# FilmTec™ Membranes

## Temperature and pH – Best Practices in Preparation of Cleaning Solutions

## Description

When Clean-In-Place (CIP) solutions fall outside the pH and temperature ranges provided on the Product Data Sheet of FilmTec™ reverse osmosis and nanofiltration elements, rapid degradation of the membrane will occur and shorten its useful lifetime. The following are general precautions to consider when preparing cleaning solutions for CIP procedures documented in the FilmTec™ operating manual.

## Relationship between Temperature and pH

Water is a weak electrolyte, that can dissociate, in relatively small amounts in, to hydronium ($H_3O^+$) and hydroxyl ($OH^-$) ions. Its equilibrium can be written as:

$$2H_2O_{(l)} \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

The ionic product of water can be written as:

$$K_w = [H_3O^+][OH^-]$$

The ionic product of water (Kw) is typically given as 1.0 x $10^{-14}$ $mol^{2\cdot}$ $dm^6$ at room temperature, at 25°C. However, like all equilibrium constants, Kw is temperature dependent and so is the pH (Table 1).

*Table 1 Value of Kw at different temperatures and pH of pure water*

| T (°C) | Kw ($mol^{2\cdot}$ $dm^6$) | pH |
|---|---|---|
| 0 | 0.114 x $10^{-14}$ | 7.47 |
| 25 | 1.008 x $10^{-14}$ | 7.00 |
| 50 | 5.476 x $10^{-14}$ | 6.63 |
| 100 | 51.30 x $10^{-14}$ | 6.14 |

The equilibrium of water plays a role in the determination of pH, even in the case of strong acids (e.g. HCl) and bases (e.g. NaOH), such as those typically used in membrane cleaning solutions.

Additionally, the effect of temperature on pH is greatest for highly basic solutions, like those typically used for the mitigation of biofouling (Table 2).

*Table 2 Effect of temperature on the pH of acid, neutral, and basic solutions*

| | 10°C | 25°C | 35°C | 50°C |
|---|---|---|---|---|
| HCl (0.01M) | 2.00 | 2.00 | 2.00 | 2.00 |
| Pure Water | 7.27 | 7.00 | 6.84 | 6.63 |
| NaOH (0.01M) | 12.53 | 12.00 | 11.68 | 11.26 |



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# Guidelines for Preparing a Cleaning Solution(s)

- It is important to remember that pH values in the Product Data Sheet are given at a reference temperature (e.g. 25°C). CIP tanks are commonly heated during cleanings. If the temperature effect on pH is not considered when preparing a CIP solution, the temperature can be adjusted to a range that falls outside the recommended safe pH range provided on the Product Data Sheets of the elements being cleaned.
- Operators should check that the target pH reading is within the measurement range of the pH-meter available to them. As good practice, on-line and off-line pH meters should always be calibrated across the pH range in which measurements are taken. During this process, the effect of temperature should be taken into consideration.
- If the pH of the cleaning solution is being measured directly in the CIP tank with on-line pH-meters, it is safest to adjust the pH at ambient temperature and then heat to the desired temperature to avoid use too much chemical that could damage the membrane. In Figure 1 you can find the variation of pH for standard caustic solutions.

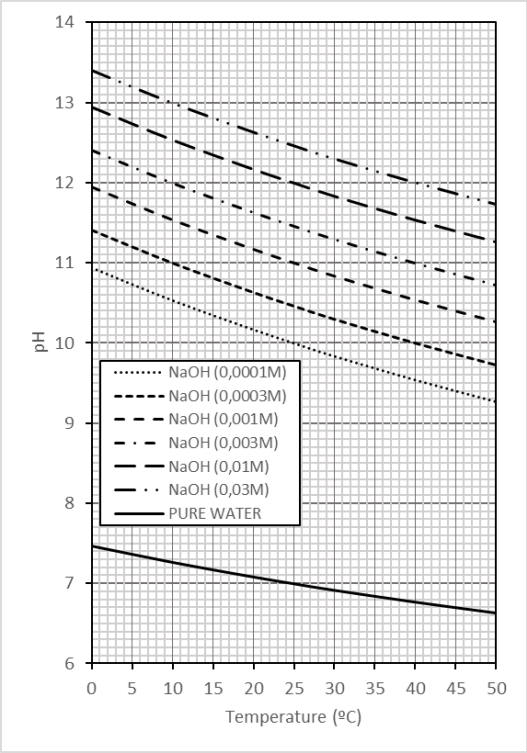


*Figure 1: Variation of pH with Temperature for Reference Caustic Solutions*

If on-line pH-meters of appropriate range are not available, a sample can be taken from the cleaning solution in the CIP tank and the pH measured separately in the laboratory. Because the temperature at which the pH measure is taken is not the same as in the tank, the cleaning solution pH can be adjusted improperly if the pH measurement is not corrected to account for the temperature difference.

## Summary

- The pH value of a solution is directly dependent on the temperature.
- pH values in the Product Data Sheet are given at the reference temperature (25°C).
- pH adjustment during cleaning solution preparation should always be carried out at the reference temperature (25°C) and before heating up the cleaning solution.
- Erroneous pH values exceeding Product Data Sheet recommendations may cause membrane degradation and lead to premature failure.

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