

Introduction

The design of a clean in place system for a spiral wound membrane system is often a trade off between economic considerations and technical benefits. On typical plants, the CIP system is used three or four times per year. Effective cleaning is dependent on a number of factors, such as the type of foulant, the cleaning chemicals that are applied, and the manner in which they are employed. Optimisation of the system design is the only one that can be carried out at the design stage. This note details the main components of a CIP system and their ideal design.

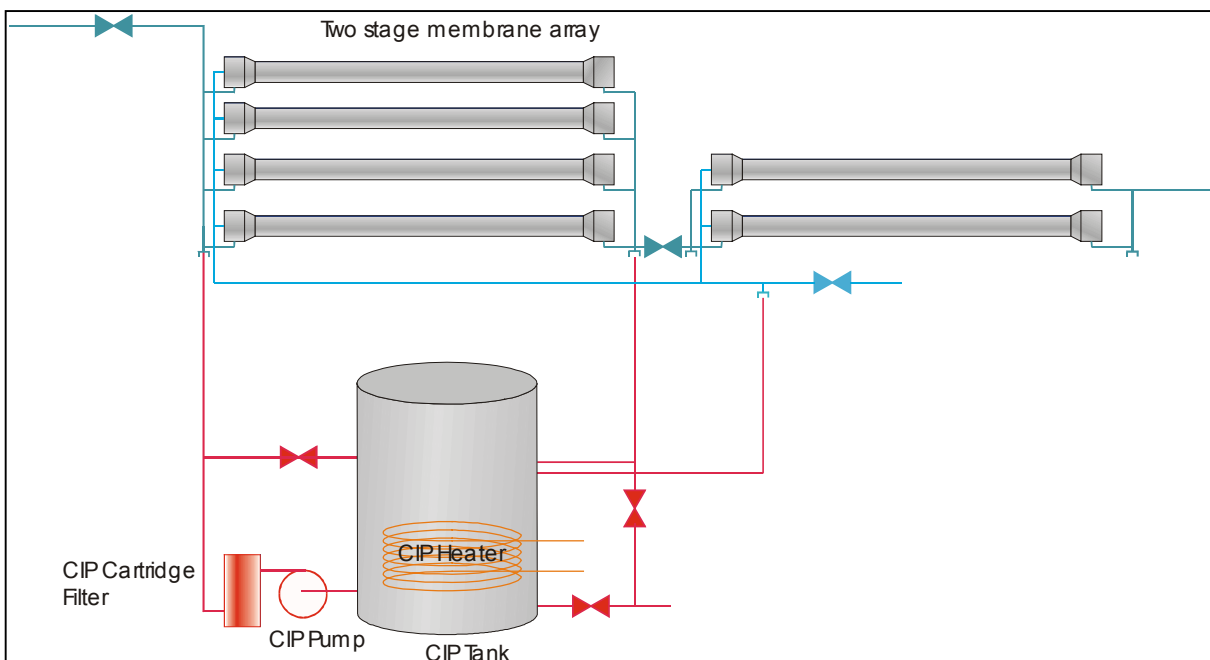


Figure 1 Sketch of Typical membrane CIP system

Elements of a CIP System

A schematic of a clean in place system is shown in Figure 1. The principal components are:-

Chemical Tank: Holds the cleaning solution, and often the heating/cooling element.

Recirculation pump: Pumps the cleaning solution through the pressure vessels

Cartridge Filter: Removes larger particulates from the cleaning solution

Cleaning Tank

As a minimum the tank capacity should be sufficient to hold the required cleaning chemical, such that it can be introduced into the system under pressure. If powdered cleaning chemicals are used, then it will be necessary to allow for the volume of the chemical once it has been dissolved into a liquid form. A more realistic volume is to allow for the volume held in the membrane vessels and the associated pipework. As a rule of thumb, allow 30 litres for each 8040 element, 45 litres for each 8060 element and 8 litres for each 4040 element, and allow a further 10-20% for the capacity of the pipework. Therefore if a system is equipped with vessels containing 6 -8040 elements, assume 180 litres per vessel.

The tank should have a close fitting lid, to minimise heat loss, and minimise any foam from the solution overflowing the tank.

A mixing system should be incorporated to ensure the chemicals are thoroughly dispersed through the cleaning solution. This can either be a mechanical mixer or a line from the outlet of the cleaning pump back to the tank.

Pump Capacity

The recirculation pump capacity should be set to provide a good crossflow through the membranes, as this increases the turbulence and creates a "scouring" action within the element. This helps to lift foulants from the surface of the membrane, and thus improves cleaning efficacy. The minimum recommended flowrates per vessel to be cleaned are 7m³/hour for an 8" vessel and 1.5m³/hour for a 4" vessel. Significant improvements can be achieved by using >9m³/hour for 8" vessels and 2m³/hour for 4" vessels. The pressure applied should be

as low as possible to achieve these flowrates, as excess pressure can result in permeate being produced, which creates a driving force to hold the foulant onto the surface of the membrane. The maximum head required for a cleaning system pump would be 4-5bar at the maximum recirculation rate.

Cartridge Filter

Having removed foulants from the system, an effort should be made to ensure they are not pumped back into the system. If the contaminants have been dissolved or broken down, then they are unlikely to cause any further problems. However, if it is particulate material that has been removed, then recirculating this to the membranes can reduce the effectiveness of the clean. Generally a cartridge filter with a nominal cut off of 10-20 microns is sufficient to remove particulates. If the membranes are heavily fouled then a bag filter may be more suitable as these have a higher capacity for solids holding.

Heater

Cleaning efficacy is invariably improved with increased temperature. Maximum temperatures for common membranes vary between 30 and 45°C. As a general rule membranes should be cleaned at the highest temperatures permitted by the manufacturer. Larger heaters will naturally increase the rate at which the contents of the cleaning tank will reach the required temperature, but will have a higher capital cost. External heating systems are advantageous in that the water can be heated for use in the cleaning tank while another clean is underway. It should be noted that in warmer climates a chiller loop

may be required instead to ensure the CIP solution does not increase above the maximum temperature for the membranes.

Pipework

The pipework should be arranged to allow each stage of the plant to be cleaned independently. In an 8:4 array, this means that the first 8 vessels should be cleaned as a separate event to cleaning the final 4 vessels. This is important because the recommended flowrate per vessel cannot be achieved if the stages are cleaned together. In addition, if the stages are cleaned together then the subsequent stages will impose a backpressure on the first pass, causing them to generate permeate. As mentioned previously, permeate production should be avoided, as this will create a force to hold foulants onto the surface of the membrane.

The return pipework from the membrane system to the cleaning tank should be of sufficient diameter as to offer no significant restriction to flow. Any restriction can cause permeate production. The return pipework should be arranged to enter the tank just below the surface of the cleaning solution, thus avoiding air entrapment as this can lead to excessive foaming. The facility to divert the cleaning chemical return directly to drain is recommended, as this allows fluid with significant contamination to be removed from the system.

As there is the possibility of chemical passing into the permeate, the permeate line should be isolated and diverted to clean in place tank.

Instrumentation

The following instruments are recommended for a cleaning system

- Flowmeter to measure the flowrate from the cleaning pump to the membranes.
- Pressure gauges to measure the differential pressure across the cartridge filter.
- Thermometer to measure the cleaning solution temperature. This can be linked to the heating system to control the temperature of the solution, and can be used to stop the pump should a high temperature be reached.
- pH meter to monitor the pH of the cleaning solution. This should be mounted on the cleaning pump discharge (or measure a sample taken from the pump discharge) as this will allow the pH of the solution to be monitored while the pump is recirculating back to the tank.

Materials of Construction

The material selection should take into account the pH range in which the membranes will be cleaned. For polyamide elements, this will typically be between 2.5 and 11.5 and for cellulose acetate elements it will be between 2.5 and 8. The temperature should also be considered.

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