Multiple Atmospheric Gas Control in Walk-in Growth Chambers (Concurrent Additive CO_2 & SO_2 & Depleted O_2)

Presented to the…

NCERA-101

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on

Controlled Environment Agriculture

by Reg Quiring

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A unique and challenging project for Dr. Jennifier McElwain's

"Programme for Experimental Atmospheres and Climate"

College of Life Sciences - University College Dublin

University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

Dr. Jennifer McElwain

By studying the responses of plant biodiversity to a natural global warming event which occurred 200 million years ago, the researchers aim to understand how plants are likely to respond to the future effects of global warming. The findings will be used to inform conservation policy.

"We want to predict extinction proneness. To identify the type of ecology that is going to be more prone to extinction over the next one hundred years" says Dr Jennifer McElwain, who is leading the research.

"We are testing the hypothesis that fairly subtle changes in plant ecology and diversity contributed to a mass extinction of land animals which existed in the Triassic period," continues Dr McElwain. The research team will conduct experiments on 'living fossil plants' grown in simulated conditions to those which existed during the 'dawn of the dinosaurs,' 200 million years ago.

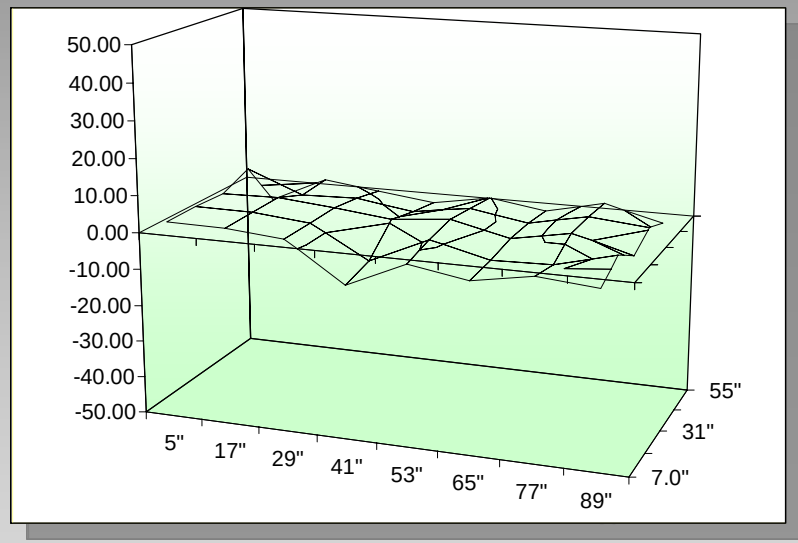
A new state-of-the-art plant growth room facility called PEAC (Programme for Experimental Atmospheres and Climate) has been constructed at UCD to provide the required environment. The facility was funded by a Marie Curie Excellence Grant and UCD College of Life Sciences.

Light Intensity and Uniformity

Specification: 1100 umols at 1 meter. Metal Halide - Dimming

Staggered MH start - minimizes start-up intensity.

Plus 3 levels supplementary tungsten incandescent.



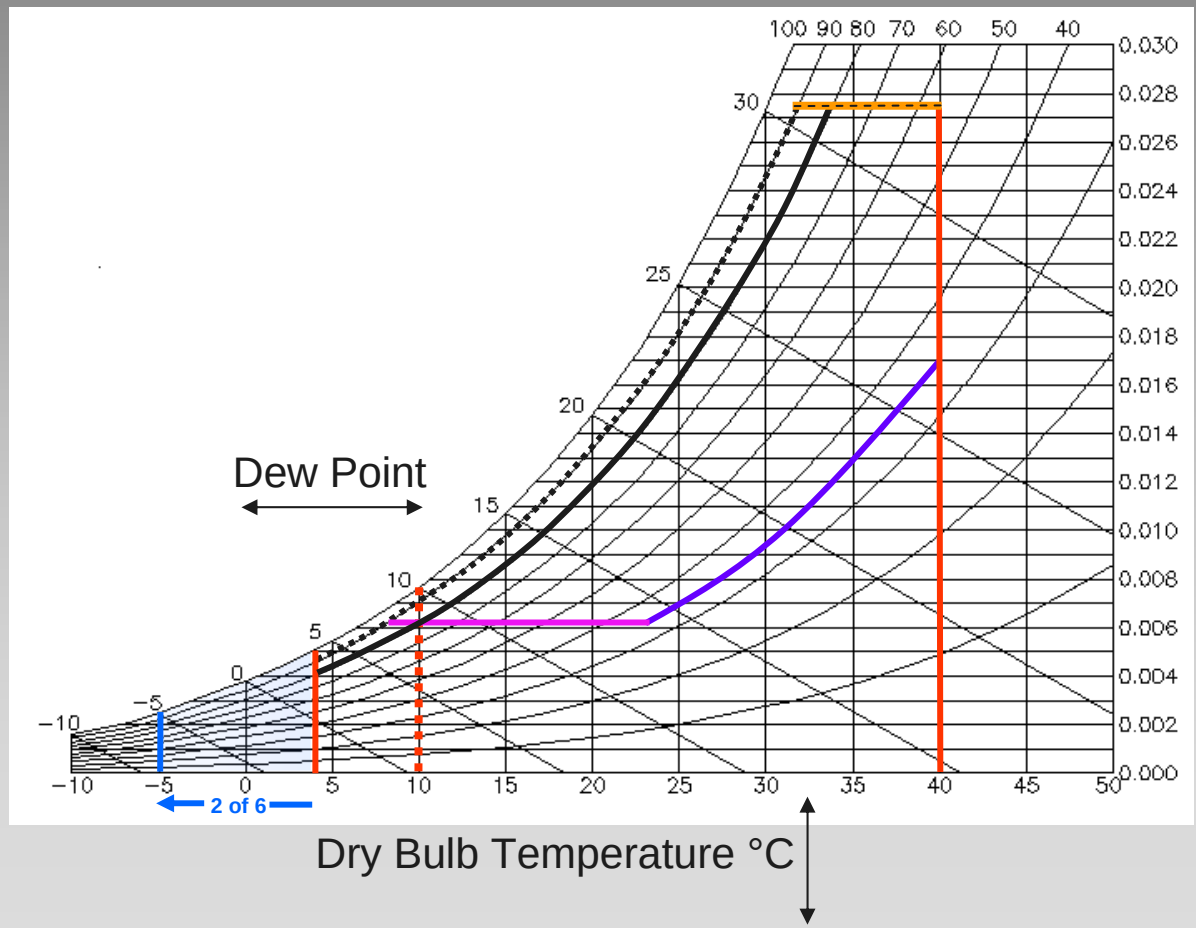
At 1m (39”) below the lamp barriers:

- **Average 40 points 1120 umols m^{-2} sec^{-1}**
- **Maximum Deviation** of any single point, **+5.28%**
- **Minimum Deviation** of any single point, **-8.37%**

Temperature & Humidity Range

Temperature Range

- 4°C L-Off to 40°C
- 10°C L-On to 40°C
- -5°C L-On/Off to 40°C (2 of 6 chambers)
- **Max. Moisture Content** 29°C dewpoint
- **Max. RH** 80% L-On
- **Max. RH** 90% L-Off
- **Min. RH** 35% L-On/Off
- **Min. Moisture Content** 7°C dewpoint




A Suite of 6 Walk-in Growth Chambers
Arranged In 3 Pairs w/Common Walls
Aisles Between Pairs
Model BDW40:
Interior Area 3.7 m²
Height 2.4 m
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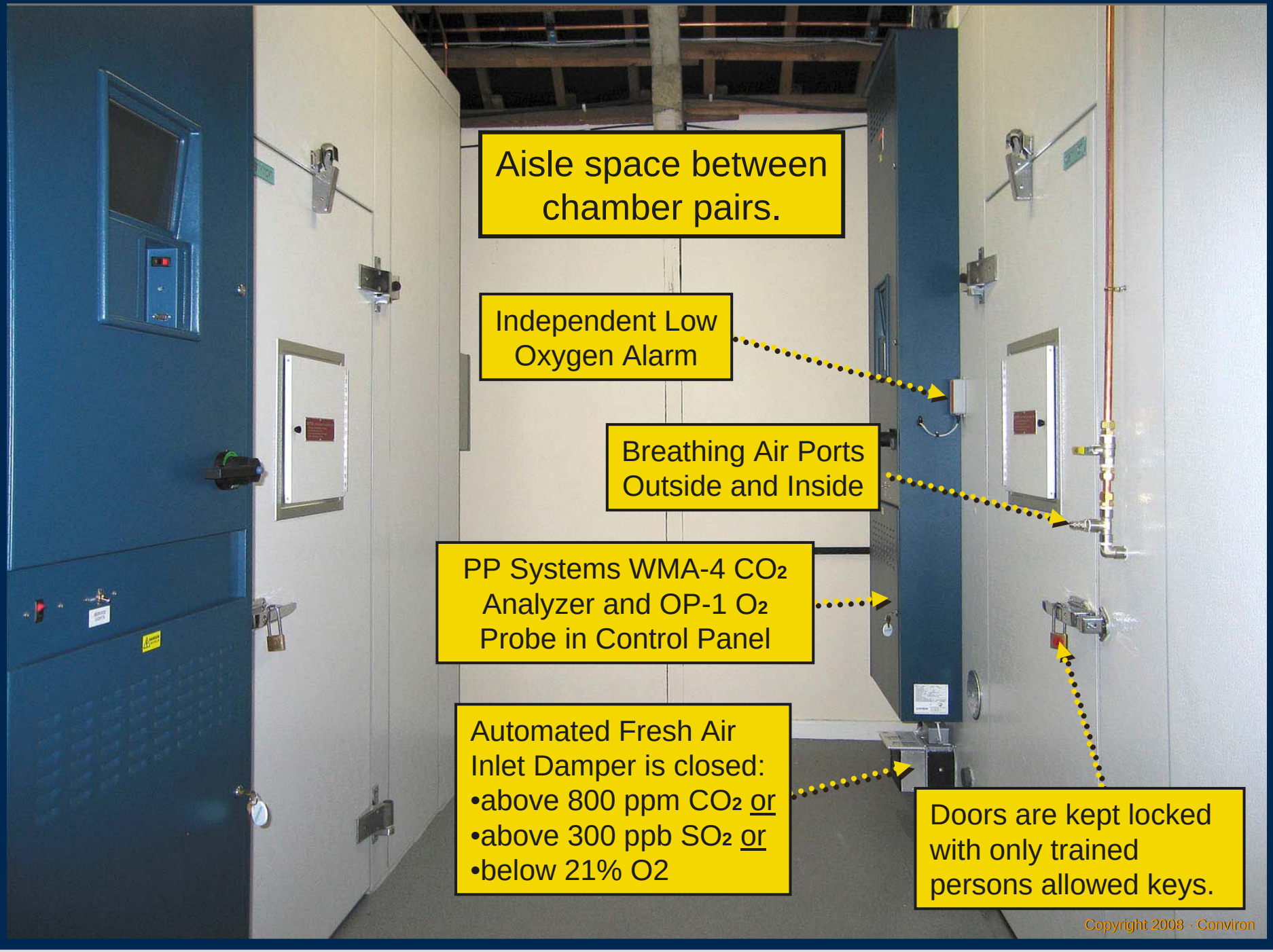
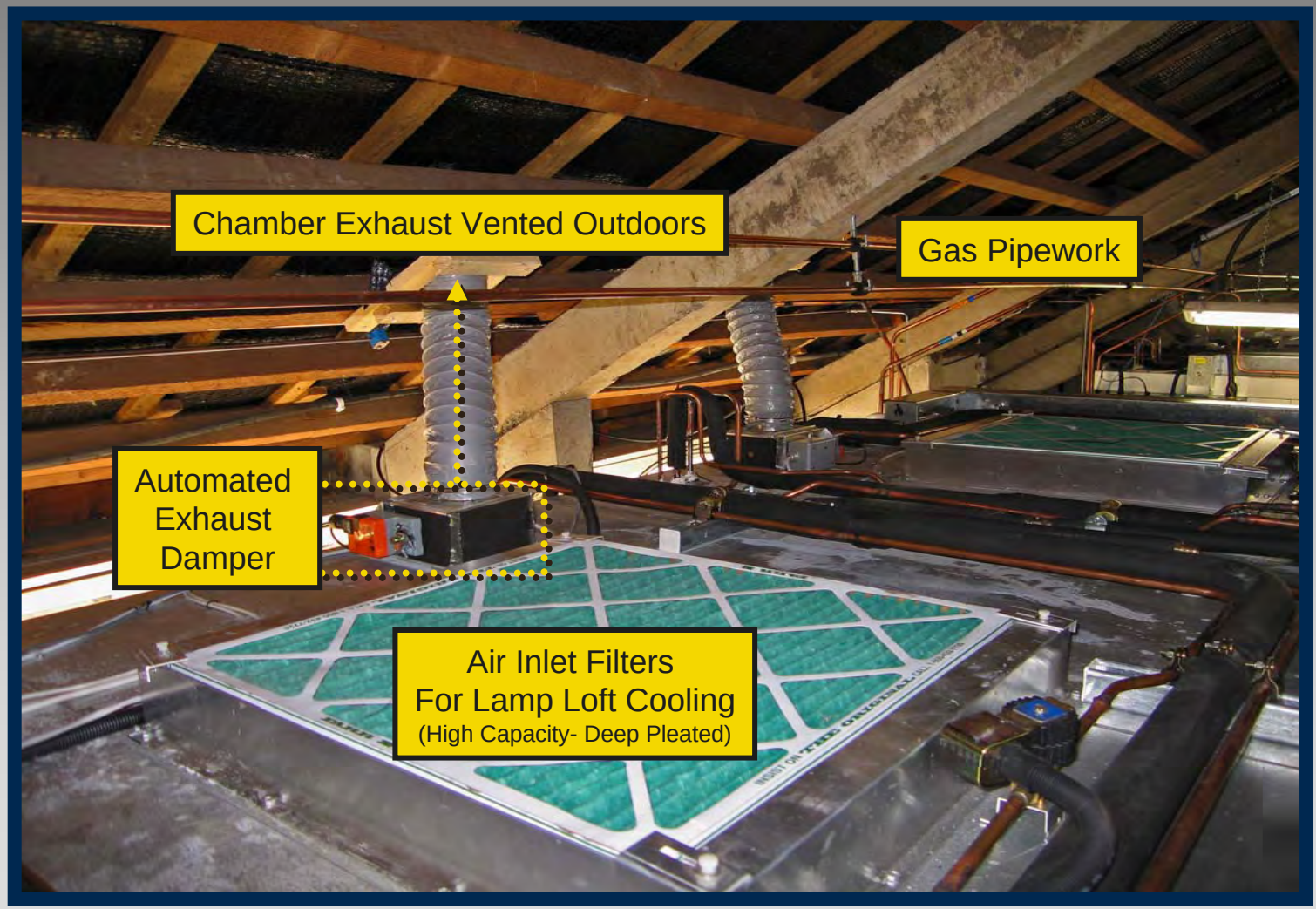


Ambient Air-cooled Lamp Lofts
(Waste Heat Warms Unheated Building)



Outdoor Air-cooled Refrigeration Units

(Variable Speed Fans – Quiet Operation)

Outdoor CO_2 Tank Array
(Two Banks of Three Tanks)

Outdoor SO_2 Tanks
(Single Tank w/Spare)

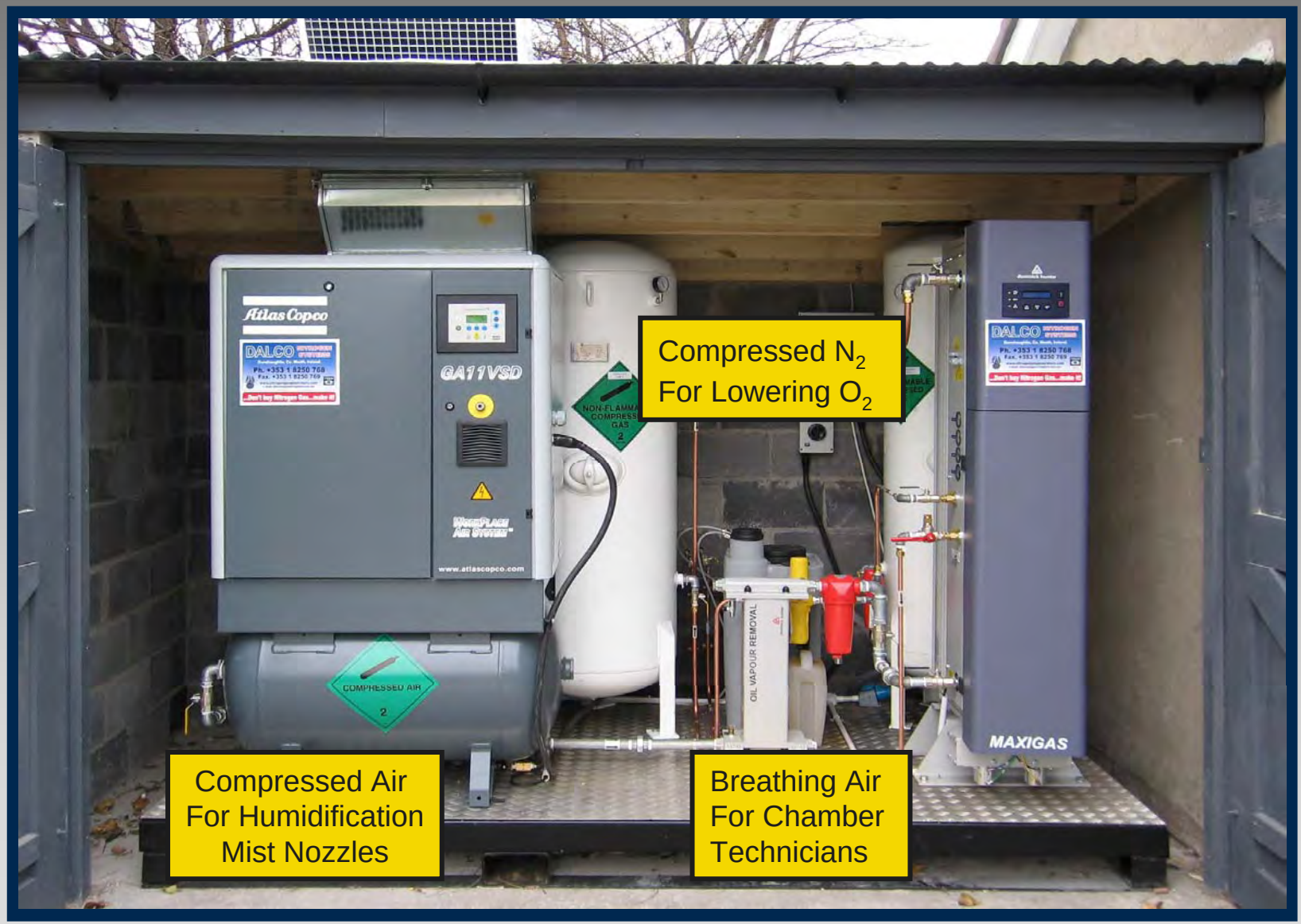
Pure SO_2 used for 1000-2000 ppb operation.

Dilute SO_2 used for <1000 ppb operation.

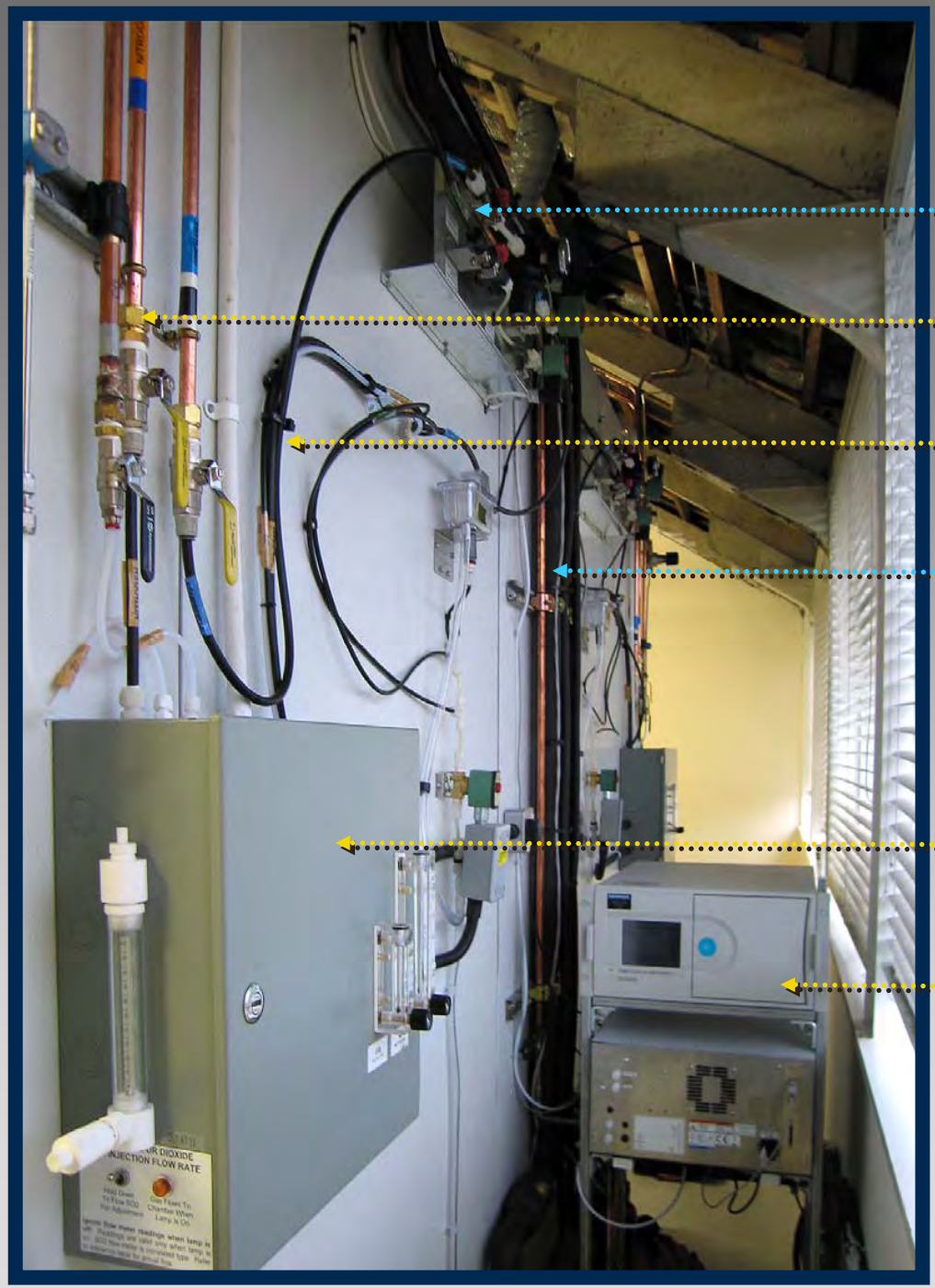
The lower concentration keeps minute injection rates in a range that enables stable control.

Nitrogen Generator

Compressed Air Driven - Molecular Sieve



Rear Utility Area



Additive RH Module

Gas Supply Lines

Gas Injection Tubes

Refrigeration Lines

Gas Control Solenoids & Flow Meters

SO_2 Gas Analyzers Horiba APSA-370

CO_2 & N_2 Injection

(all 6 chambers)

- Pure N_2 injected to reduce atmospheric O_2 concentration to as low as 13%.
- Achieved stability: +/-0.1%

- Pure CO_2 injected to increase concentration up to 2000 ppm.
- Achieved stability: +/-10 ppm

All levels achieved with a nominal chamber leakage rate of 1 air change per hour with fresh air and exhaust dampers closed.

SO_2 Injection
(3 of 6 chambers)

Pure SO_2 injected to increase concentration up to 2000 ppb.

Significant challenges in achieving repeatable stable control due to:

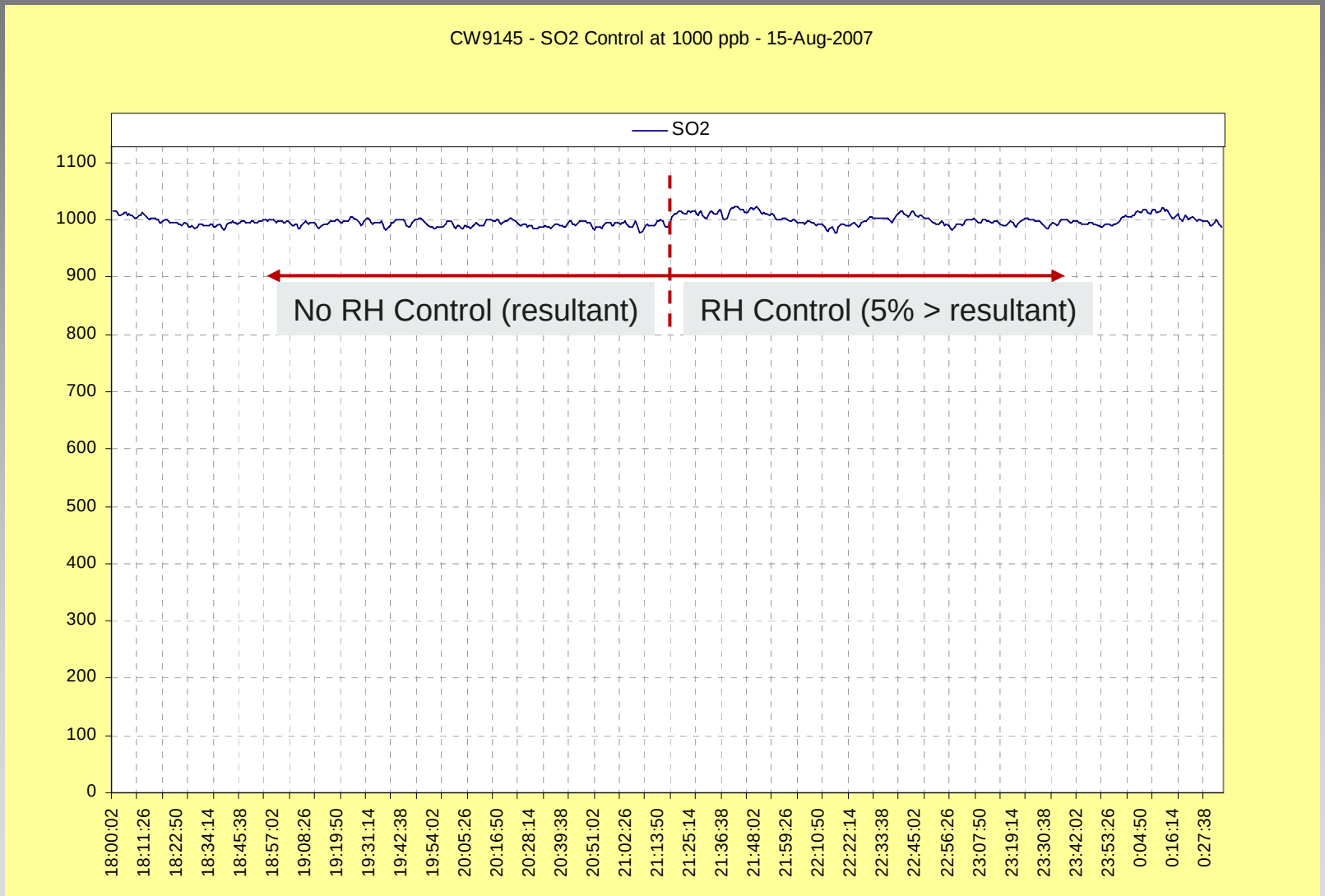
- Slow response of analyzer… T90=120 sec.
- Very low injection rate of pure SO_2 required to hold 2000 ppb (in the order of 1.5 ml min^{-1}).
- Absorption of SO_2 gas by humidification mist.
- Set points much below 1000 ppb require the use of dilute SO_2 to be practical.

Proprietary control algorithm operation via SO_2 resistant solenoid valve.

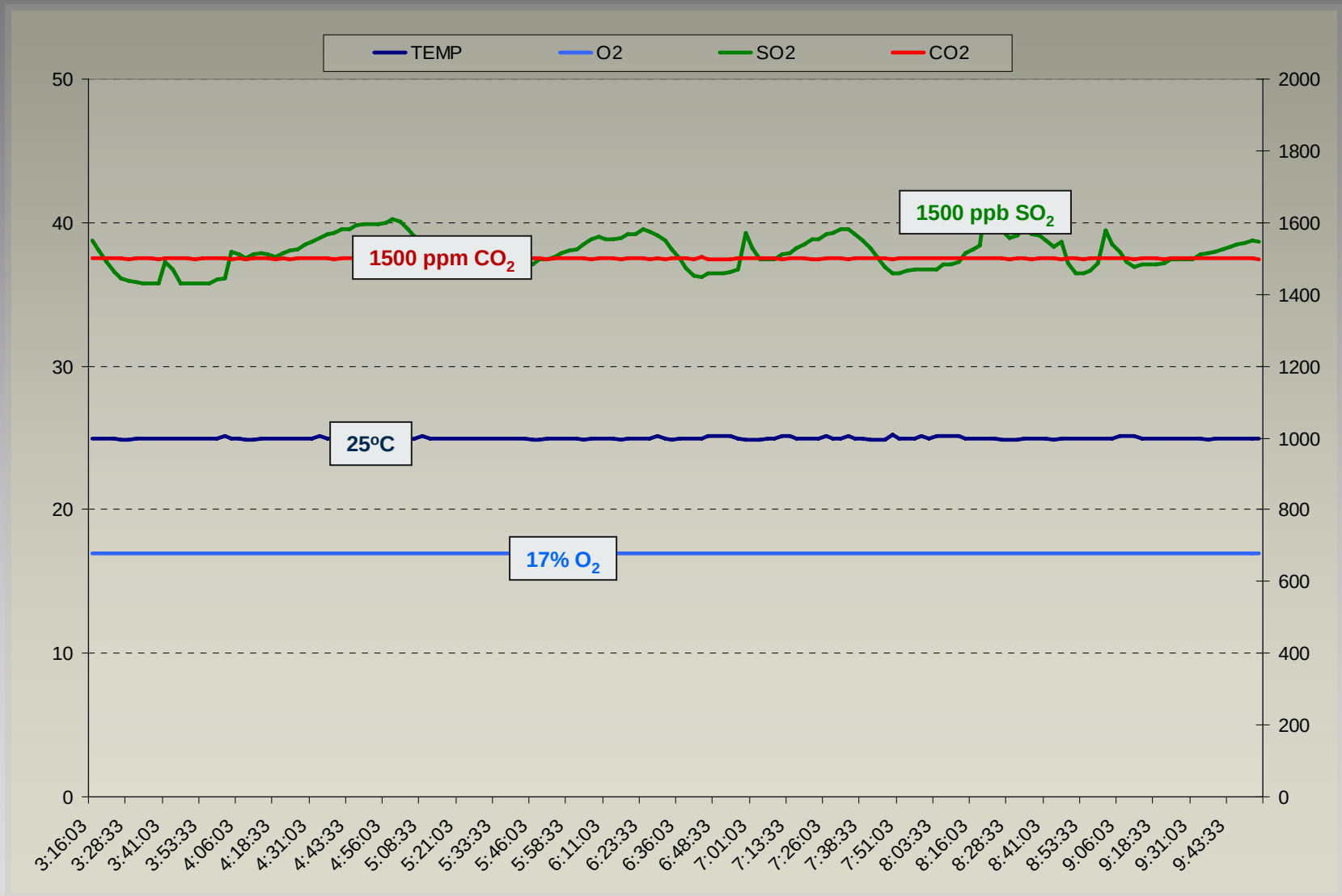
Achieved stability: +/-8% of set point >1000ppb

+/-10% of set point <1000ppb

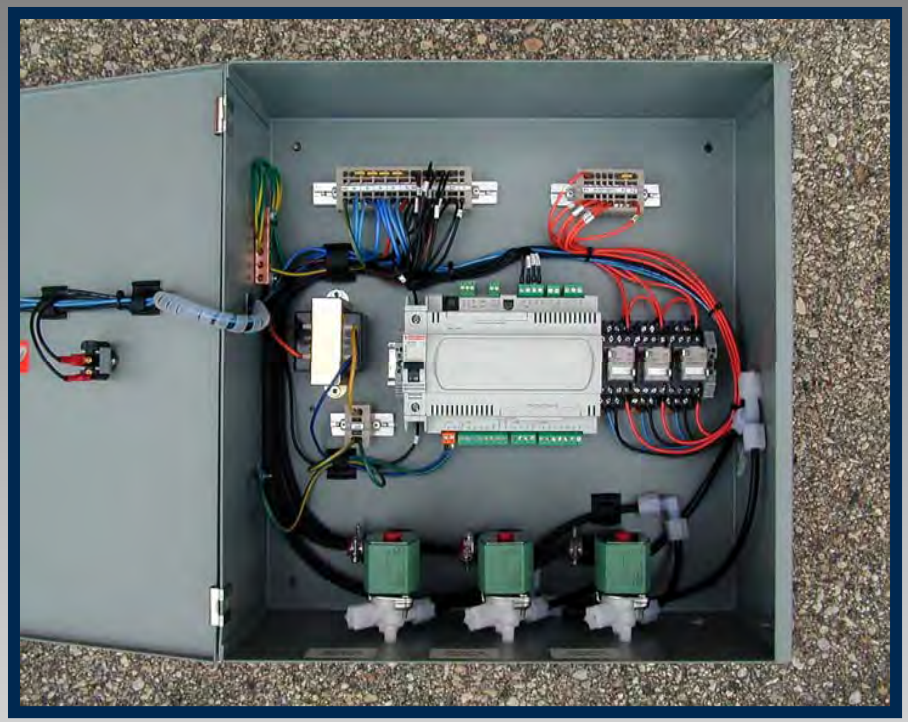
SO_2 Control Stability



CO2 / O2 / SO_2 Control Stability



SO_2 Monitoring
(3 of 6 chambers)



Purpose-built 3 channel gas sampling sequencer

Uses only a single costly analyzer with sequential sampling of chamber background SO_2 as a control against the 3 actively controlled chambers.

Slow response of SO_2 analyzer required:

- Custom designed sample multiplexer to draw a sample from each chamber for 10 minutes.
- Software “sample and hold” function in the chamber controllers.
- The background SO2 concentration in these 3 chambers is accurately recorded and updated every 30 minutes which easily exceeded the interval required.

The End