National Aeronautics and
Space Administration

John F. Kennedy Space Center

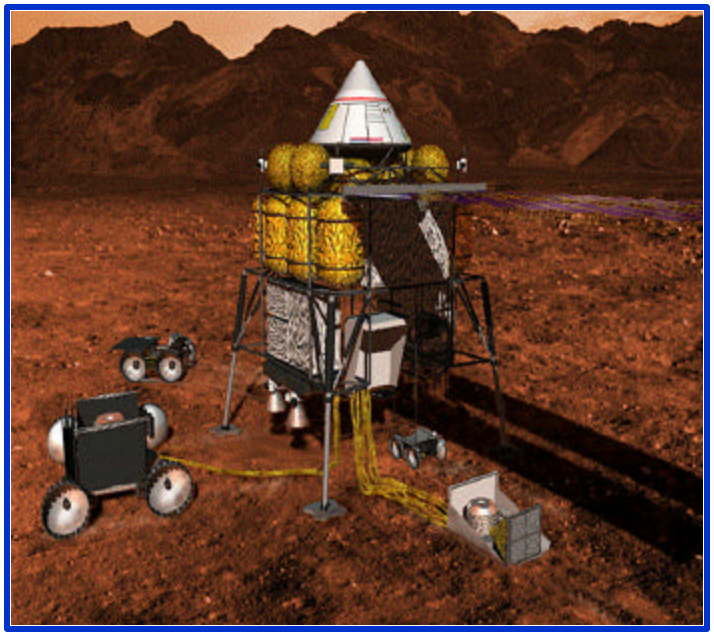
SPACEPORT ENGINEERING AND TECHNOLOGY

Processing With Mars Gases

Clyde Parrish, Senior Chemist
Engineering & Science Division
Kennedy Space Center, FL

Paul Jennings, Chairman Chemical Engineering
Florida Institute of Technology
Melbourne, FL

Acknowledgement:
Ron Barile, Paul Gamble, Lilly Fitzgerald
Dynacs Engineering Company



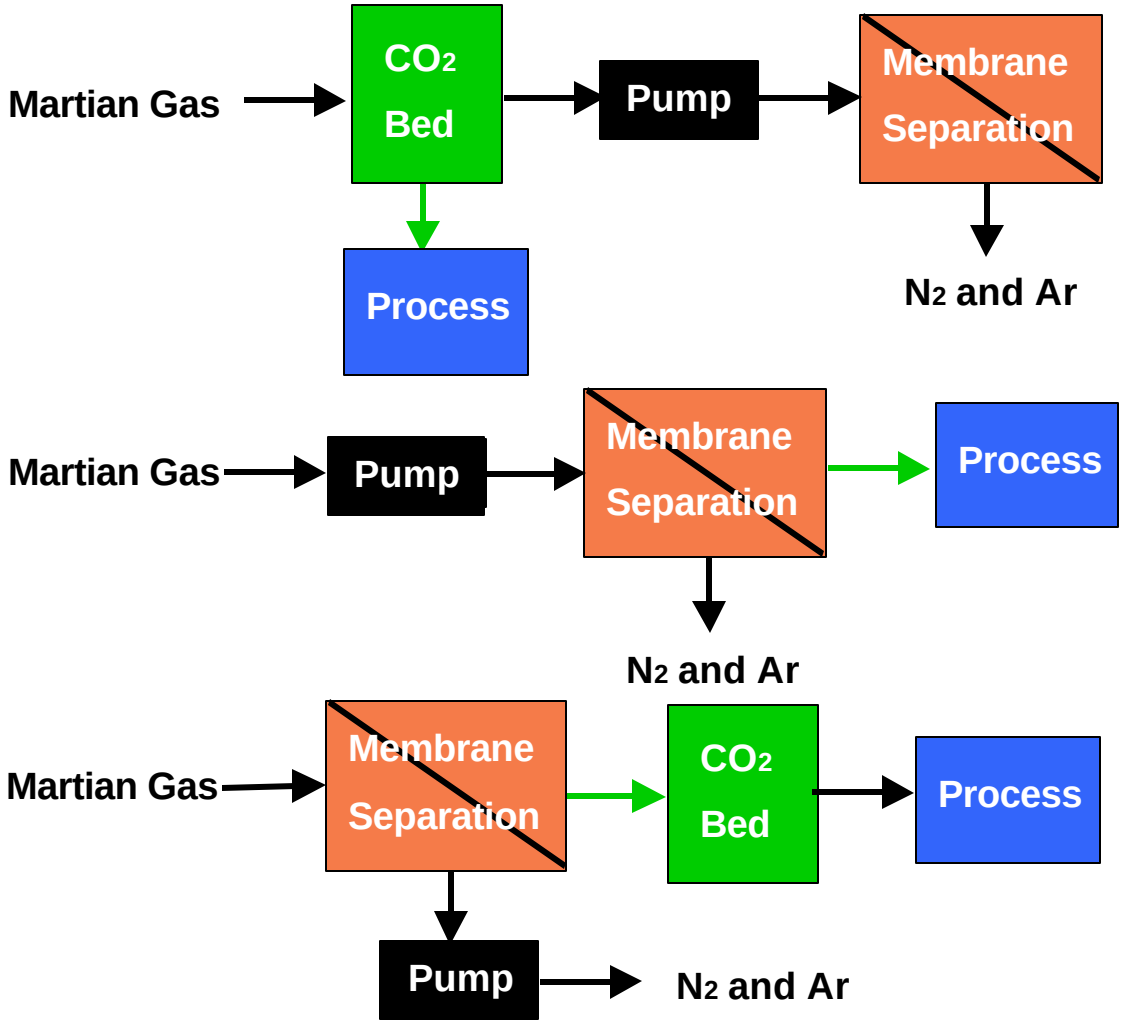
Overview

- Batch versus continuous processing
  - **Basic considerations**
  - **Capture methods**
  - **Points for comparison**
- Buffer gas purification
  - **Membrane test bed**
  - **Data collected**
  - **Membrane separation model**
- Plans

Base Conditions

- Production rate – 1 L/min
- Processing time – 1 Sol (25.3 hr)
- Sun light for processing – 8 hr
- Ambient temperature – 200 K
- Ambient pressure – 1 kPa
- Process temperature – 300 K
- Process pressure – 100 kPa
- Separate Ar and N2 from CO2
- Mars Gas
  - **Carbon Dioxide – 95%**
  - **Nitrogen – 2.6%**
  - **Argon – 1.7%**

Membrane Applications



Batch Versus Continuous Processing

- **Basic considerations**
  - Production rate
  - Theoretical power requirements
  - Power supply requirements
- **Capture methods**
  - Temperature swing adsorption
  - Cryogenic
  - Compressor
- **Points for comparison**
  - Weight
  - Power
  - Complexity

Production Rate

- 1.0 standard liter of carbon dioxide per minute
- Assume 12.5 hrs of sun light and 12.5 hrs night

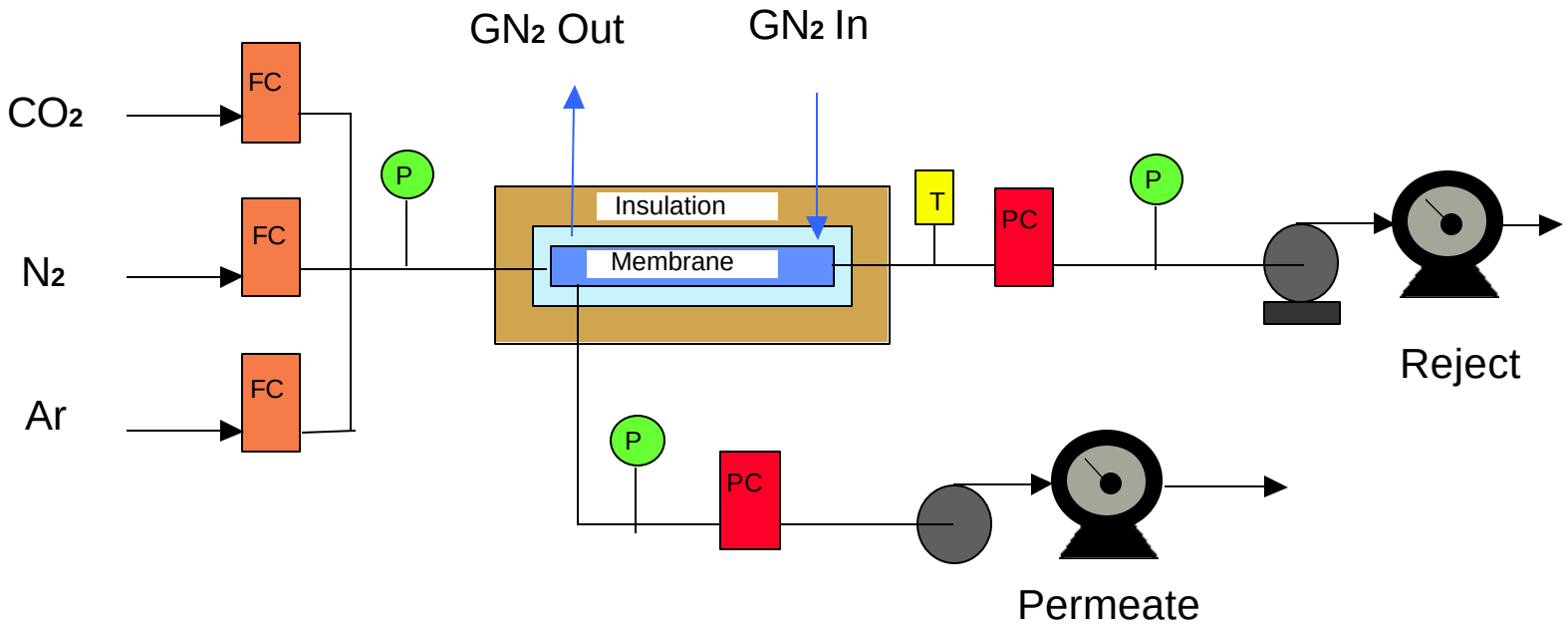
Buffer Gas Purification

- **Membrane test bed**
  - Test bed design
  - Test procedures
- **Data collected**
  - Separation data
  - Permeation
  - Temperature effects
- **Membrane separation model**
  - Model development
  - Model comparison with permeation data

Mars Gases Separation

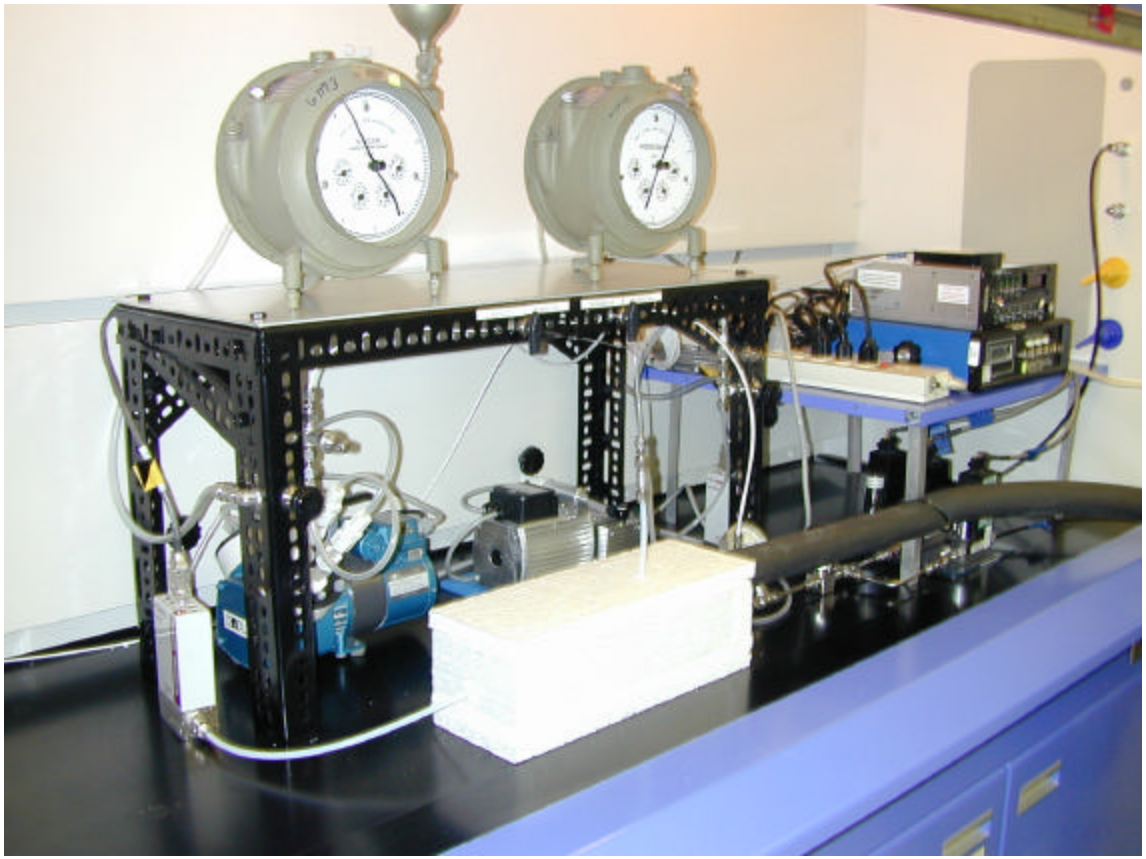
- Separation methods
  - **Hollow-fiber membranes**
  - **Low temperatures and reduced pressures**
  - **Apparatus**
- Applications
  - **After capture of carbon dioxide**
  - **Before capture of carbon dioxide**
  - **Continuous process**
- Technical challenges
  - **Efficient separation of carbon dioxide from buffer gases**
  - **Separation of argon and nitrogen**

Membrane Test Bed

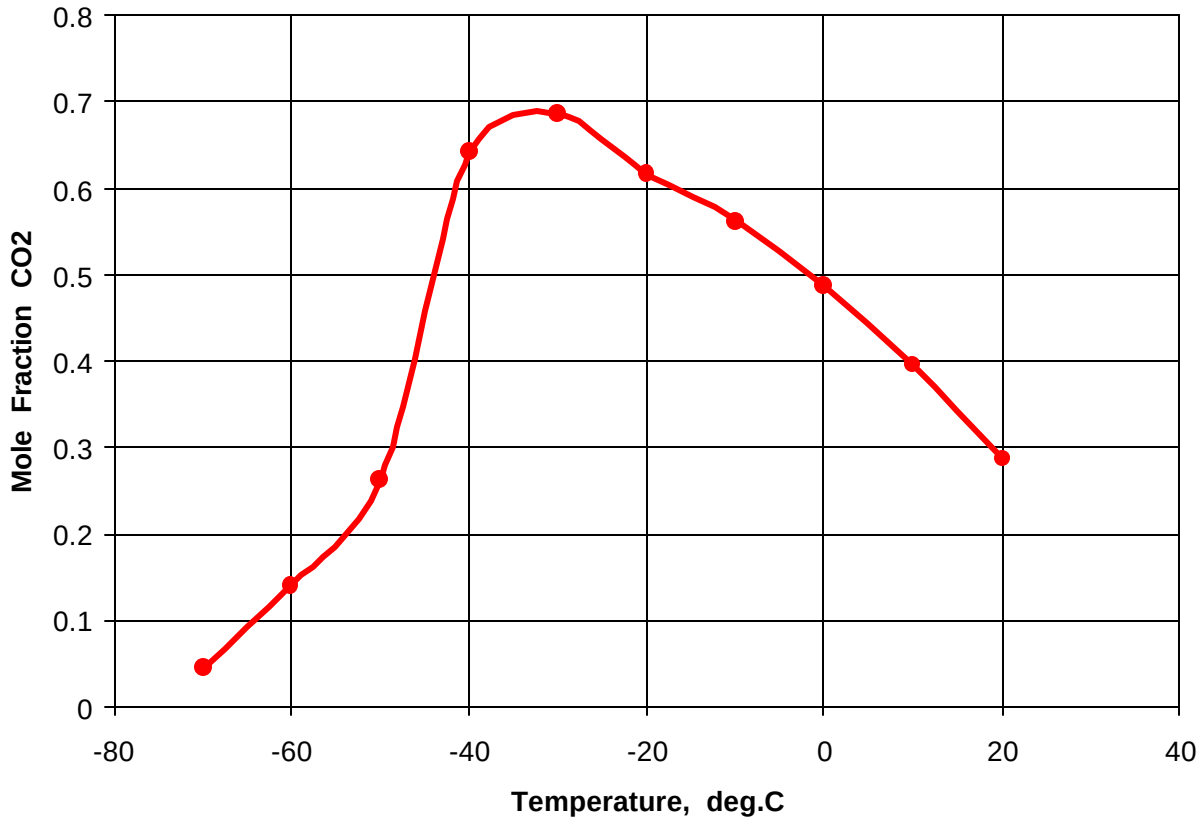


**SPACEPORT
ENGINEERING AND
TECHNOLOGY**

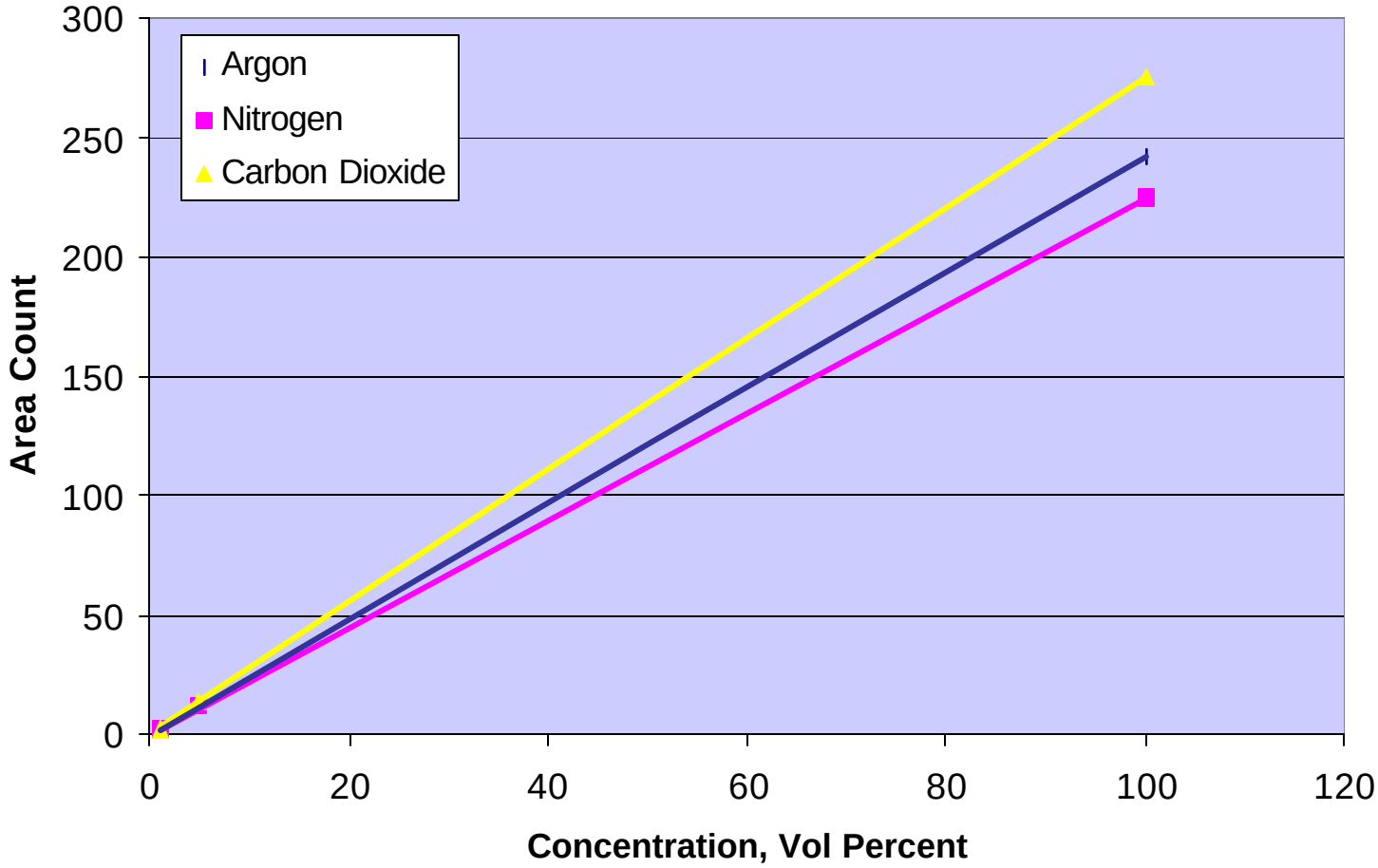
Membrane Test Bed



Permeate Concentration versus Temperature



Calibration, 0.2 mL Sample



Future Plans

- Build Prototype Mars Gas Capture System
- Test Performance in KSC Mars Chamber