Engineering Services Contract

Partnering To Engineer the Future

# A regenerable VOC control system (RVCS) for characterizing properties of sorbents used in separation technologies


Sara D. Nolek

Oscar A. Monje

*ESC - Team QNA*

*Space Life Sciences Laboratory*

*Kennedy Space Center, FL 32899*


Team QinetiQ North America

© QinetiQ North America, Inc. 2010

# Introduction

Partnering To Engineer the Future

## Bed and System Design

## Methods

- Thermal Regeneration
- Static Adsorption Test
- Pressure Swing Adsorption and Regeneration

## Testing

## Discussion

- Adsorptive Capacities
- Roll-over Effect

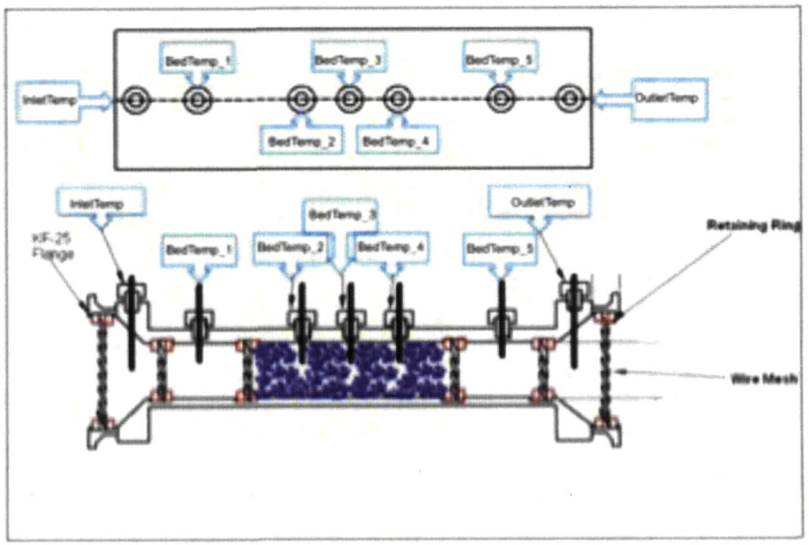
## Conclusions

Team QinetiQ North America

© QinetiQ North America, Inc. 2010

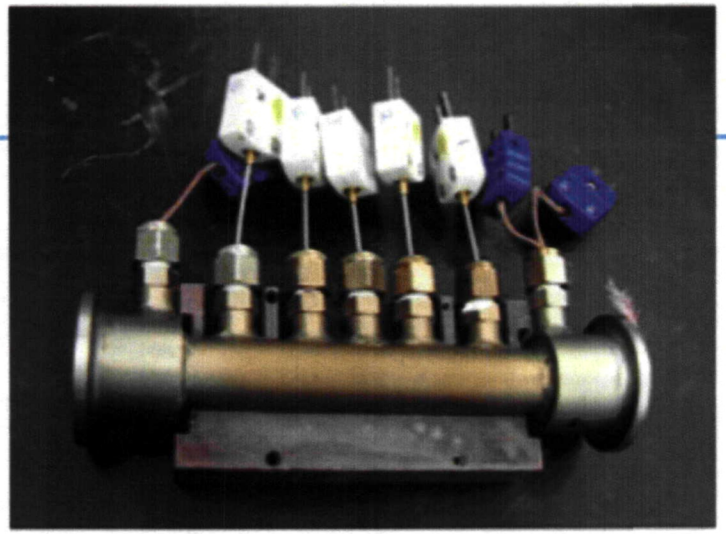
# Bed design

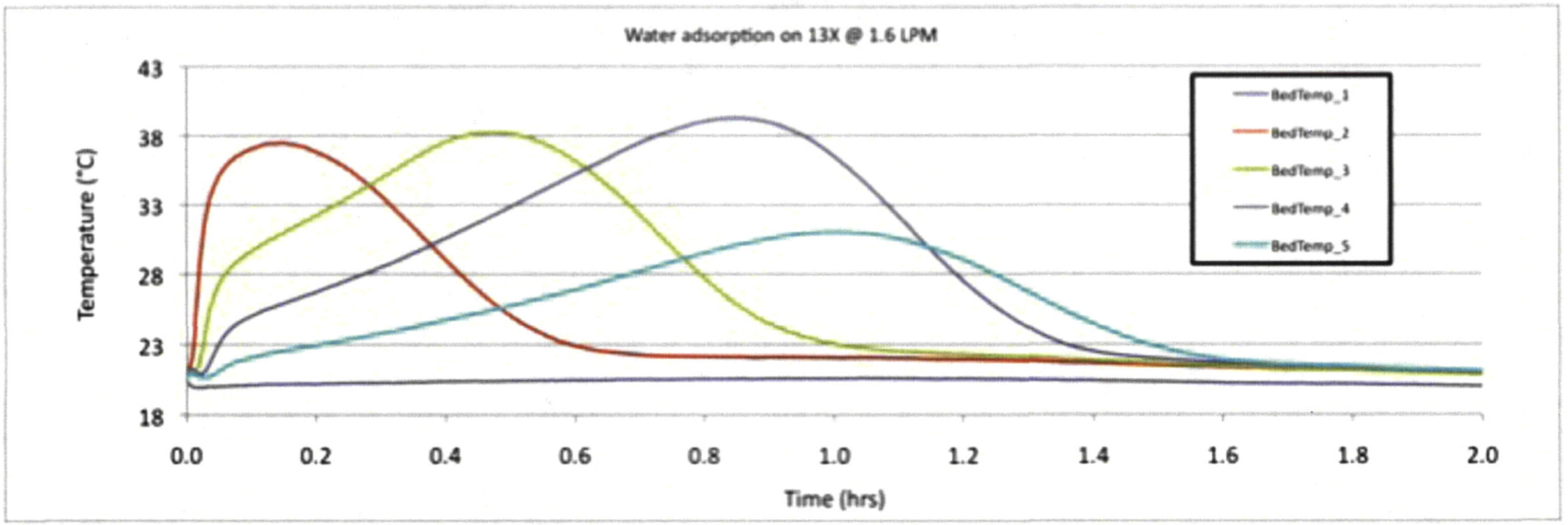
- 2 bed diameters
  - Adjust contact times with gas stream flowrate and bed diameter
- Measurements
  - Temperature
    - 25%, 50%, 75% length of bed
    - Inlet/outlet
  - Humidity
    - Inlet/outlet
  - Pressure
    - Inlet/outlet




Team QinetiQ North America

© QinetiQ North America, Inc. 2010





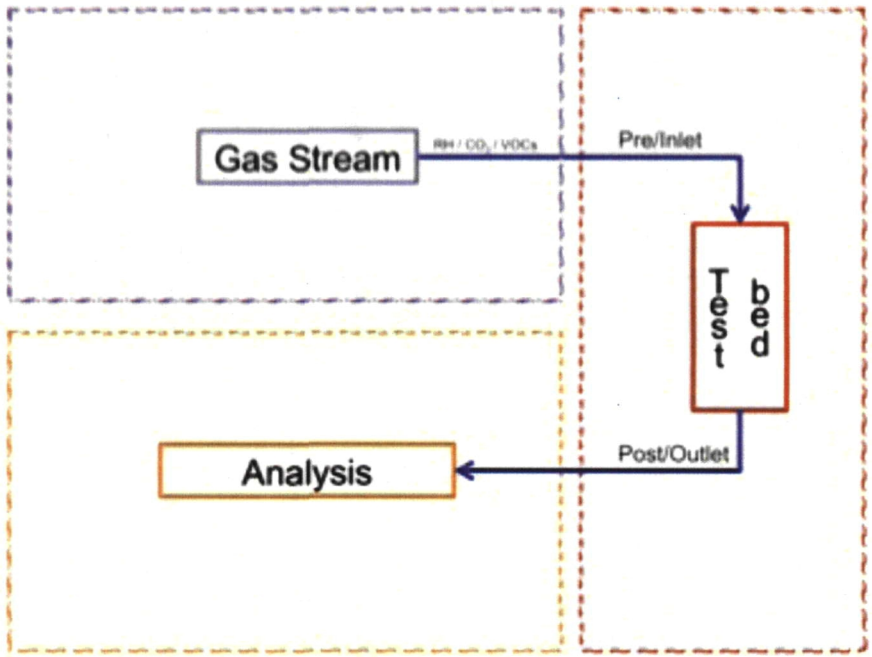

Partnering To Engineer the Future

Team QinetiQ North America

© QinetiQ North America, Inc. 2010

# System Design

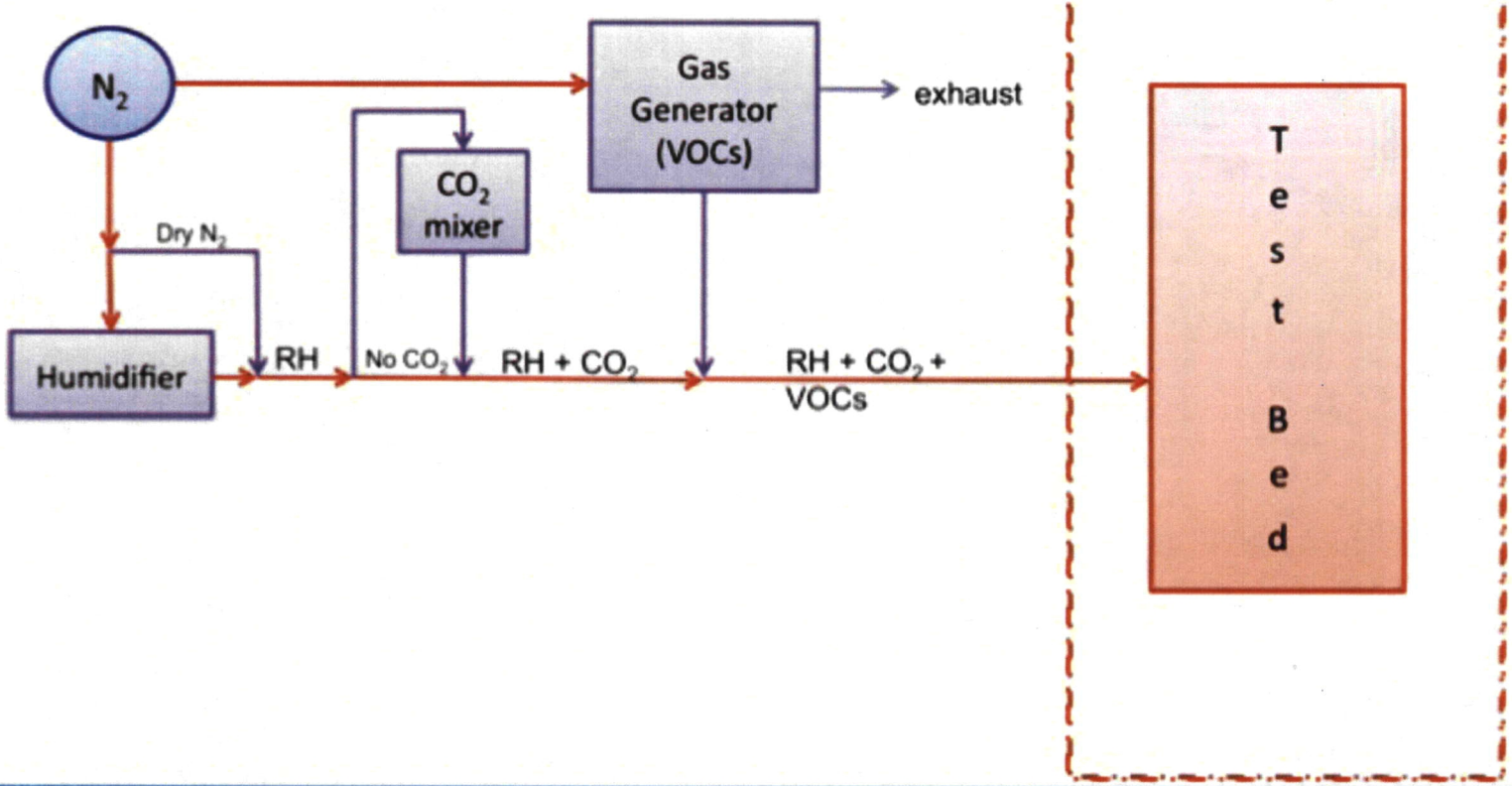
- Gas stream
- Operation through test bed
- Analysis
  - FTIR
  - GC
  - Dewpoint hygrometer
  - $CO_2$, P, T, Rh sensors
  - Datalogger




Team QinetiQ North America

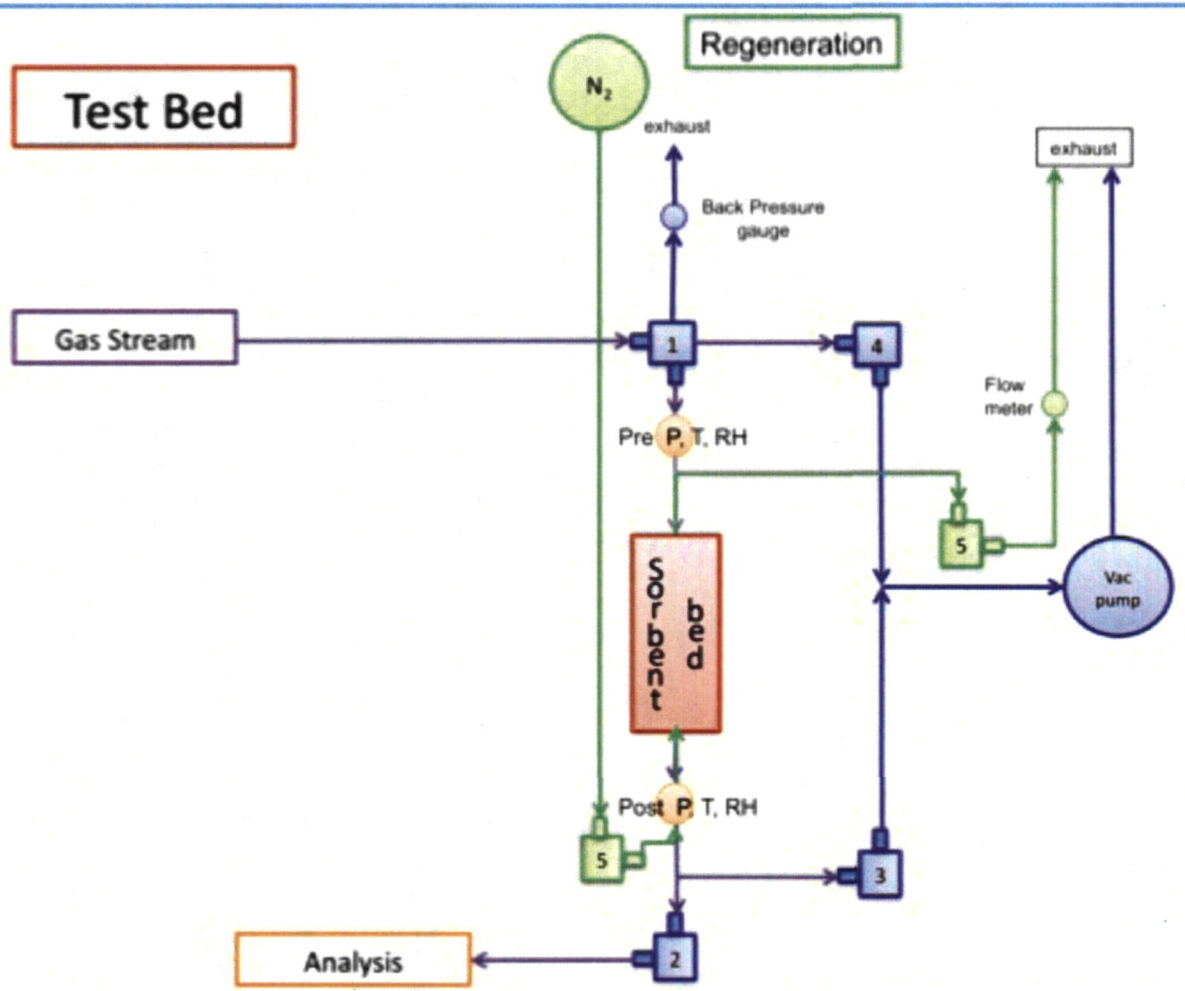
© QinetiQ North America, Inc. 2010

# Gas Stream





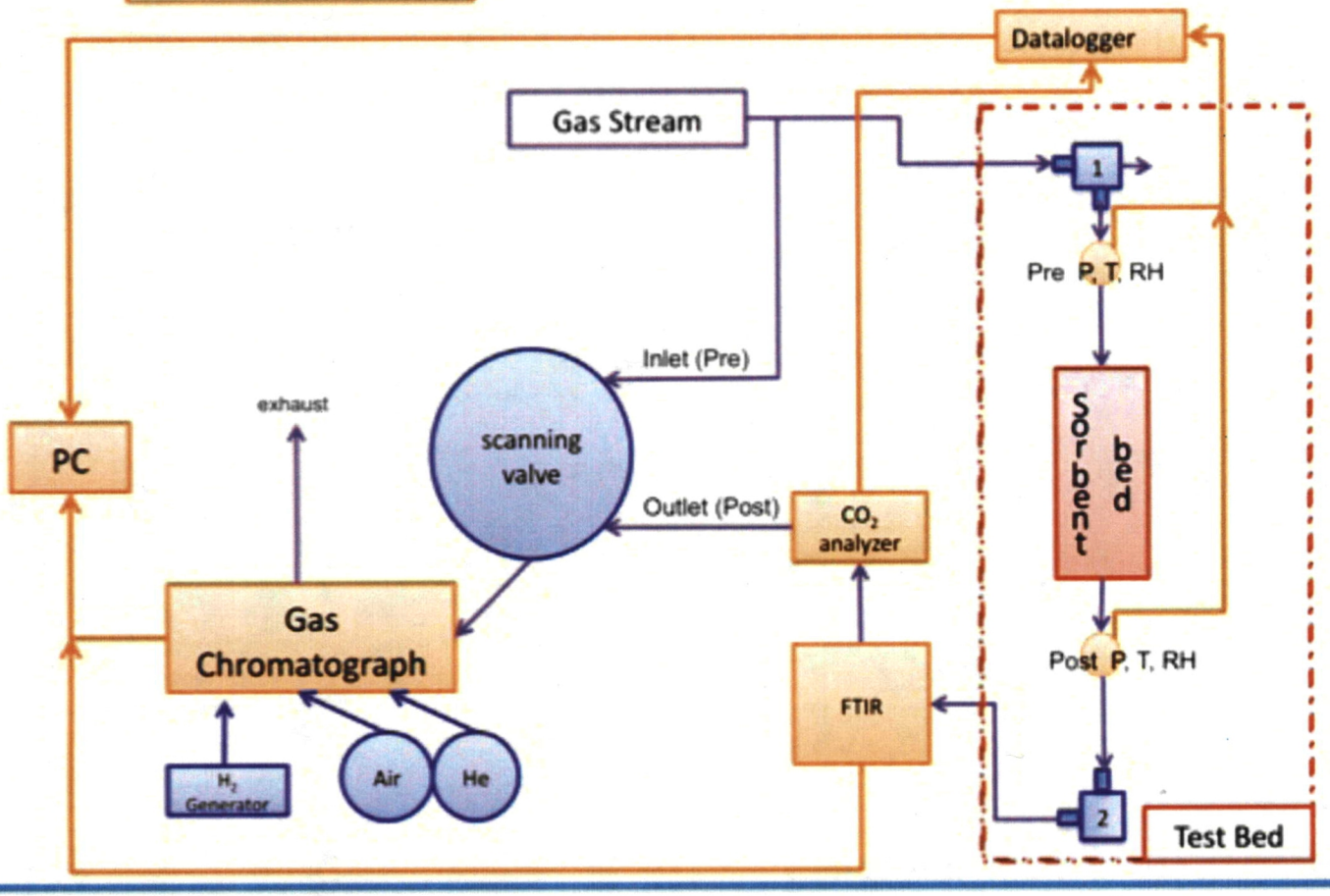

© QinetiQ North America, Inc. 2010





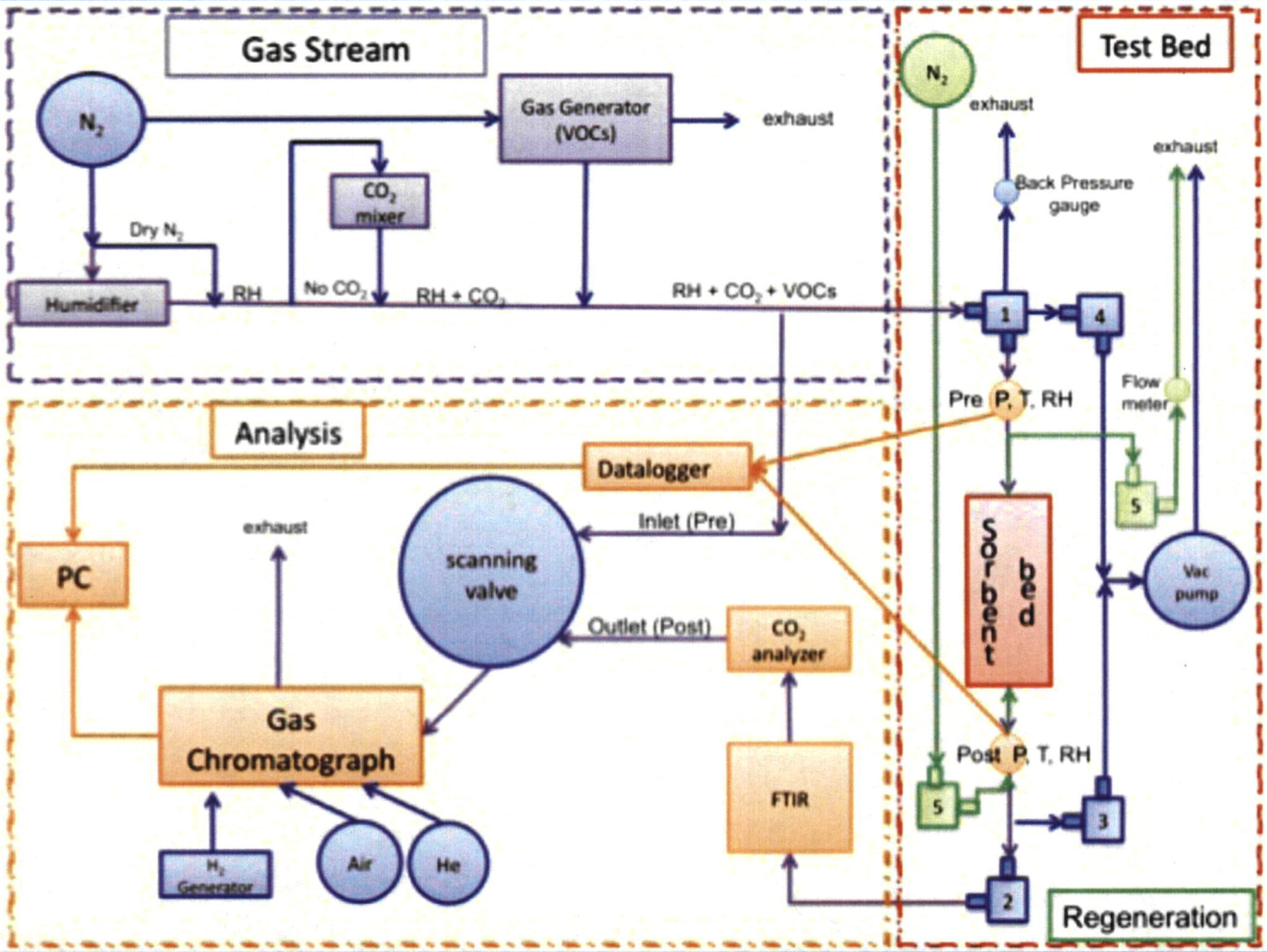

© QinetiQ North America, Inc. 2010

# Analysis




Team QinetiQ North America

© QinetiQ North America, Inc. 2010

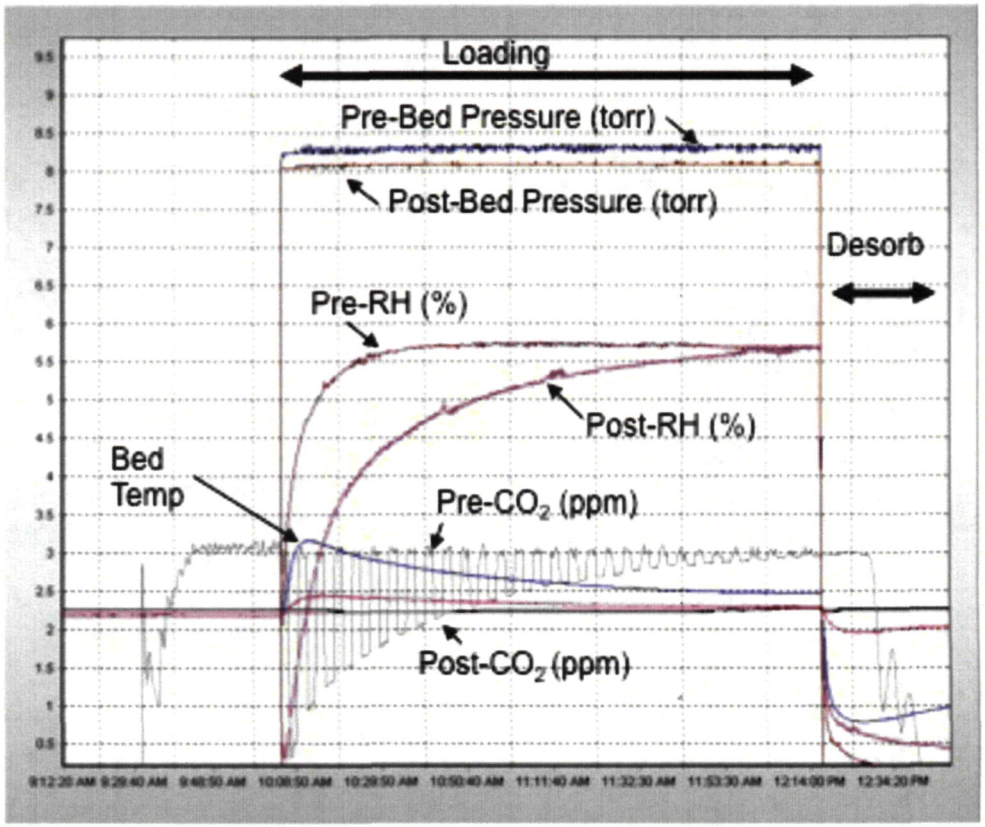



Team QinetiQ North America

© QinetiQ North America, Inc. 2010

# Methods cont.

- Static adsorption test
  - Simulated spacecraft gas stream
    - 6000 ppm $CO_2$
    - 52% Relative Humidity
    - 1-5 ppm VOC
    - 23°C ambient temperature



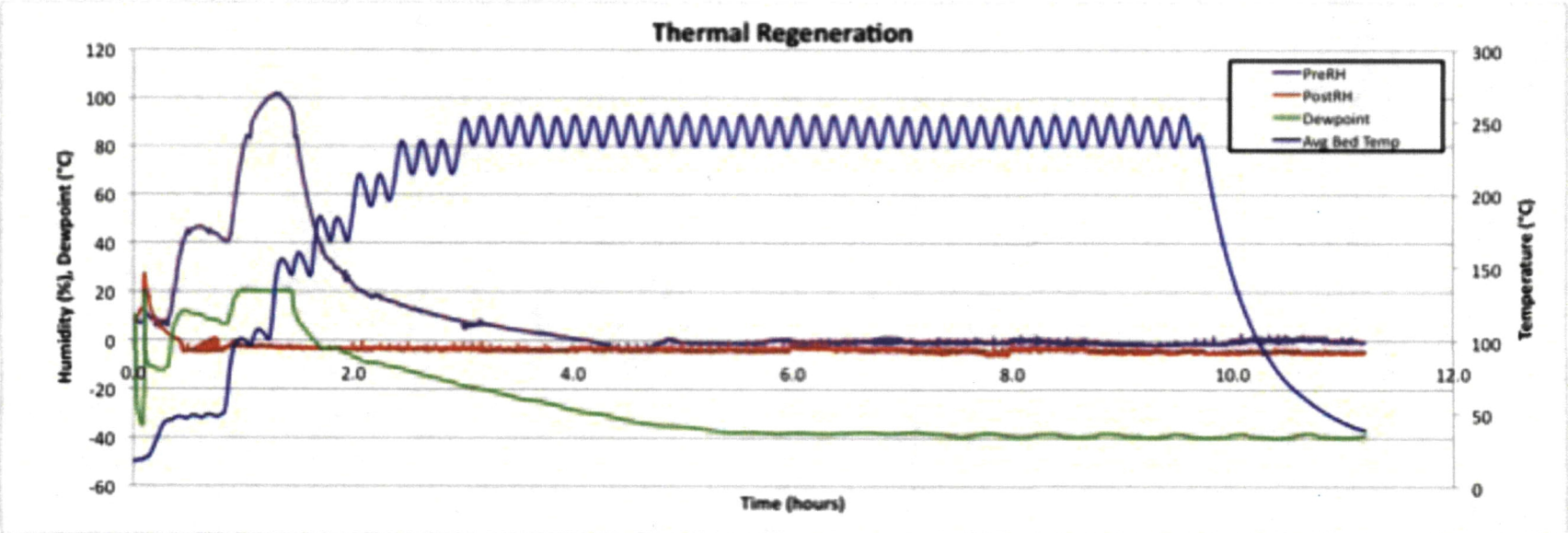

Typical data set collected in the RVCS during a static test measuring breakthrough curves of $CO_2$ and water vapor

Team QinetiQ North America

© QinetiQ North America, Inc. 2010

# Methods

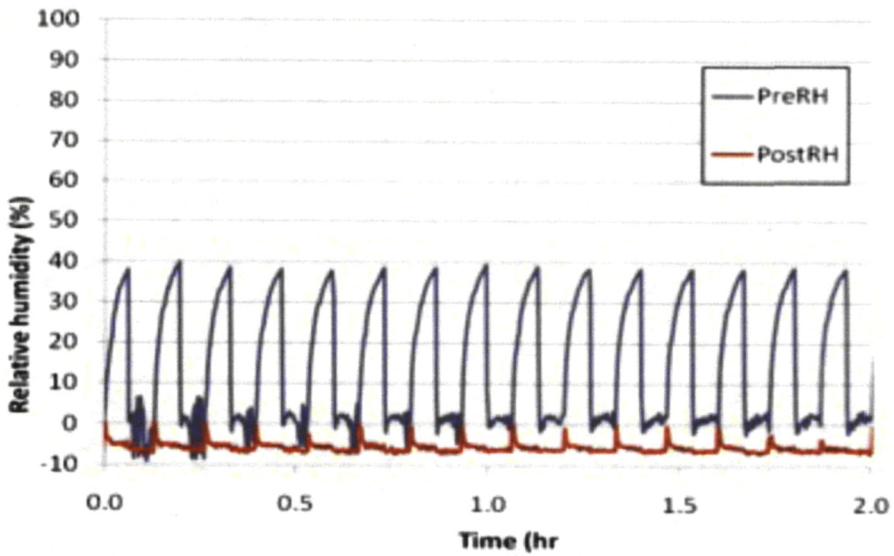
- Thermal regeneration
  - Zeolites require high temperature for desorption (>300°C)
  - Heating system designed/built for high temperature but also ability to hold stable at intermediate temperature
  - Reverse flow sweep gas




© QinetiQ North America, Inc. 2010

# Methods cont.

- PSA (Pressure Swing Adsorption)
  - <0.5 Torr (0.04 kPa) vacuum
  - Capability to cycle at integral minute intervals




Inlet (PreRH) and outlet (PostRH) relative humidities of a Zeolite 13X bed undergoing 8 min PSA cycles. The bed kept the air exiting the bed dry.

Team QinetiQ North America

© QinetiQ North America, Inc. 2010

# Testing

- Flow rate/carrier gas/pre & post accuracy
  - Does $N_2$ compete with the $CO_2$ or the VOC adsorption?
    - Test with He vs. $N_2$ as carrier gas
  - Does the flow rate affect the $CO_2$ breakthrough or VOC adsorption?
    - Test with higher flow vs. lower flow
  - Is the carryover from previous measurement enough to skew results?
    - Test "stickiness" of VOC for pre/post concentration error



© QinetiQ North America, Inc. 2010

# Testing cont.

- What are the effects of
  - Single VOC on $CO_2$ adsorption/$CO_2$ on VOC adsorption?
  - Water on $CO_2$ adsorption?
  - Water on VOC adsorption/VOC on water adsorption?
  - Adsorption effects of multiple VOCs?
- Comparison with adsorption models



© QinetiQ North America, Inc. 2010

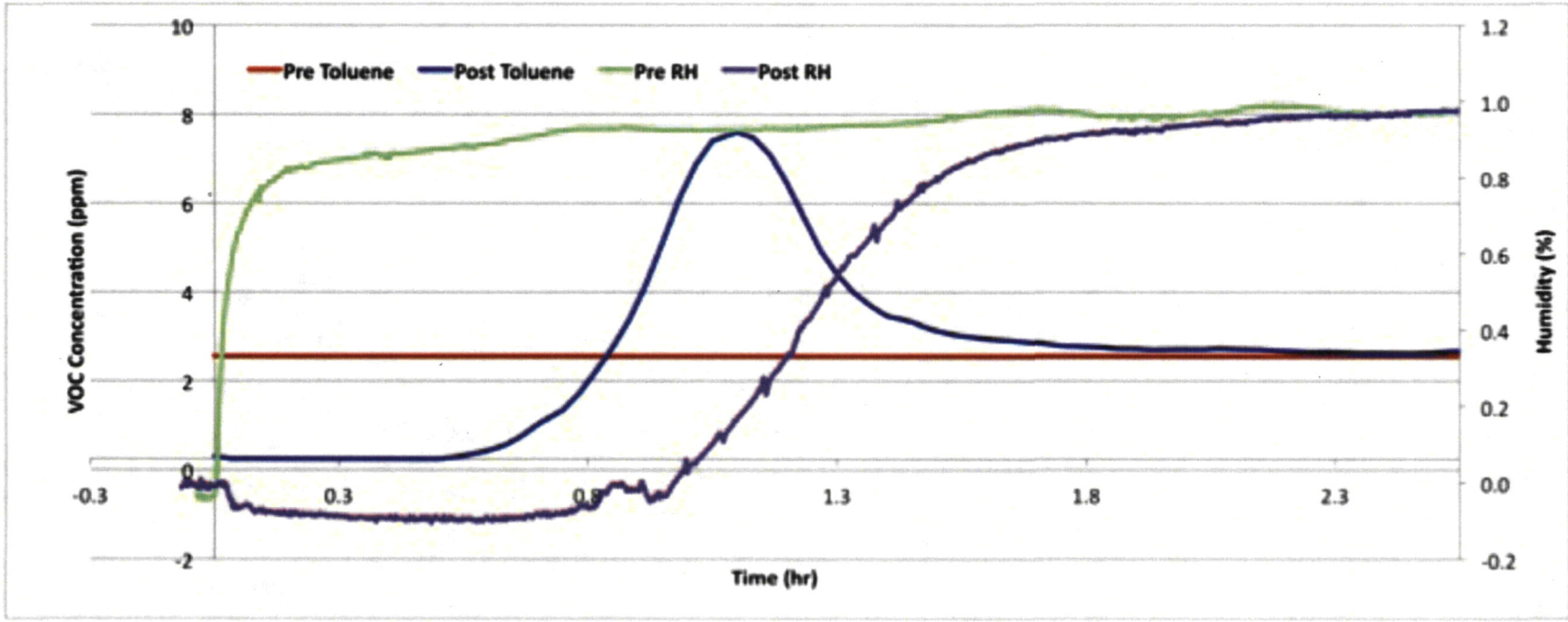
# Discussion

- Adsorptive capacities
- Rollover effect
- Stickiness of VOCs to system components
- Small diameter sorbents (powder)



© QinetiQ North America, Inc. 2010

# Adsorptive capacity and rollover effect




Breakthrough curve of toluene + water. Once water begins to breakthrough, roll-over of toluene is observed as the water displaces the adsorbed toluene off the bed.

Team QinetiQ North America

© QinetiQ North America, Inc. 2010

# Conclusions


- Recap of system uses
- Correlation with models
- Future capabilities to be added

Team QinetiQ North America

© QinetiQ North America, Inc. 2010

## Acknowledgement


- Support of this research was provided by NASA's Exploration Life Support and Habitation Systems Project– Atmosphere Revitalization Element and NASA's ISS research.




© QinetiQ North America, Inc. 2010