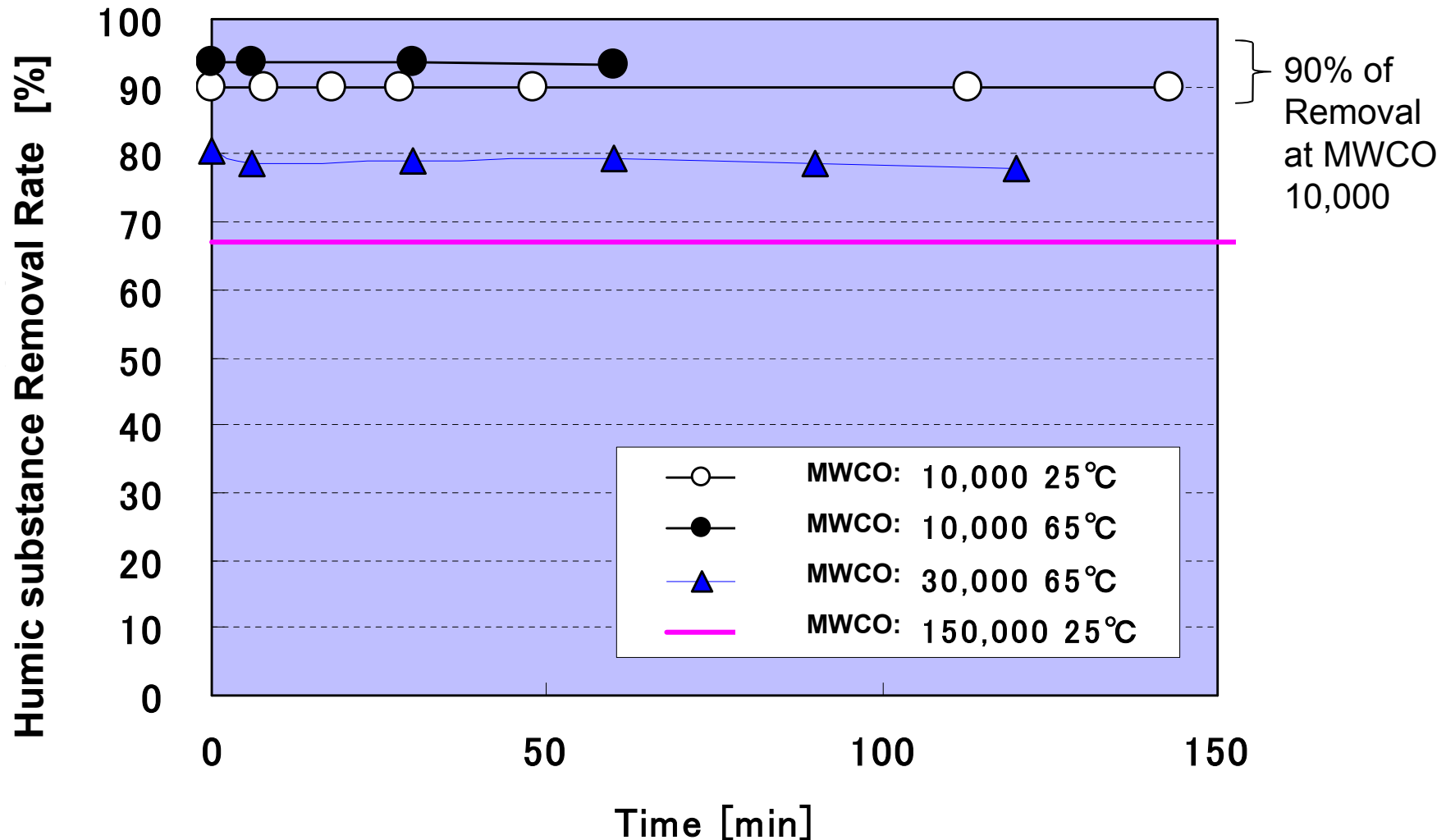
Pore Size	1 Å	0.001 μm	0.01 μm
Molecule Size	Ion, Low Molecular Na^+ , Cl^- , Ca^{2+}		Macro Molecular
Membrane Type	RO	NF	UF

Stable Permeation Flux



It is estimated that a stable permeation flux would be approximately 1.3 - 1.5 $\text{m}^3/(\text{m}^2 \text{ day})$ at any of these molecular weight cutoffs under a filtration pressure of 0.05 MPa.

Humic Substance Removal Rate



Humic substances removal rate:

$$R = (1 - 465 \text{ nm absorbance of permeating water} / 465 \text{ nm absorbance of feed water}) \times 100$$

Picture of UF Module Permeated Water

Feed Water

**Concentrated
Water**

**Permeated
Water**
(MWCO:10,000)

**Permeated
Water**
(MWCO:150,000)



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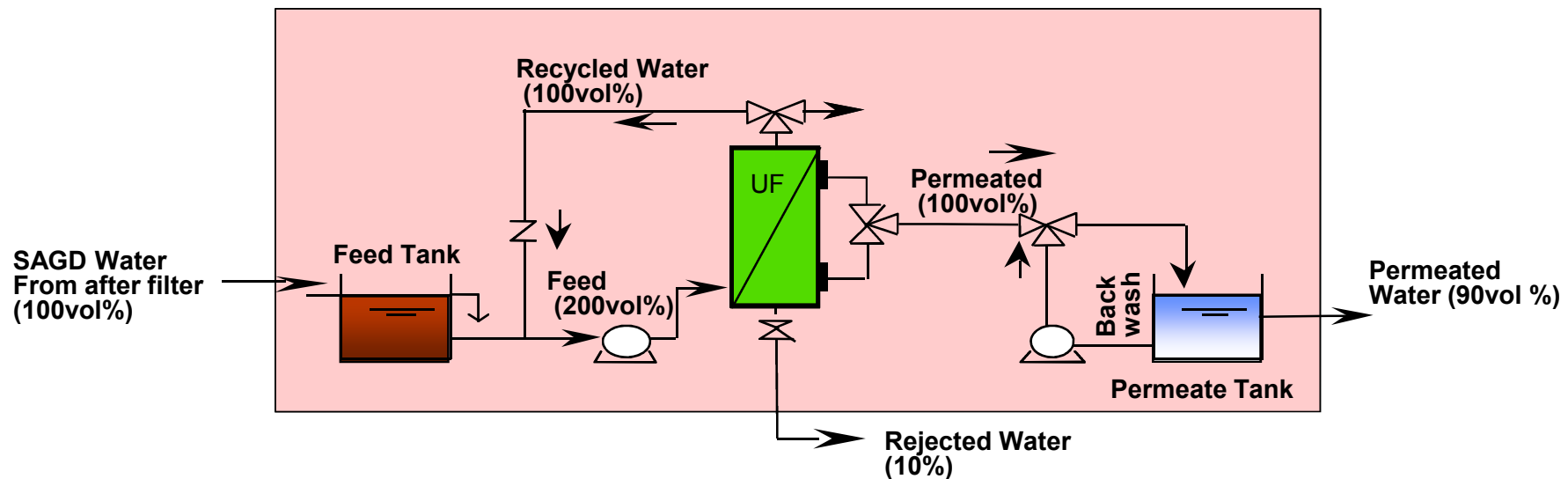
UF Membrane Module Operation

UF membrane for SAGD Water

- Filtration speed: $1.0 \text{ m}^3/(\text{m}^2 \cdot \text{day})$
- Filtration pressure: 0.1 Mpa
- Back washing frequency: $1 \text{ min.}/60 \text{ min.}$
- Recovery rate: 90%

RO for Sea Water (for reference)

- $0.01 \text{ m}^3/(\text{m}^2 \cdot \text{day})$
- 5 MPa
- $n/a.$
- 30%



Case Study: OPEX of UF Membrane System 1,000 m³ /day

Equipment cost:

- 790,000 USD
(incl. UF Membrane: 590,000 USD)

Depreciation cost:

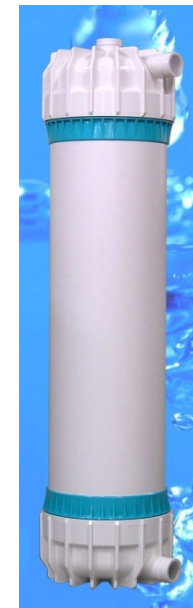
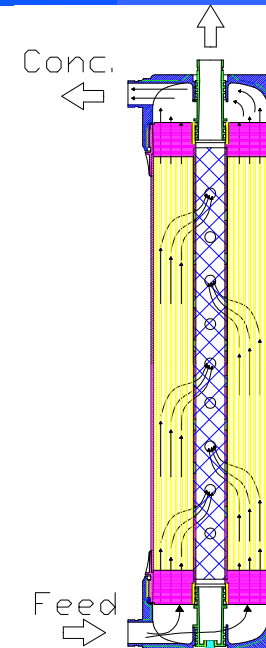
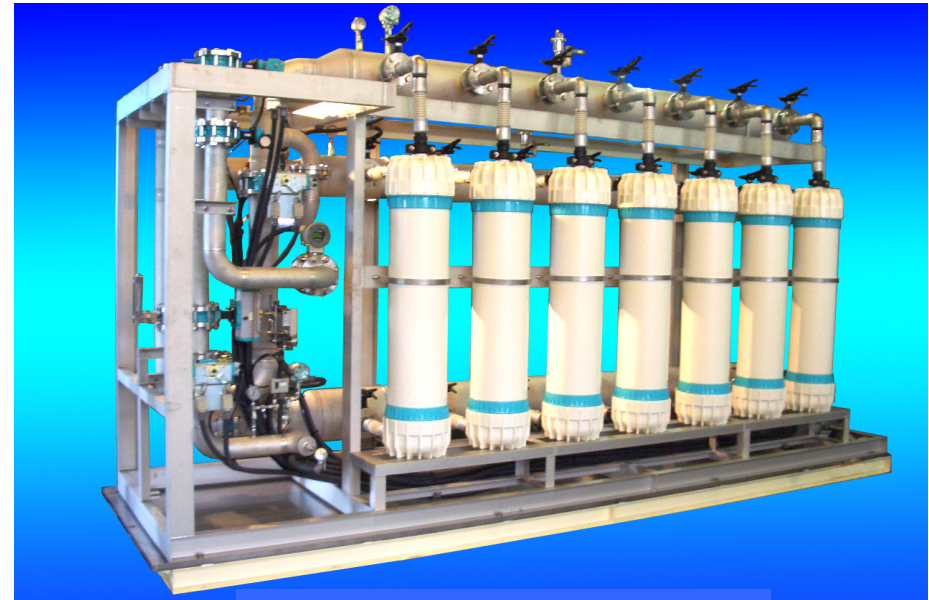
- 158,000 USD/year
= 42 ¢ /m³ of water
(five-year straight-line)

Running costs:

- Membrane: 160,000 USD/year
(replacement once a year)
- Electricity : 29,000 USD/year
- Other: 26,000 USD/year
- Total: 213,000USD/year
= 58 ¢ /m³ of water

Total OPEX :

- \$1.00 /m³ of water



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UF Membrane System to Water Recycle System

1. Integration of UF Membrane System with SAGD:

- Reduction of Humic Substance content would be a key to higher reliability and lower maintenance costs of SAGD Boiler.
- Minimizing of discharge waste water to environment and saving of intake water are expected.

2. Ultra Filtration Bench Test Performance:

- Stable permeation flux of 1.3 - 1.5 m³/(m² day) is confirmed using JGC/Daicen's Ultrafiltration Membrane
- Removal rate of humic substances of about 90% is attained.

3. Application to Water Recycle System:

- Cost effective compared to Sea Water RO system
- OPEX of US\$1.00 / M³ - water is estimated at a SAGD site in Canada.

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