Technical Service Bulletin

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Procedure for Chemically Cleaning HYDRAcap® MAX Module(s)

This Technical Service Bulletin provides information for chemically cleaning HYDRAcap® MAX module(s). This applies to both conventional HYDRAcap® MAX racks as well as HYDRAcube skids.

Background

Two types of chemical cleanings for HYDRAcap® MAX modules are required: Maintenance Cleanings (MC) and Recovery Cleanings (RC). MCs are typically performed on a time basis regardless of the temperature corrected specific flux (TCSF). RCs are also performed on a time basis, typically every 30-90 days, or when the TCSF has decreased to 2 gfd/psi (50 lmh/bar), or when the transmembrane pressure of the HYDRAcap® MAX has reached 30 psi (2 bar). Chemical cleanings are beneficial for removing inorganic, organic and biological foulants from the membrane. The following procedure describes typical cleaning solution preparation as well as cleaning procedure. The information presented in this technical bulletin is to be considered a guideline for cleaning all HYDRAcap® MAX products. Site specific variations in chemicals, flow rates and contact time may prove more effective than those described below. Verification of cleaning efficacy should be performed after every cleaning by comparing the start-up TCSF with the post cleaning TCSF. (For more on TCSF, please see TSB339.) If the TCSF has not been restored to within 30% of its original start-up value after a recovery clean, then repeat the chemical cleaning, try a different chemical cleaning, or contact Hydranautics for further assistance.

NOTE: Only use chemicals approved by Hydranautics. Chemicals not approved may damage the HYDRAcap® MAX module and void warrantees. Do not use oxidants in cleaning solutions that contain significant amounts of iron, manganese or other transition metals.

NOTE: Chemical cleaning solution make up water should contain no particles larger than 5 microns. If needed, a bag filter or other type of filter may be incorporated into the discharge line of the RC pump to meet this requirement. At a minimum, the filtrate tank should be covered.

Cleaning Solutions

Maintenance Cleaning Solutions

Typically filtrate water is used as the makeup water for maintenance cleaning. However, feed water may be used when the turbidity is less than 2 NTU depending on the organic and inorganic content of the feed water. Please contact Hydranautics for assistance determining the MC make up water.

As mentioned above, MCs are performed on a time basis regardless of the temperature corrected specific flux (TCSF). The frequency depends on the feed water quality. Typically, a chlorine MC ("MC1") will normally occur 1-2 times per day, depending on the amount of biological and organic material present in the feed water; a caustic MC ("MC2") will normally occur 0-2 times per day, also depending on the amount of organic material present in the feed water (Note, no caustic cleans for seawater applications); while Acid MCs ("MC3") are typically performed 0-1 times per day, depending on the amount of inorganic material present in the feed water and the scale forming potential. Hydranautics will provide recommendations during the design phase for each application. Please contact Hydranautics for assistance determining the MC frequency, understanding that the recommended frequency and/or chemical concentration may need to be adjusted once the plant is operational. A Maintenance Cleaning mode sequence can be seen below in figure 1.

Step	Description	Typical Duration (s)
1	Stop Filtration	0
2	Air Scour	60 – 120
3	Air Scour and Drain	60*
4	Chemical Dosing	60*
5	Soak	600
6	Air Scour	600
7	Air Scour and Pressurized Chemical Drain	90*
8	Refill	60*
9	Chemical Rinse	120
10	Resume Filtration	0
		Total ~ 27 minutes

***Figure 1:** Maintenance cleaning sequence of operations*

Cleaning solutions can be made up with generic chemicals such as sodium hypochlorite, sodium hydroxide, sulfuric acid, hydrochloric (muriatic) acid, or citric acid. These chemicals are typically as effective as and less expensive than proprietary cleaning chemicals. Concentrations for maintenance cleans should be able to maintain a low pH of 2 for acids and high pH of 12 for caustic.

NOTE: Other than cases where high transition metal content (i.e. > 0.5 ppm) is present in the feed, high pH or oxidant cleans should be conducted prior to a low pH clean.

Typical concentrations for various chemical solutions can be found in table 1:

Table 1: Recommended concentrations of chemical solutions for Maintenance Cleans

Chemical Solution	MC1 (chlorine)	MC2 (caustic)	MC3 (acid)
Sodium Hypochlorite	200 ppm	~	~
Sodium Hydroxide (50% NaOH)	~	1200 ppm	~
Sulfuric Acid (96% H_2SO_4)	~	~	1470 ppm (0.15%)
Hydrochloric Acid (33% HCl)	~	~	1470 ppm (0.15%)
Citric Acid	~	~	4000-8000 ppm (0.4-0.8%)

Removal of precipitated transition metals may be enhanced by the use of chelating agents (i.e., citric acid, EDTA, DTPA, etc.), or reducing agents (i.e., sodium bisulfite, sodium hydrosulfite, etc.). Add 22 pounds (10 kg) of chelating agent per 264 gallons (1 m^3) of solution.

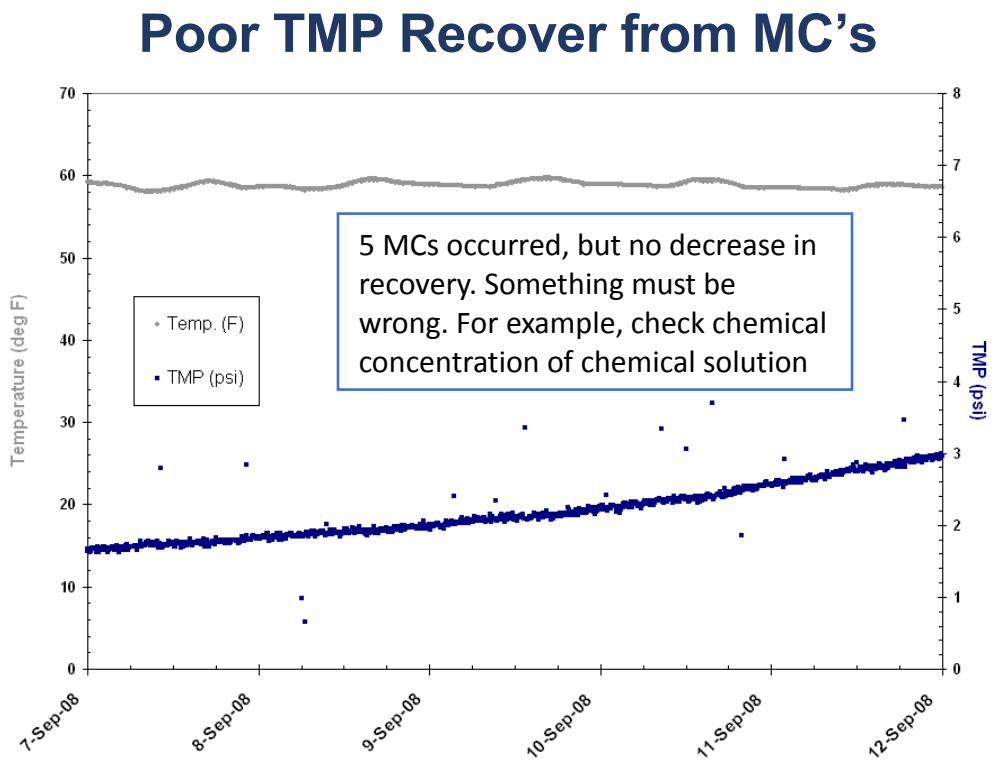

Figure 2: *Maintenance clean example with poor TMP recovery.*

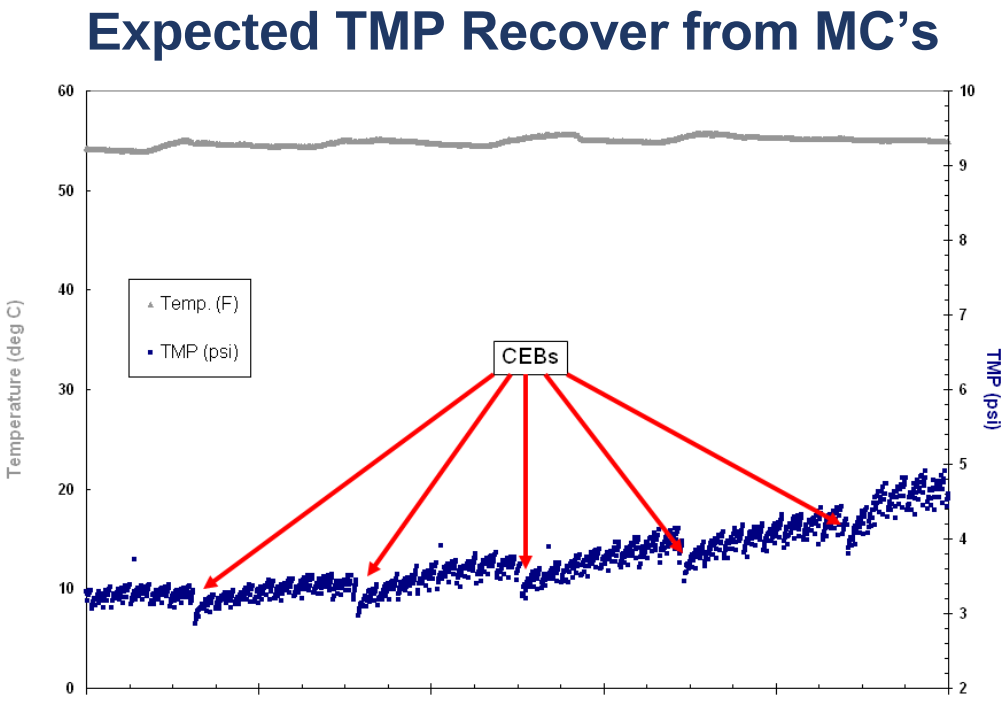

Figure 3: *Maintenance clean example with expected TMP recovery.*

IMPORTANT SAFETY WARNING: For feed waters containing high concentrations of silicon, special care needs to be taken when cleaning with sodium hydroxide. Silicon and sodium hydroxide in the presence of water generate hydrogen gas in an exothermic reaction as follows:

$$Si + 2NaOH + H_2O \rightarrow Na_2SiO_3 + 2H_2 + 423.8(kJ/mol)$$

In order to prevent accumulation of hydrogen gas and heat inside the module(s) and system, THE VENT VALVE SHOULD REMAIN OPEN AT ALL TIMES THAT THE SODIUM HYDROXIDE SOLUTION IS PRESENT IN THE MODULE.

As hydrogen gas is highly combustible, SMOKING IS STRICTLY PROHIBITED IN THE VICINITY OF THE SYSTEM. "NO SMOKING" signs should be posted on and around the HYDRAcap® MAX or HYDRAcube system.

Recovery Cleaning Solutions

Filtrate water will always be used as the makeup water for Recovery Cleaning. It is Hydranautics recommendation to heat up the chemical solution to 40°C to conduct a more effective clean. **DO NOT EXCEED 40°C OR MODULE DAMAGE MAY OCCUR.** The same generic chemicals used for an MC can also be used for the RC. Typical concentrations can be found in table 2:

Table 2: Recommended concentrations of chemical solutions for Recovery Cleans

Chemical Solution	RC1 (chlorine)	RC2 (caustic)	RC3 (acid)
Sodium Hypochlorite	1000 ppm	~	~
Sodium Hydroxide (50% NaOH)	~	3500 ppm Target pH = 12 – 12.5	~
Sulfuric Acid (96% H_2SO_4)	~	~	5000 ppm (0.5%) Target pH = 1.5 – 2
Hydrochloric Acid (33% HCl)	~	~	5000 ppm (0.5%) Target pH = 1.5 – 2
Citric Acid	~	~	10000-20000 ppm (1-2%) Target pH = 1.5 – 2

NOTE: The chemical concentrations provided for the MCs and RCs are to be used as a reference values only. Actual concentrations will vary relative to the make-up water quality.

As mentioned above, RCs are performed on a time basis, typically every 30-90 days, or when the TCSF has decreased to 2 gfd/psi (50 lmh/bar), or when the transmembrane pressure of the HYDRAcap® MAX has reached 30 psi (2 bar). If the TCSF has not been restored to within 30% of its original start-up value, then repeat the chemical cleaning, try a different chemical cleaning, or contact Hydranautics for further assistance. The sequence of operations may be seen in the figure below. The frequency and duration of recovery cleans (RC's) are highly dependent on the feed source and its elements. Hydranautics RC cleaning Recommendations can be seen in figure 4 below.

Step	Description	Typical Duration (s)
1	Stop Filtration	0
2	Air Scour	60 – 120
3	Heated Fill with Filtrate	60
4	Soak	300
5	Air Scour and Drain	60
6	Chemical Dosing	60
7	Soak	2700
8	Air Scour	600
9	Chemical Dosing	10
10	Soak	2700
11	Air Scour and Pressurized Chemical Drain	60
12	Refill	60
13	Chemical Rinse	120
14	Resume Filtration	0

***Figure 4:* Recovery cleaning sequence of operations.**

An alternative method for recovery clean if the previous process does not return the modules back to recommended specs can be 4 x 45min soak and 4 x 5min air scour with partial refill after each air scour.

	Chemical Soak (Minutes)	Air Scour (Minutes)	Partial Refill/ Chem. Dosing (Seconds)
1	45	5	10
2	45	5	10
3	45	5	10
4	45	5	10

***Figure 5:** Alternative method for Recovery Cleaning*

Oxidant Limits

Polyvinylidene Fluoride (PVDF) membranes can be exposed to feed water containing oxidants such as chlorine. The maximum instantaneous chlorine (Cl_2) concentration for the HYDRAcap® MAX is 5000 ppm.

Preparing Cleaning Solution

A chemical cleaning solution can be created via a dosing system, which doses chemical at a fixed rate into either the feed (only applicable for MC in certain applications) or filtrate line to create the desired chemical concentration; alternatively, for an RC, the amount of chemical necessary can be measured separately and poured directly into the RC tank, which holds the makeup water. The following describes a procedure to makeup a chemical solution in an RC tank.

NOTE: Cleanings should be performed after an air scour to ensure that the membrane surface is as clear as possible. This will also flush out particulate material that is contained in the feed water and entrapped in the rack. If the module is heavily fouled, multiple air scours may need to be conducted prior to introducing the chemical solution.

1. Ensure proper safety precautions have been met (i.e., goggles, gloves etc.).
2. Ensure adequate ventilation.
3. Fill the cleaning tank with filtrate from the HYDRAcap® MAX, RO permeate, municipal water, or similar quality water**.**

NOTE: When using filtrate from the HYDRAcap® MAX or municipal water, care should be taken not to exceed the solubility of sparingly soluble salts (i.e. calcium carbonate) upon addition of the cleaning chemicals.

4. Heat the solution to desired temperature. At this point, after the air scour procedure has completed, while the modules are still full of feed water, the heated filtrate solution without chemical is introduced slowly to the modules from the filtrate side of the fibers. This heated water will gradually heat the module and slowly increase the temperature within the module to avoid possible damage to the modules by thermal shock.
5. Once the modules have been filled, the modules will need to soak in the heated water for approximately 5 mins. During this time, introduce chemicals into the water filled cleaning tank. Never introduce water into chemicals as extreme heating may occur.
6. Mix solution with a static mixer or via a special recirculation loop. Some cleaning skids may not contain a “mixing loop” and other techniques must be implemented, such as utilization of a static mixer.
7. After mixing and heating, ensure that the concentration and/or pH is still in the target range.

Introducing the Cleaning Solution

1. Once the modules have been heated, the heated water solution described in step 4 under “Preparing Cleaning Solution” section is air scoured and drained out. It is now time to fill the module with the cleaning solution.
2. Ensure the rack to be cleaned is offline and isolated from the rest of the system.

NOTE: VERY IMPORTANT: OPEN THE VENT VALVE PRIOR TO INTRODUCING THE CHEMICAL SOLUTION.

3. If cleaning is a manual procedure ensure that the cleaning loop connections have been made (i.e. cleaning solution in, cleaning solution out and filtrate out) and that the valve positions are set properly (only the concentrate and RC feed valves as well as the chemical injection valve, if applicable, should be open now).
4. Introduce the cleaning solution using the RC pump. The filling flow rate of the RC pump is typically less than or equal to the filling flow rate of the feed pump. Please contact Hydranautics to determine sizing of RC pumps. Slowly introduce the heated solution.
5. If the solution is made inside a RC tank, continuously monitor the pH and temperature of the cleaning solution inside the tank to verify that they are still in the desired range.
6. Verify the concentration, pH, and temperature within the modules. If the desired concentration, pH, and/or temperature have been achieved inside the modules, allow the membranes to soak in the cleaning solution for 45 minutes. Otherwise, make any necessary adjustments prior to soaking the membranes in the solution.
7. After the soak period, air scour the membranes for 10 minutes. Note that some solution will be displaced out of the concentrate line during this procedure.

8. After air scouring, it is necessary to replace the volume of solution that had been displaced in step 7. Refill the modules to the point where water can be seen in the clear section of piping connected to the concentrate port at the top of the modules. Once the modules have been refilled, continue to soak the fibers for another 45 minutes.

Rinsing

1. Next, conduct an air scour and pressurized chemical drain. Air at 15 psi (~1 bar) will be applied to the filtrate side of the fiber to force filtrate and any chemical on the filtrate side out of the modules through the drain.
2. Then the module is refilled, and any residual chemical is removed by sending feed water from the feed side of the module to the filtrate side and straight to drain upstream of the common filtrate header. The filtrate valve should remain closed during this rinse step to prevent any chemical from mixing into the product water piping. The vent valve may be closed at this step.
3. After sufficient rinsing, the rack is returned to filtration mode.

NOTE: Neutralization of the cleaning solution(s) is often required. If the cleaning skid is supplied with two cleaning tanks, then the high pH and low pH solutions may be neutralized by mixing them together. Otherwise, chemical addition or dilution with water will be required to neutralize the solution(s). Do not neutralize cleaning solution through the module(s) as excessive heat and membrane damage may occur.

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