O_2 Removal Efficiency of the Liquicel

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A Hoerst Celanese membrane degasser (Liquicel) has been installed underground in parallel with the monitor degasser. It has been evaluated as a possible device to degas the D_2O system.

The theory of operation of a Liquicel is described in the manufacturer's brochure. Water flows through hollow fiber membranes and on the outside of the membrane a combination of vacuum and low pressure sweep gas is applied to take away the gasses and water vapor which comes through the wall of the fibers.

In this report the water flow rate and nitrogen gas sweep rate in the Liquicel are varied and the resulting dissolved O_2 level in the water exiting the Liquicel is measured.

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Experiment I: O_2 degassing efficiency as a function of the water flow
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Time		H_2O flow (gpm)	O_2 levels (ppb)	O_2 degassing efficiency (%)
35	Measure O_2 of incoming feed water : 6.11ppm			
4.45	Set-up N_2 sweep gas through LC to 5.5 scfh			
4.50	Start H_2O thru LC	5.0		
5.00		5.2	106.	
5.05		5.2	91.	
5.20		5.2	73.7	
5.35		5.4	66.0	
5.50		5.8	65.5	
6.40		5.0	48.2	99.2%
6.42	H_2O flow to	6.5		
7.02		6.5	85.0	
7.20		6.5	60.4	
7.30		6.5	60.2	99.0%
7.30	H_2O flow to	8.0		
7.35		8.0	85.6	
7.45		8.0	88.0	98.6%
7.45	H_2O flow to	10.0		
8.00		10.0	138.0	97.7%
0	H_2O flow to	6.5		
5		6.5	59.0	
8.15		6.5	57.5	99.1%
8.15	H_2O flow to	5.0		
8.20		5.0	41.5	
.30		5.0	39.3	99.4%

8.30	H2O flow to	4.0		
8.40		4.0	34.3	
9.15		4.0	31.0	99.5%
9.15	H2O flow to	5.0		
9.30		5.0	35.9	99.4%
9.30	H2O flow to	8.0		
9.40		8.2	89.5	
9.45		8.2	91.5	98.5%

9.55 Measure O2 in feed water : 6.07ppm

Summary of best O2 degassing efficiencies with the LiquiCel :
(N2 sweep gas flow at 5.5 scfh)

4.0	31.0	99.5%
5.0	35.0	99.4%
6.5	57.5	99.1%
8.0	88.0	98.6%
8.2	91.5	98.5%
10.0	138.0	97.7%

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Experiment II: O2 degassing efficiency as a function of the N2 sweep flow
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Time		N2 sweep flow (scfh)	O2 levels (ppb)	O2 degassing efficiency (%)
10.00	Measure O2 of incoming feed water :		6.40ppm	
10.20	Set-up H2O flow through LC at 5.0 gpm (small fluctuations in water flow observed throughout the day).			
10.30		0 (vac. only)	280.	
10.53		0	190.	
11.05		0	177.	97.2%
11.07	Set N2 flow to	5		
11.25		5	81.4	
12.05		5	68.5	
12.35		5	57.5	
12.45		5	54.5	
12.50		5	53.7	99.2%
12.50	Set N2 flow to	15		
13.30		15	61.2	
13.50		15	48.0	
14.10		15	44.0	
14.20		15	43.2	99.3%
14.20	Set N2 flow to	10		
14.35		10	41.4	
14.40		10	41.4	99.3%
14.40	Set N2 flow to	20		
14.50		20	41.5	

15.00		20	40.4	99.4%
15.00	Set N2 flow to	5		
15.10		5	38.8	
15.20		5	38.6	99.4%
.20	Set N2 flow to	2		
.30		2	38.1	99.4%

15.35 Stop water flow (no positive pressure on O2 meter, but still degassed water in line)

15.40 O2 level with no pressure 28.0 99.6%
(this quantum jump from 38.1 ppb to 28.0 ppb does indicate a calibration problem with the O2 meter. The O2 levels appear to be strongly dependent on the water pressure at the O2 probe head).

15.45 Measure O2 in feed water @ 6.31ppm

Comments :

a) The degassing efficiency gets better with time which indicates that steady state has not been reached in the 30 minutes or so during the readings before a change in water or N2 flow.

b) In the N2 flow range of 2 to 20 scfh, it appears that the O2 degassing efficiency is fairly stable around 99.4%.

We may want to study the range between 0.1 to 2 scfh. This requires a lower range flowmeter be purchased and installed.

d) There is an obvious systematic bias in the O2 readings due to pressure dependence of the probe head. The readings above are higher than the actual O2 value in the water which means the above data can be regarded as lower limits.

There is a table in the O2 operating manual that gives some corrections for the pressure dependence. We need a water pressure gauge near the O2 probe head to be able to correct the pressure dependence.

e) The water vapor load is about 0.9 ml per minute for 5 cfm N2 flow and 5 gpm water flow.

f) The water vapor load and efficiencies measured above are used to design a process/monitor degasser for the D2O system.