Technical Service Bulletin

December 2023 TSB 339.05

Data Logging, Normalization and Performance Analysis for HYDRAcap™ MAX Modules and Elements

This Technical Service Bulletin provides information for manual data logging, data normalization and performance analysis for systems that use HYDRAcap™MAX modules. This applies to both HYDRAcap™MAX modules (either with a conventional rack or using HYDRAcube skids) as well as elements used in pressure vessels.

General

Most HYDRAcap™MAX UF systems have supervisory control and data acquisition (SCADA) such that operating data is capable of being automatically acquired and stored at least every minute. Despite this technical convenience, manual data logging should be performed at every HYDRAcap™ MAX plant. Not only does the physical act of data logging allow operators to inspect their systems, but it also facilitates corroboration amongst transmitters and gauges. Data sheets are also a good backup source of data should the electronic data be lost.

Data Logging Sheet

A sample data logging sheet is provided below. This sheet lists all parameters that are necessary to determine HYDRAcap™MAX performance. Some systems incorporate supplemental equipment as part of the HYDRAcap™MAX process, such as a screen filter, chemical injection, tanks, particle counters and pH probes. Data from each of these items should be logged, as well, to ensure proper plant performance and establish baseline characteristics.

A data set from each rack should be manually logged at least once per day (minimum), and preferably once per operator shift. A data set includes data logged two minutes prior to and two minutes after air scour. This allows for an accurate assessment of air scour efficacy and HYDRAcap™MAX performance.

The following is a description of parameters used in the data logging sheet:

- Date – calendar date.
- Time – local time.

- Hour Meter –machine time, usually in hours.
- Temperature – feed water temperature in degrees Celsius, [^oF, ^oC].
- Screen Filter Pressure In – water pressure entering the screen filter, [psi, bar].
- Screen Filter Pressure Out – water pressure exiting the screen filter, [psi, bar].
- Feed Pressure (P_{feed}) – Water pressure on the feed side of the UF skid or rack, as measured on the feed water header, which is connected to the bottom center port of HYDRAcap™MAX module(s)/element(s), [psi, bar].
- Concentrate/Top Feed Pressure ($P_{concentrate}$) – Water pressure on the concentrate side of the UF rack, as measured on the concentrate/top feed water header, which is connected to the top center port of HYDRAcap™MAX module(s)/element(s), [psi, bar].
- Filtrate Pressure ($P_{filtrate}$) – Water pressure on the filtrate side of the UF skid, as measured on the filtrate water header, which is connected to the bottom side ports of HYDRAcap™MAX module(s)/element(s), [psi, bar]. Note: The filtrate pressure for HYDRAcap™MAX skids should be measured on the common filtrate header, after bottom and top filtrate headers have joined.
- COD – chemical oxygen demand, [ppm]
- TOC – total organic carbon, [ppm]
- TSS – total suspended solids, [ppm]
- Feed Turbidity – feed water turbidity, [NTU].
- Filtrate Turbidity – filtrate water turbidity, [NTU].
- Filtrate Flow – instantaneous filtrate flow, [gpm, m^3/h].
- Concentrate Bleed Flow - instantaneous concentrate bleed flow, [gpm, m^3/h].
- Concentrate Flow - instantaneous recycle flow, [gpm, m^3/h].
- Comments – time remaining until next air scour [minutes], type of maintenance clean (i.e., chlorine, caustic or acid), chlorine concentration, or other notable events.

Data normalization is required to determine HYDRAcap™MAX performance. As feed water temperature changes, so does the membrane permeability. Temperature change not only affects feed water viscosity, but also membrane permeability. Significant temperature fluctuations yield significant fluctuations in observed transmembrane pressure (TMP) due to changing feed water viscosity, which may or may not indicate actual changes in plant performance. For this reason, it is necessary to normalize operating data to a reference temperature. For simplicity, the reference temperature for normalization is 20º Celsius. The following equations should be used in determining HYDRAcap™MAX skid performance:

Filtrate Flux is filtrate flow rate per unit area of membrane. Flux is a system design parameter that has a direct correlation with membrane fouling rate. As flux is increased, so is the fouling rate. As much as possible, the temperature corrected flux should be kept constant. As the temperature of the feed water changes, the instantaneous flux may need to be changed accordingly. If possible, flux should be monitored and controlled by the SCADA. Any change on the flux should be accompanied with the appropriate adjustment of the air scour frequency and sequence durations.

- Flux calculation (U.S. units):

$$J = \frac{1440 * Q}{A_m}, \text{[gfd]}$$

where :

J - filtrate flux, [gallons/ft^2 day].

Q - filtrate flow,[gallons/minute].

A_m - effective membrane area, [ft^2]

- Flux calculation (SI units):

$$J = \frac{1000 * Q}{A_m}, \text{[lmh]}$$

where :

J - filtrate flux, [liters/m^2 hour].

Q - filtrate flow,[m^3/hour].

A_m - effective membrane area, [m^2]

Trans Membrane Pressure (TMP) is the net driving pressure on the membrane. This is the effective pressure for forcing water through the membrane. A clean membrane will have a relatively low TMP, whereas a fouled membrane will have a relatively high TMP, depending on the severity of fouling. When TMP reaches 30 psi (2 bar) on a HYDRAcap™ MAX skid a chemical cleaning is recommended, regardless of other scheduled cleanings.

When flux and temperature are constant, the TMP is indicative of the degree of fouling on the membrane. A clean membrane will have a constant TMP, assuming the previous conditions are met. However, water viscosity and membrane resistance are dependent on temperature. When water temperatures change, TMP changes as well. This effect is common for every membrane process. In some cases, when water temperature fluctuates significantly, TMP fluctuations will also occur. This is also true when flux varies. Thus, an increasing TMP does not necessarily indicate fouling, only the possibility of fouling.

- Trans Membrane Pressure calculation:

$$TMP = \frac{(P_{feed} + P_{concentrate})}{2} - P_{filt}, [psi, bar]$$

where :

TMP- trans membrane pressure,[psi, bar].

P_{feed} - bottomfeed pressure,[psi, bar].

$P_{concentrate}$ - concentrate pressure,[psi, bar].

P_{filt} - filtrate pressure,[psi, bar].

NOTE: 1) All pressure gauges need to be corrected to same elevation (see figure 1a and 1b below).
2) Taps for the pressure gauges should be located as close to the ports of the module as possible.

Figure 1a: Example of pressure gauges at same elevation.

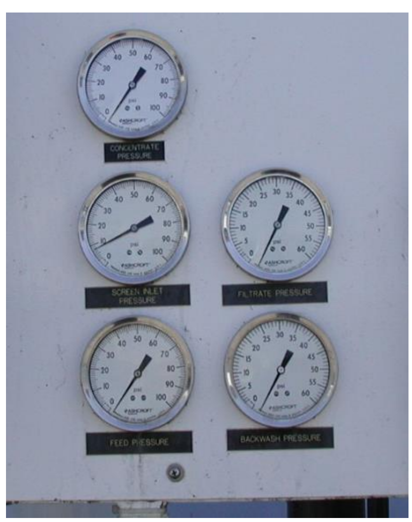

Figure 1b: Example of pressure gauges at different elevations that will need correction.

Temperature Corrected Specific Flux (TCSF), or permeability is the most important parameter to monitor membrane fouling. In relation to the startup TCSF, a significantly high TCSF may indicate chemical degradation of the membrane, whereas a low TCSF may indicate fouling. When the TCSF reaches 2 gfd/psi (50 Lmh/bar), a chemical cleaning is required.

For any HYDRAcap™MAX skid it is critical that the TCSF be monitored. TCSF represents the fouling condition of the membrane regardless of the changes in temperature or flux. The benefits of properly maintaining TCSF will translate into the energy usage as well. As the membrane fouls, and the TCSF decreases, energy requirements will increase (if system operating parameters remain constant).

- Temperature corrected specific flux calculation (U.S. units):

$$\mathrm{TCSF} = \frac{\mathrm{J}}{\mathrm{TMP}} * e^{(-0.031*(\mathrm{T}-20))}, \text{ [gfd/psi]}$$

where:

TCSF - temperature compensated specific flux.

J - flux,[gfd].

TMP- trans membrane pressure,[psi].

T - water temperature,[$^{\circ}$C].

- Temperature corrected specific flux calculation (SI units):

$$\mathrm{TCSF} = \frac{\mathrm{J}}{\mathrm{TMP}} * e^{(-0.031*(\mathrm{T}-20))}, \text{ [lmh/bar]}$$

where:

TCSF - temperature compensated specific flux.

J - flux,[lmh].

TMP- trans membrane pressure,[bar].

T - water temperature,[$^{\circ}$C].

TCSF and TMP are the minimum parameters that should be calculated and monitored to determine HYDRAcap™MAX performance. For a complete assessment of the HYDRAcap™MAX skid performance, other parameters should be monitored as well (i.e., turbidity, TSS rejection etc.)

Useful Tips:

1. Take data daily and, if possible, once per shift. Keep on-line data as a more reliable information source and record a complete data set at least every minute.
2. Plot each parameter versus time in such scale to observe sudden spikes on data trends.
3. Log graphs in journal and keep them available at operator control room.
4. Log events of errors in control on the HYDRAcap™MAX skid as well bad service and operation.
5. Analyze upsets in data trends (especially TMP, Flux and TCSF, Feed and Filtrate turbidity).
6. Trace water quality and its relation to system performance.
7. Trace the effect on water temperature to fouling ratio.

Hydranautics
401 Jones Rd.
Oceanside, CA 92058
Tel: (760) 901-2500
Fax: (760) 901-2578
email: info@Hydranautics.com