

Date: August 29,2008
To: ChE 433 Class
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Subject: Gas Separation using Membrane

There are pilot scale gas separation units that contain four membrane modules in BEL 334. Usually pilot scale units are used to generate performance data to design Full-scale plants. These units (in BEL 334) are mounted on a clear plastic (Acrylic) stand in the process control lab. The units contain an undetermined number of hollow fibers in the modules that separate oxygen and nitrogen from air to a required concentration of each gas (as needed) in the reject side (nitrogen rich) and permeate side (oxygen rich).

Each of the groups needs to develop a theoretical model describing how the membrane gas separation process works and quantify this using the experimental set-up in room BEL 334. Most often the mathematical description of the system and the actual data gathered are used to generate graphs that operators can use. With this in mind, your task is to write an operation and safety procedure for the pilot scale design so that a plant operator will be able to safely run the system. This means you are expected to derive the mathematical model and generate graphs for the conditions that are outlined in the other handout using software that you are comfortable with, such as EXCEL..... The preliminary calculation and report is due October 7. The corrected preliminary report will be available to you on October 10. **The revised report with changes as required should be brought and discussed with me before running your lab.**

Membrane Gas Separation

Gases can be separated utilizing semi-permeable polymer membranes. The separation process utilizes the difference in physical properties between the gases. A gas passes through the membrane by absorbing on the high-pressure surface, diffusing through the membrane polymer, and desorbing from the low-pressure side. Also, depending on the microstructure of the membrane, a gas can travel directly through the membrane pores.

You have a membrane system for the separation of oxygen and nitrogen from air. Your assignment is to build a mathematical model describing the process and setting up an Excel spreadsheet that can be used by an operator. This model should predict the exit gas compositions for both reject and permeate side for inlet air pressures of **120, and 150 psi**, using separation factors (selectivity) of **6, 7 and 8** for each pressure. The operator can only adjust the reject valve to set reject or permeate side concentration as needed at a given pressure. That means you need to generate graphs (**three sets**): **1**) one set for separation factor of 6 at 120 and 150 psi ; **2**) one set for a separation factor of 7 at 120, and 150 psi; and **3**) one set for a separation factor of 8 at 120 and 150 psi using your model. The graphs should be presented as **% oxygen (1-10%)** in the **reject side (X-axis)** and **% recovery (Y-axis)** for each pressure and another graph of **% oxygen (>21%)** in the **permeate side (X-axis)** versus **% recovery (Y-axis)** for each pressure and selectivity mentioned above. These graphs are to be used by a technician as reference to operate the separation process to produce a particular concentration product in either side of the output i.e., reject or permeate side.

The graphs you generated are used as an operating manual, that should include safety precautions, that describes the process, and the physical configuration while operating the system. You are expected to present your rigorous mathematical model, in terms of chemical engineering mass transport, in your final report. (**A good reference: McCabe, Smith and Harriott, 5th or 6th edition, Chapter 26**).

Using the plots you generated, **% oxygen versus % recovery** for both the reject side and permeate side for pressures and selectivity that were mentioned above, validate the accuracy of your model with experimental measurements and **predict what the actual selectivity are for each of the modules you tested**.