Cryogenic Pollutant Balances

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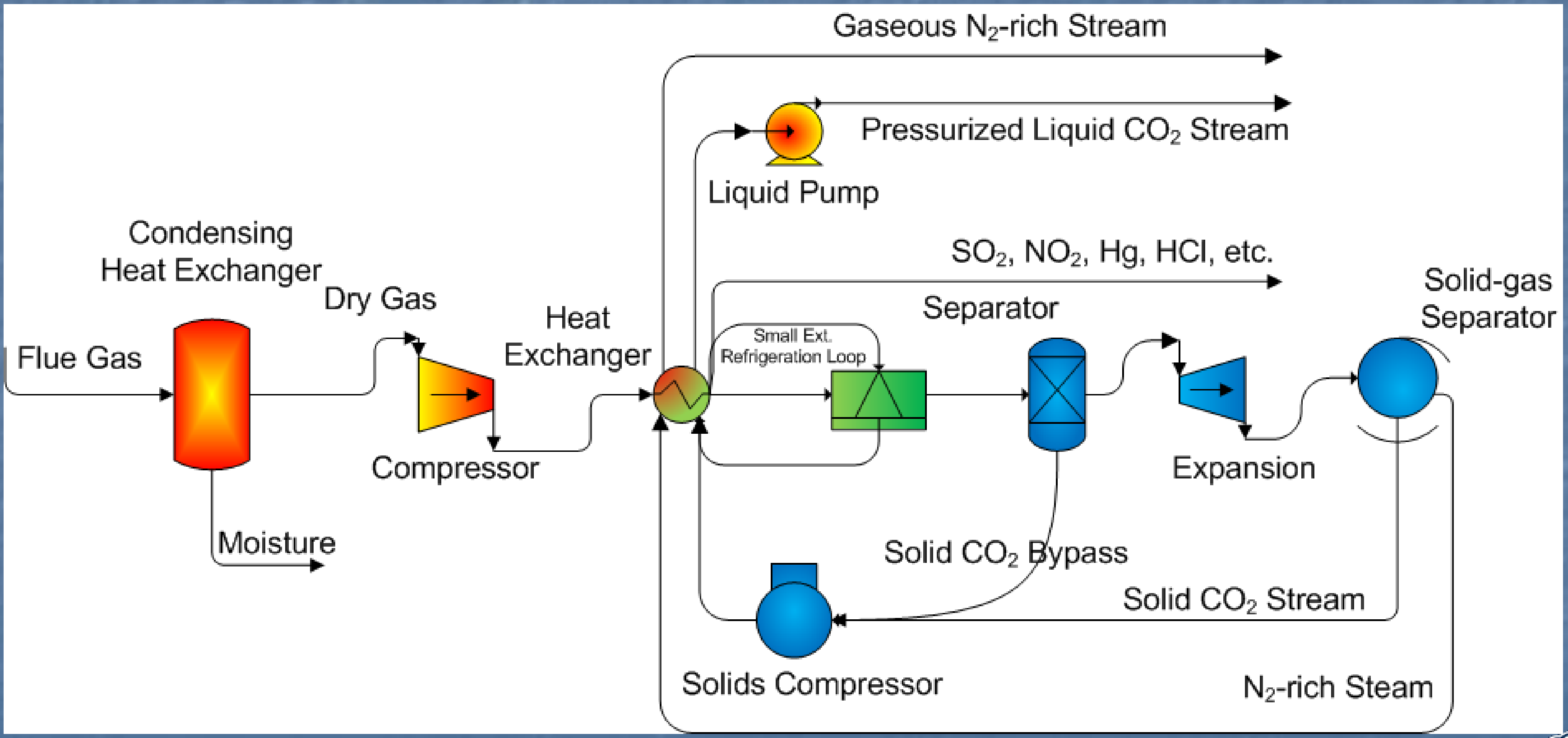
Introduction

- Cryogenic carbon capture also removes other pollutants such as Hg, HCl, SO_2, SO_3, NO_2, and NO.
- Thermodynamic data for these chemicals exist at higher temperatures but not at the lowest CCC temperatures (135 K)
- Experiments help determine (1) equilibrium data and (2) whether pollutants exist at equilibrium.

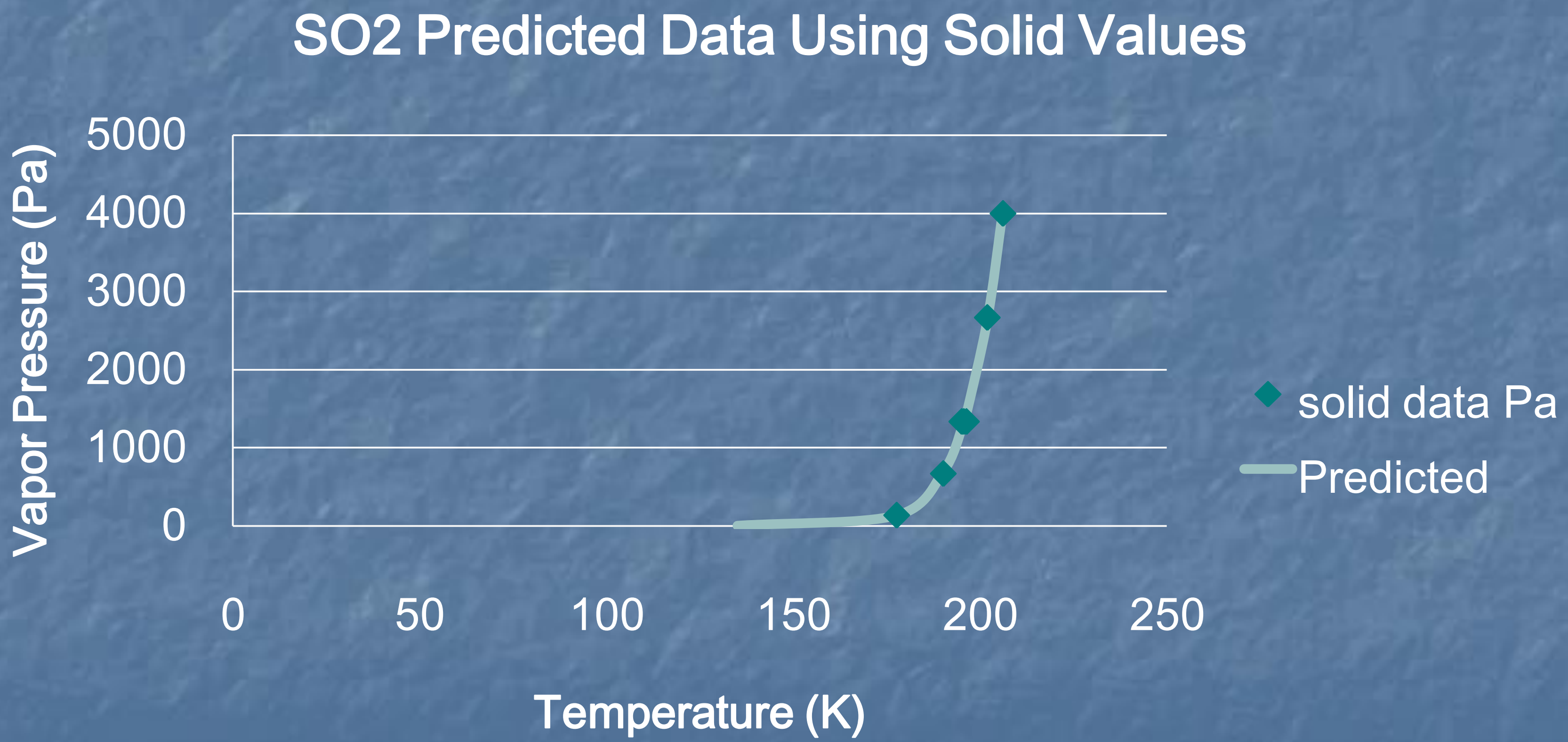
Process Diagram



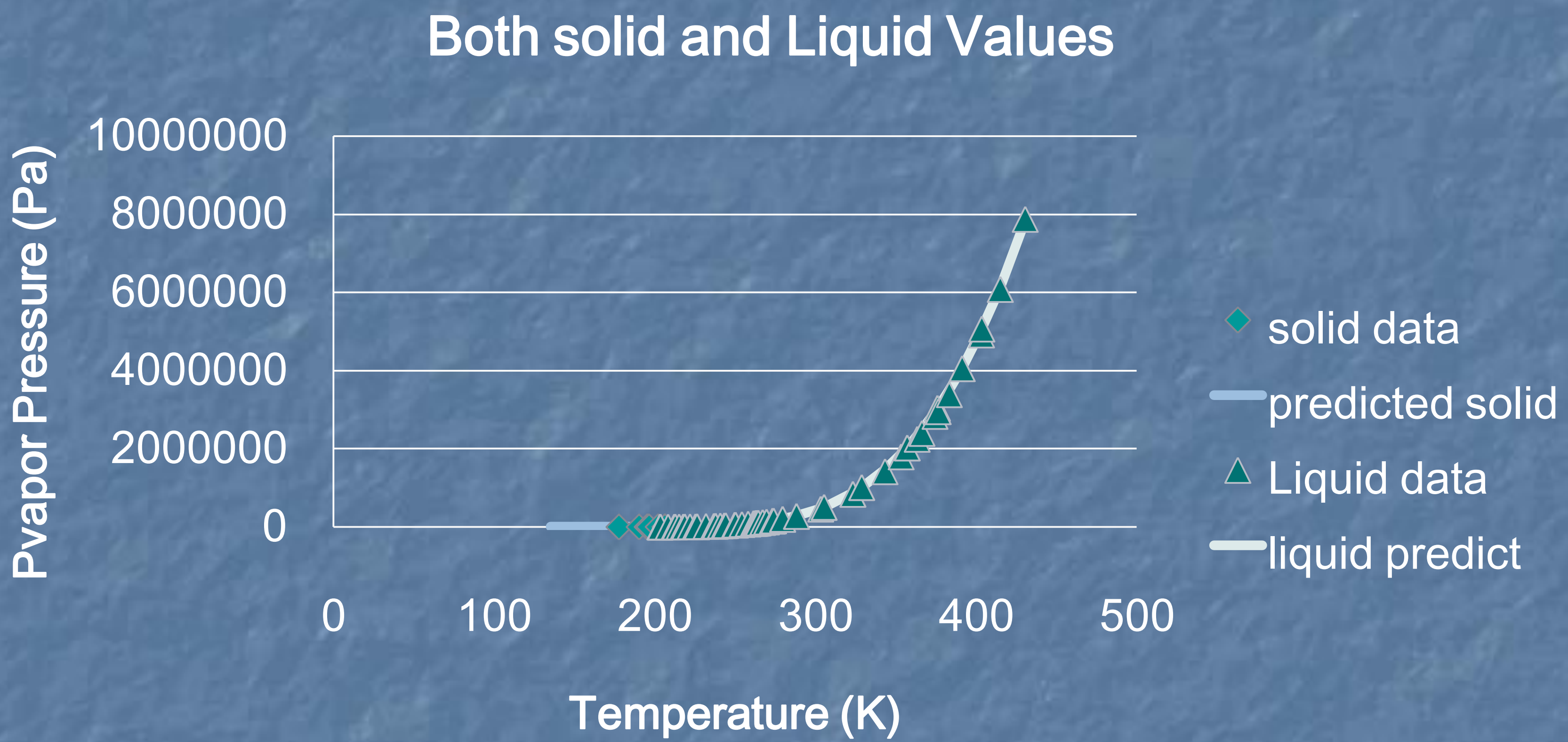
Thermodynamic Calculations

- Using data and equations from Dippr Database
- Extrapolated vapor pressure to135 K to predict vapor phase
- Experiments verify low-temperature behavior and validate equilibrium assumptions

SO2

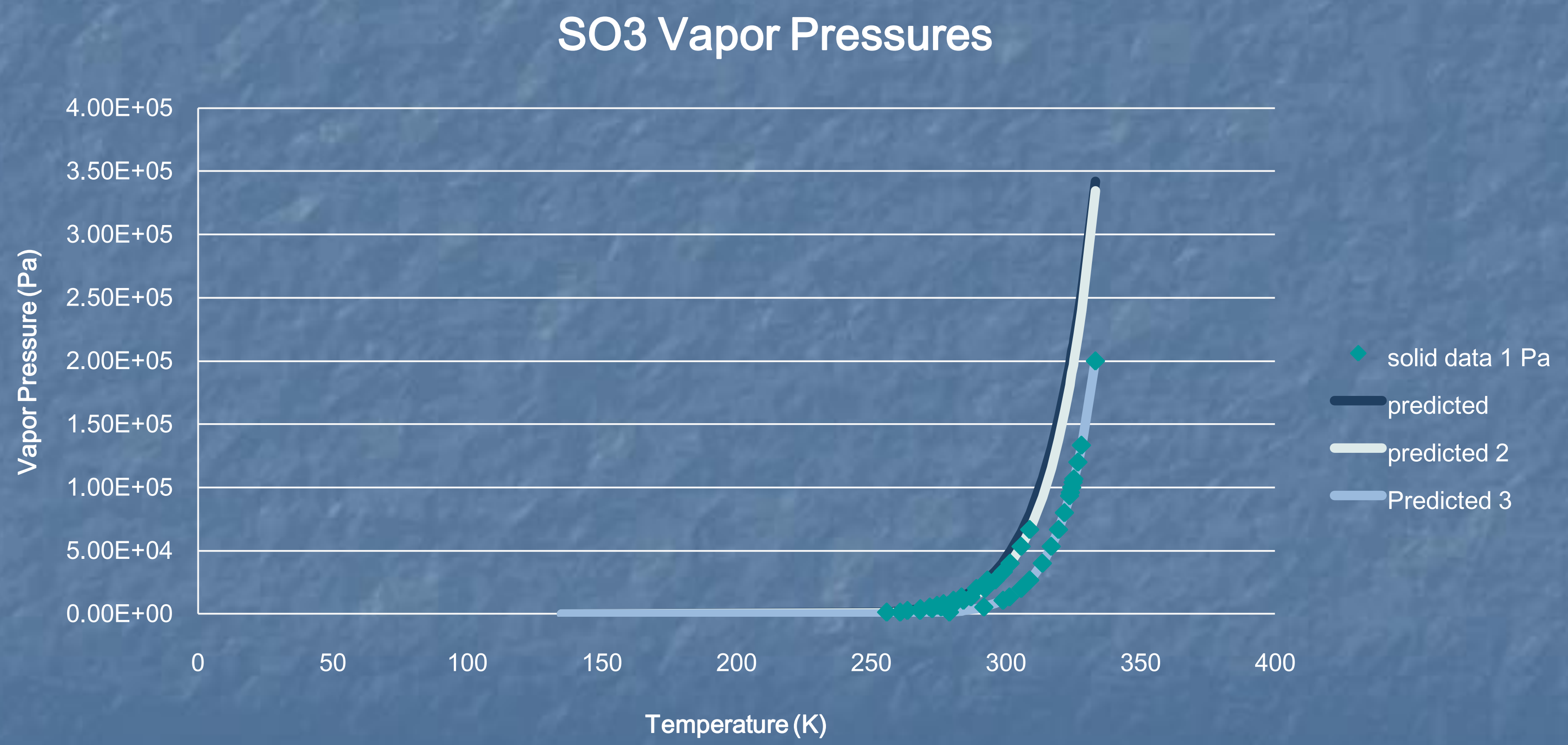

SO2 Predicted Data Using Solid Values
5000
4000
3000
2000
1000
0
Vapor Pressure (Pa)
0
50
100
150
200
250
Temperature (K)
solid data Pa
Predicted

SO2



The vapor pressure of solid SO2 predicted at 135 K is 0.0264 Pa

SO3

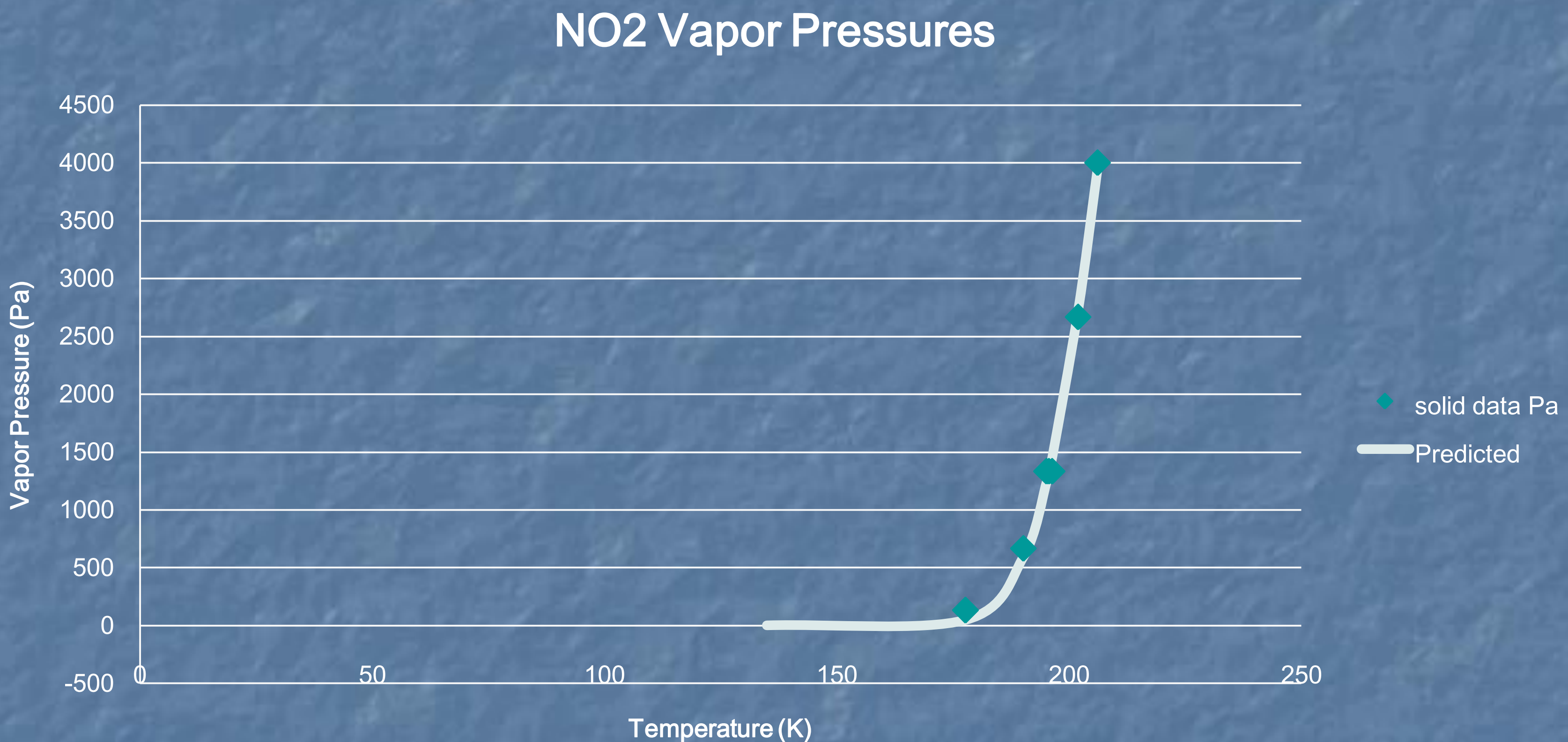


SO3 Vapor Pressures
Vapor Pressure (Pa)
4.00E+05
3.50E+05
3.00E+05
2.50E+05
2.00E+05
1.50E+05
1.00E+05
5.00E+04
0.00E+00
0
50
100
150
200
250
300
350
400
Temperature (K)
solid data 1 Pa
predicted
predicted 2
Predicted 3

SO3

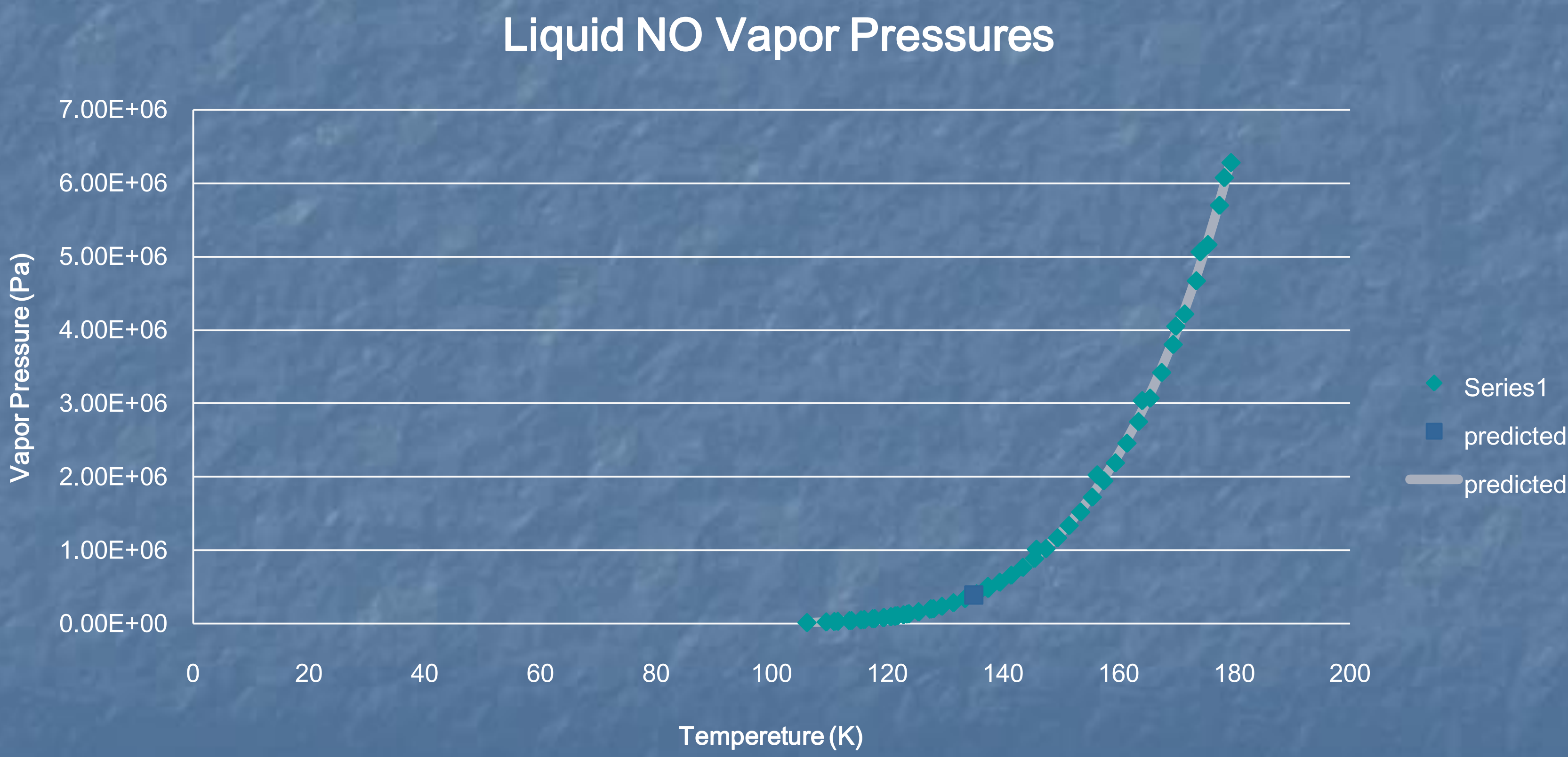
- Because it is hard to tell what the correlation is for solid vapor pressures, the estimates for all three follow
- The vapor Pressure of solid SO3 is 5.57E-07 Pa using the first method
- 1.75E-09 Pa using second method
- 6.06E-13 Pa using the third method
- As there are no data below 250 K for SO3 currently, these extrapolations will be far off

NO2



Vapor Pressure is predicted to be 1.30E-26 Pa

NO

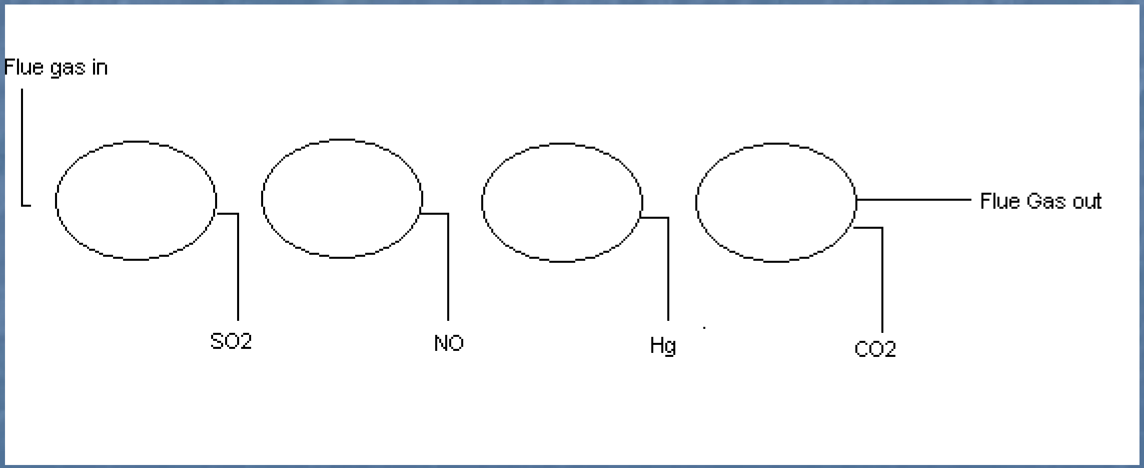

Liquid NO Vapor Pressures
7.00E+06
6.00E+06
5.00E+06
4.00E+06
3.00E+06
2.00E+06
1.00E+06
0.00E+00
Vapor Pressure (Pa)
0
20
40
60
80
100
120
140
160
180
200
Tempereture (K)
Series1
predicted
predicted

NO

- Because there are current data on NO at those temperatures, we can be fairly certain of the vapor pressure of NO
- The predicted vapor pressure of NO is 392626.4 Pa
- This is rather high, so NO would have to be removed by first converting to NO2

Big Picture

- Series of heat exchangers that would remove almost pure streams of SO2, SO3, NO2, and NO

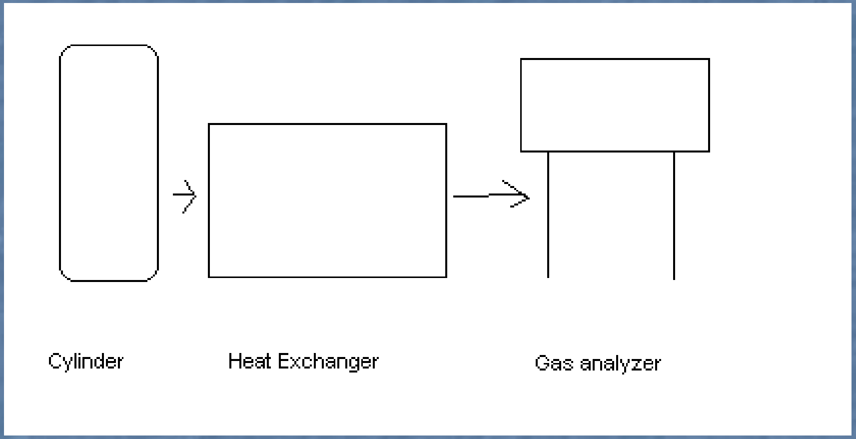


Experimental Equipment

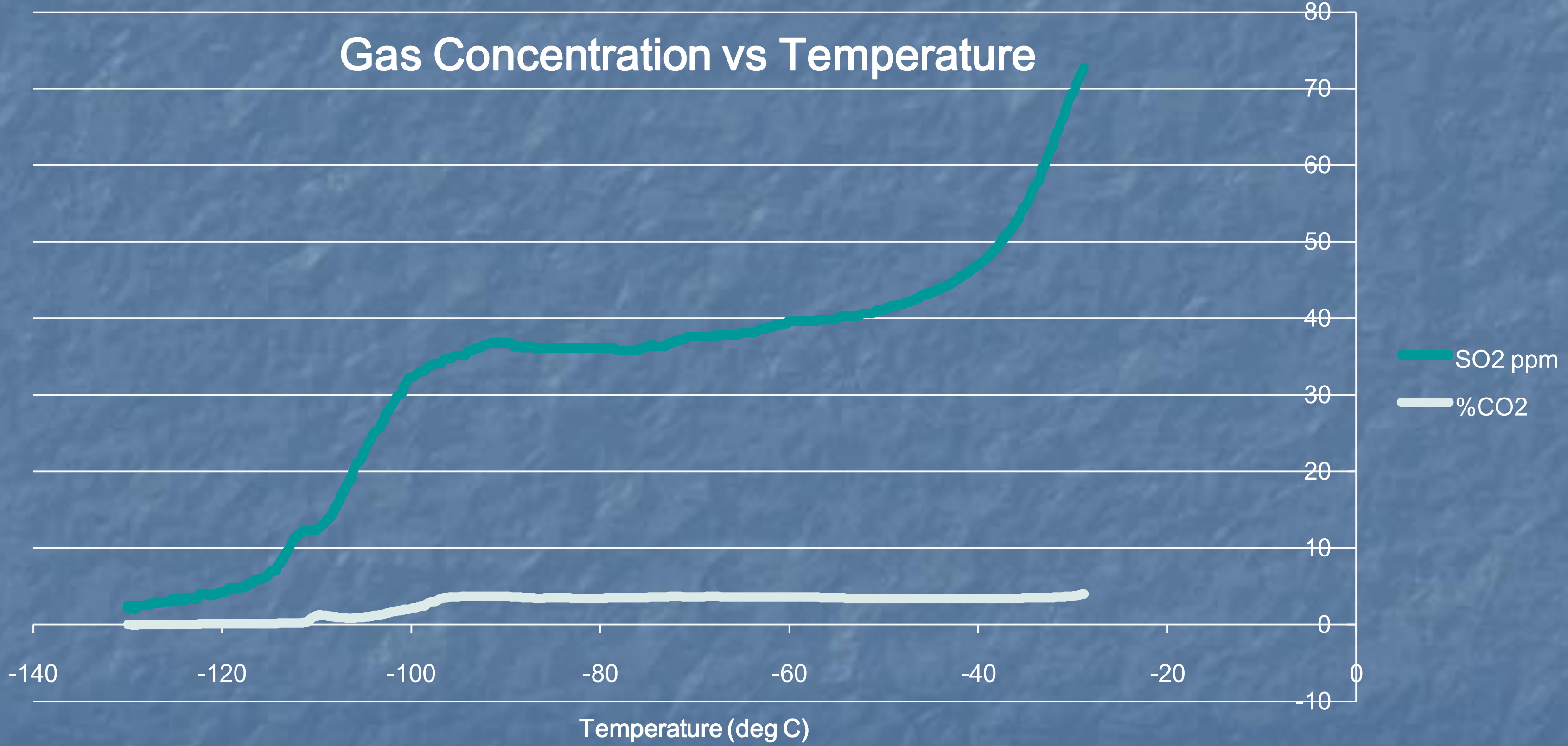
- Heat exchanger made of stainless steel ¼ in tubing
- Thermocouples and flow control meters controlled by Dac equipment
- Gas analyzer for CO2, NO, SO2

Experimental Set-up

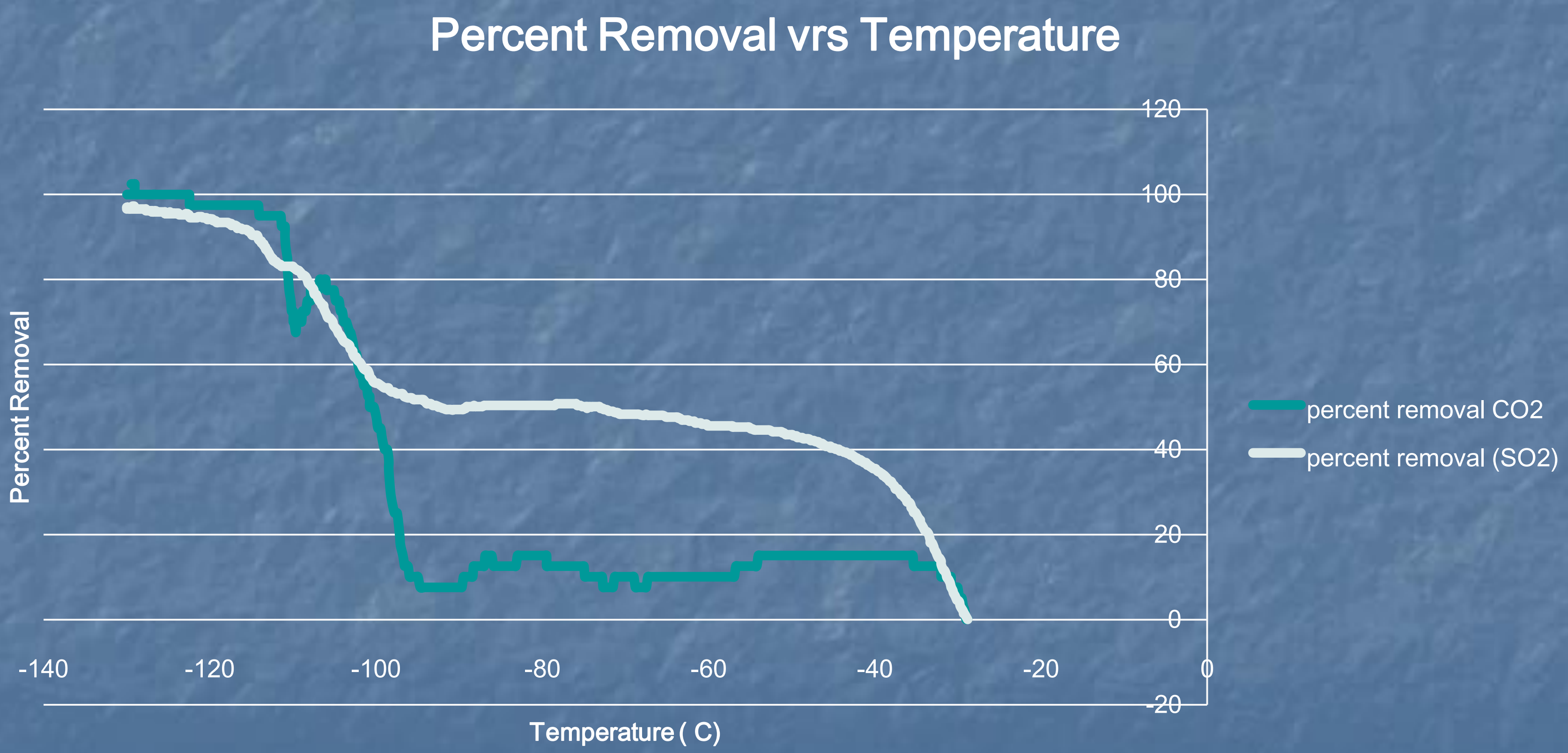
- Flue gas goes through heat exchanger cooled by liquid nitrogen
- Cooled to -130 ˚C
- Cooled gas goes through gas analyzer



Experimental Data



Experimental Data



Future Plans

- Currently waiting on Simulated flue gas cylinder for further experimentation
- Hope to be able to show more clearly the removal of SO_2, SO_3, NO_2, and NO