

# Ceramic Membrane Cleaning

## What is membrane cleaning?

In Tangential Flow Filtration (TFF), also known as Crossflow Filtration, the ability to clean and recover the initial performance of membranes after each cleaning is crucial for the operational success in the long-term.

One goal of cleaning the TFF system is to make the unit (including the pumps, piping, tanks, membranes and housings) ready to be in contact with the product of interest. This is achieved by the use of cleaning agents and specific procedures to eliminate the organic and inorganic contaminants that may accumulate in the unit during normal operation.

A second and specific objective of the cleaning in TFF is to remove the impurities that accumulate inside or on the surface of the membranes and reduce their performance.

The cleaning of TFF systems involves the use of different chemical or biological agents in aqueous solution at different temperatures, pressures and concentrations. This is performed considering the compatibility of the cleaning agents with the system (such as housings, gaskets and membranes) and their efficacy in eliminating the contaminants.

## Ceramic membranes

One of the key advantages of Ceramic Tangential Flow Filtration (CTFF) is the possibility of cleaning the complete unit with strong cleaning agents, which would permanently damage polymeric membranes.

Even if the product of interest does not require the superior robustness

offered by ceramic membranes during operation, the use of ceramic membranes combined with the right gasket and housing materials can greatly enhance the quality of the cleaning of CTFF units.

There are two procedures commonly used for this purpose in CTFF: CIP and SIP.



Range of TAMI Industries silicone, FKM and EPDM gaskets for different cleaning agents and temperatures.

## CIP (Clean-in-Place)

This is the standard procedure used in CTFF units, the ceramic membranes “remain in the system” during the cleaning. There is no need to remove the ceramic membranes from the unit or manually handle them during the cleaning.

The CIP is the operation of the unit with water and cleaning agents in turns to eliminate the organic and inorganic contaminants.

<b>Alkaline Cleaning</b>	▪ NaOH at 85°C (30 min)
<b>Acid Cleaning</b>	• HNO <sub>3</sub> at 50°C (15 min)
<b>Oxidizing agents (optional)</b>	• H <sub>2</sub> O <sub>2</sub> • NaOCl

Cleaning agents commonly used in CTFF.

The standard CIP procedure includes the draining of the unit, rinsing with water, alkaline cleaning, rinsing and acid cleaning. The duration of each step will depend on the efficiency of the cleaning procedure. Oxidizing agents can also be used to enhance the efficacy of the CIP.

The optimal CIP procedure is developed for each CTFF project during the pilot testing stage. Some of the most important parameters to be defined at this stage are the specific cleaning agents and their respective concentrations, the duration of each cleaning step and the temperatures. Decision is also made at this stage to design the CTFF unit with automatic or manual CIP features.

## SIP (Sterilization-in-Place)

SIP, performed after the CIP, does not affect the performance of the ceramic membrane; however, it is widely used when a sterile condition is required from the system, such as in the pharmaceutical industry.

Unthinkable for TFF units equipped with polymeric membranes, in CTFF, steam at 121°C is applied for up to 30 minutes without the need of disassembling the ceramic membranes and housings. The objective is to maintain a high temperature for long enough to eliminate all forms of life, such as bacteria and fungi.

Similar to CIP, the optimal SIP procedure specific for each project is defined at the pilot testing stage.

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Range of TAMI Industries stainless steel (316L) housings suited for CIP and SIP.

## Reverse flow cleaning

To delay the fouling of ceramic membranes and therefore maximize the operating time between CIPs, a reverse flow cleaning technique known as back-pulsing can be used in CTFF. This technique also reduces the consumption of water and cleaning agents by reducing the total number of CIPs. Back-pulsing does not improve the overall cleanness of the unit, but acts specifically on the performance of the ceramic membranes by displacing the fouling from the surface to the retentate.

In this procedure the flow of permeate is reversed for a few seconds periodically, which displaces the particles accumulated on the surface of the membrane. The difference from back-washing, which is the reverse flow of permeate for longer and at a lower pressure, is the high pressure and the reduced duration of back-pulsing. The higher pressure used in back-pulsing makes it efficient even if this is done briefly and in pulses, therefore reducing fouling without losing productivity.

The back-pulsing technique, with its frequent change of permeate flow direction, can be used in ceramic membranes because their supports

and active layers have the mechanical strength necessary to resist this action in the long-term.

It is important to note that the effect of back-pulsing on operating times varies from project to project. The decision to include or not this feature in CTFF units is made during the pilot testing stage, at which parameters such as frequency and pressure are optimized.

## Testing the cleanness of the system

The procedure to verify whether the CTFF unit was properly cleaned and ready to be in contact with the product of interest is specific to each industry and application. For instance, the level of cleanness expected from a CTFF unit processing milk for cheese production will be higher than the one expected from a CTFF unit processing textile effluent. Therefore, different kinds of tests can be required to verify the absence of chemical and biological contaminants relevant to the application. Such verifications can range from visual examinations to swab tests.

## Testing the performance recovery

The efficiency of the CIP in terms of performance recovery is tested following a standard procedure applicable to all CTFF installations. The same level of CIP efficiency will be expected from both the CTFF unit processing milk and the unit processing textile effluent. The objective is to verify whether the permeability of the ceramic

membrane was restored to initial values after the CIP.

This test is conducted with water after the end of the CIP, and is called the water permeability test (also known as water flow test).

The CTFF unit is fed with water and the permeate flow is measured. The result is the flow of water (permeate side) per square meter of ceramic membrane at 1 bar of TMP (Transmembrane Pressure) at 25°C, which is known as DE125 and is calculated as follows:

$$DE\ 125 = \frac{Q_p \times K_t}{TMP \times A}$$

where:

- $Q_p$  = is the flow of permeate measured in l/h
- $K_t$  = is the water temperature coefficient
- $TMP$  = is the transmembrane pressure in bar
- $A$  = is the filtration area in  $m^2$

The water permeability test is part of the CIP, which means that DE125 must be calculated after each CIP. The monitoring of DE125 allows the objective comparison of different CIP procedures and the pattern of its variation over time provides valuable information on the condition of the ceramic membrane.

## Related articles:

- What is Ceramic Tangential Flow Filtration and how it works
- Ceramic Tangential Flow Filtration design

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