Improvements in Atmosphere Generators Used in Chemical Challenge Testing of Air Purifying Respirators

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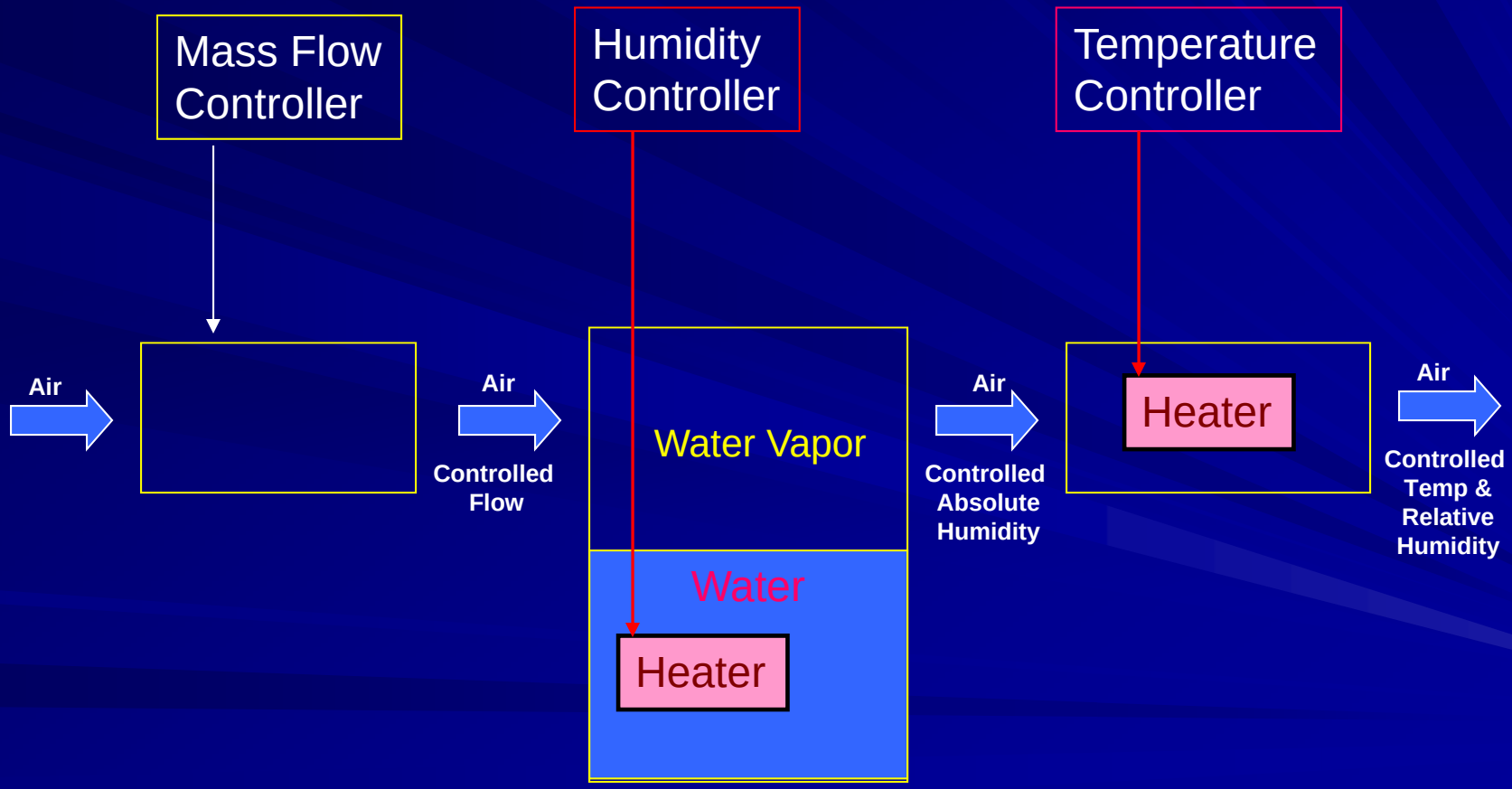
What is an Atmosphere Generator?

An Instrument that provides a constant flow of clean air for chemical challenge testing of air purifying respirators.

- **Flow Rate**
  - **Range: 10- 500 L/min**
  - Tolerance: ± 2%
- **Temperature**
  - **Range: 20 – 30°C**
  - Tolerance: ± 0.5°C
- **Humidity**
  - **Range: 20 – 85%**
  - Tolerance: ± 3%

How Atmosphere Generator Works

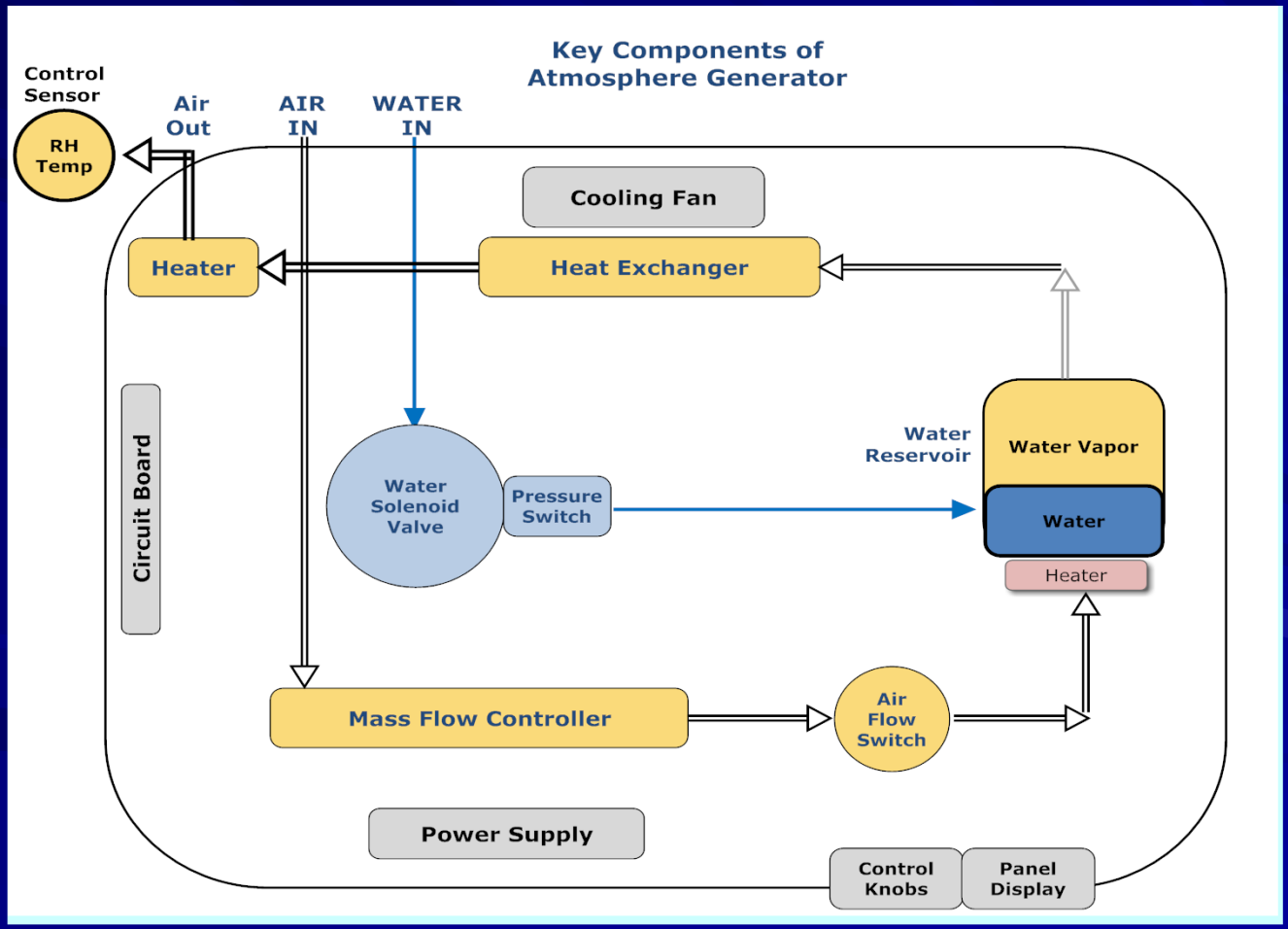
(simplified)



Miller-Nelson

HCS-401 and HCS-501

(component diagram)



Atmosphere Generator

Atmosphere Generator
Desired Improvements

- Performance Factors
  - Accuracy, Precision
  - Reliability
- Efficiency Factors
  - Convenience
  - Avoiding Crashing & Burning
  - Avoiding Repairs

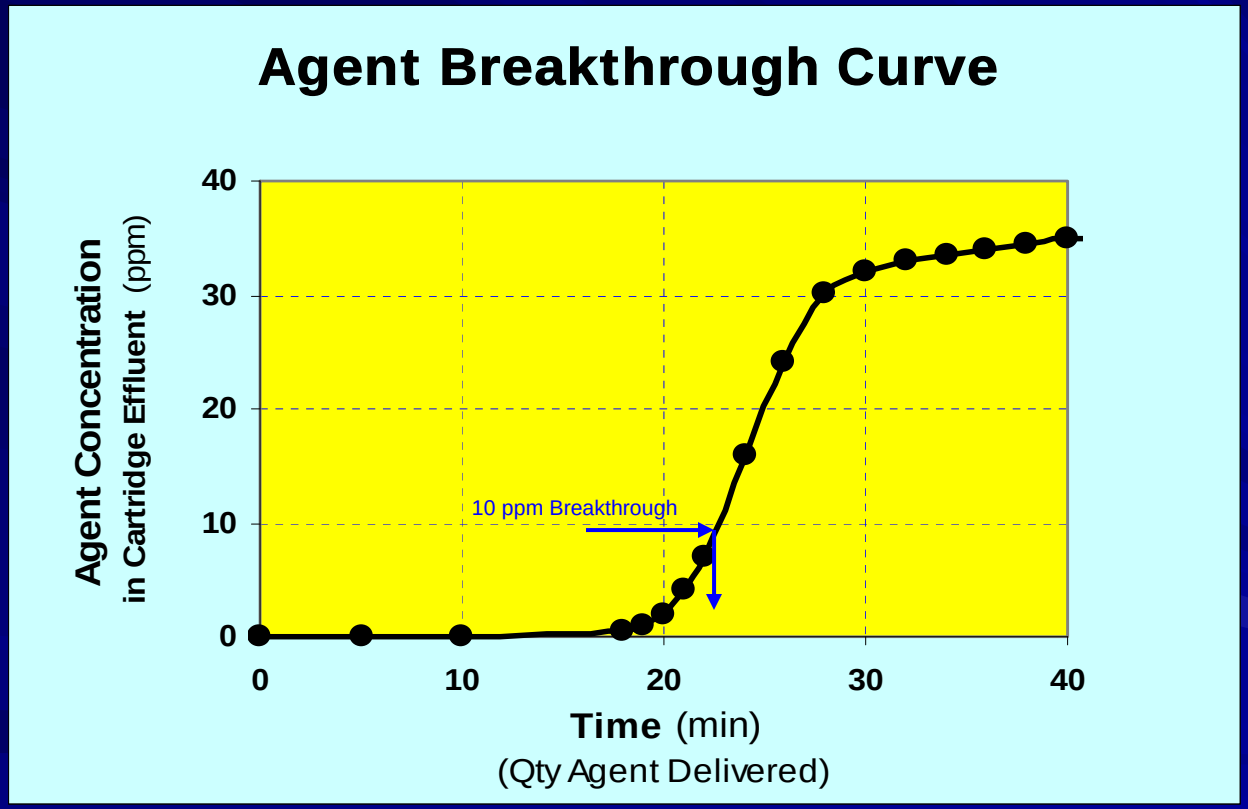
Performance Factors

Test Parameters to Control

- Mass of Agent applied *per time unit*
  - Air Flow Rate
  - Agent Concentration
    - Agent Flow Rate
- Temperature
  - Temperature at Atmosphere Generator
  - Temp at APR Cartridge
- Mass of Water applied *per time unit*
  - Absolute Humidity
  - Relative Humidity
- Effluent Monitor Accuracy
  - Calibration
  - Interference by Moisture, etc.

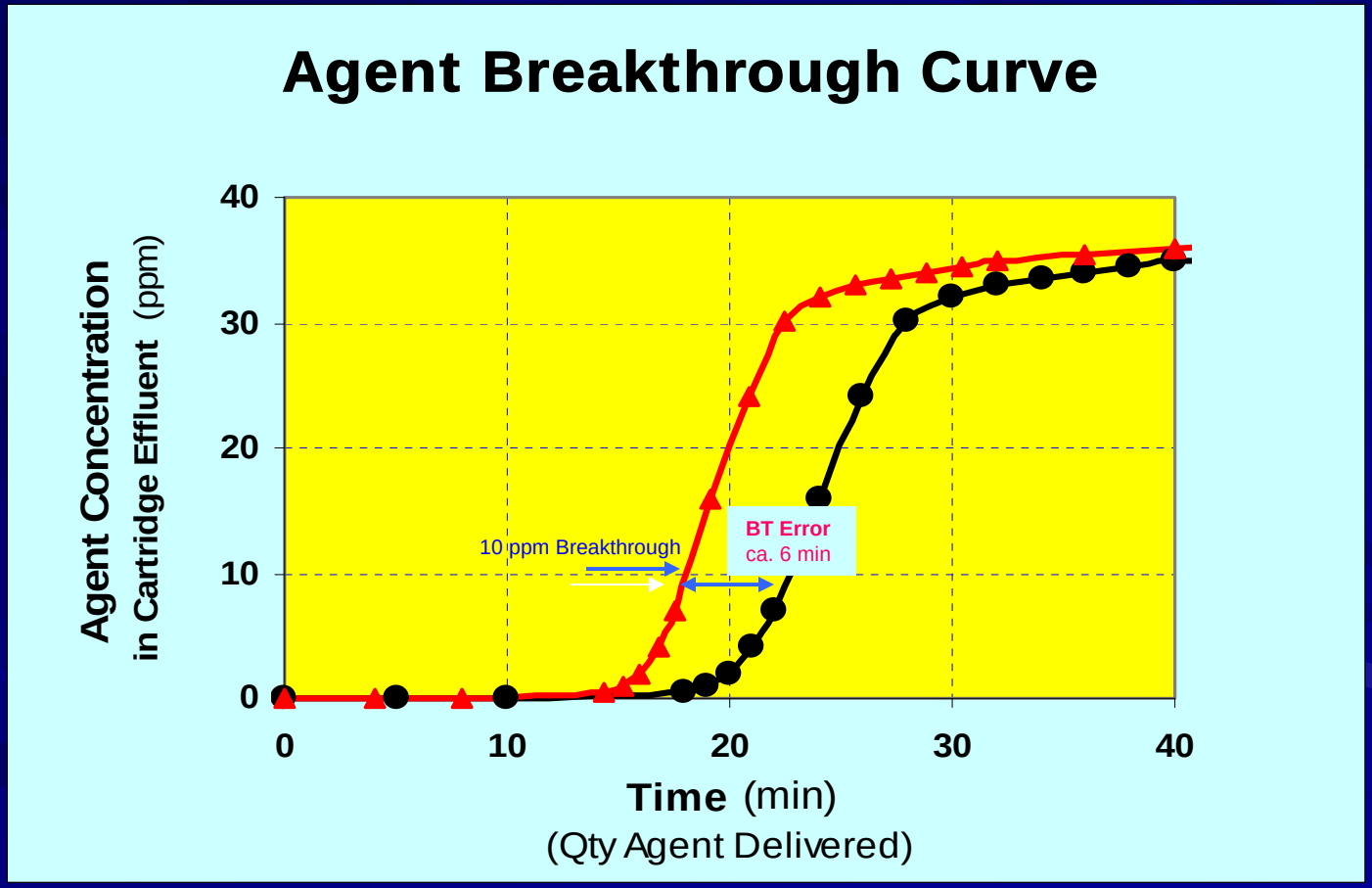
Service Life Estimated

from Breakthrough Time Measurement



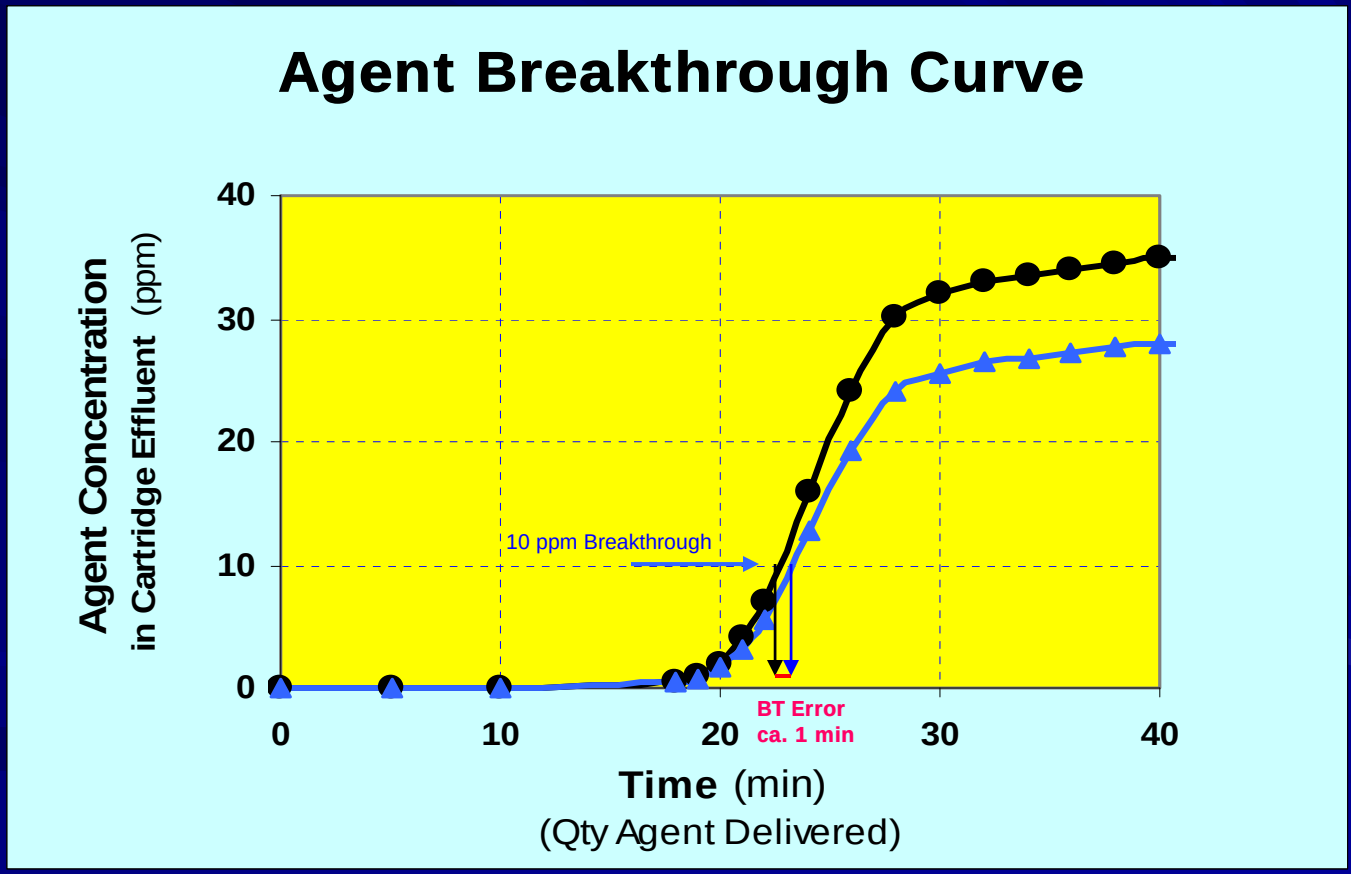
Breakthrough Time Error

induced by 20% variation in measurement of
Time or **Flow**

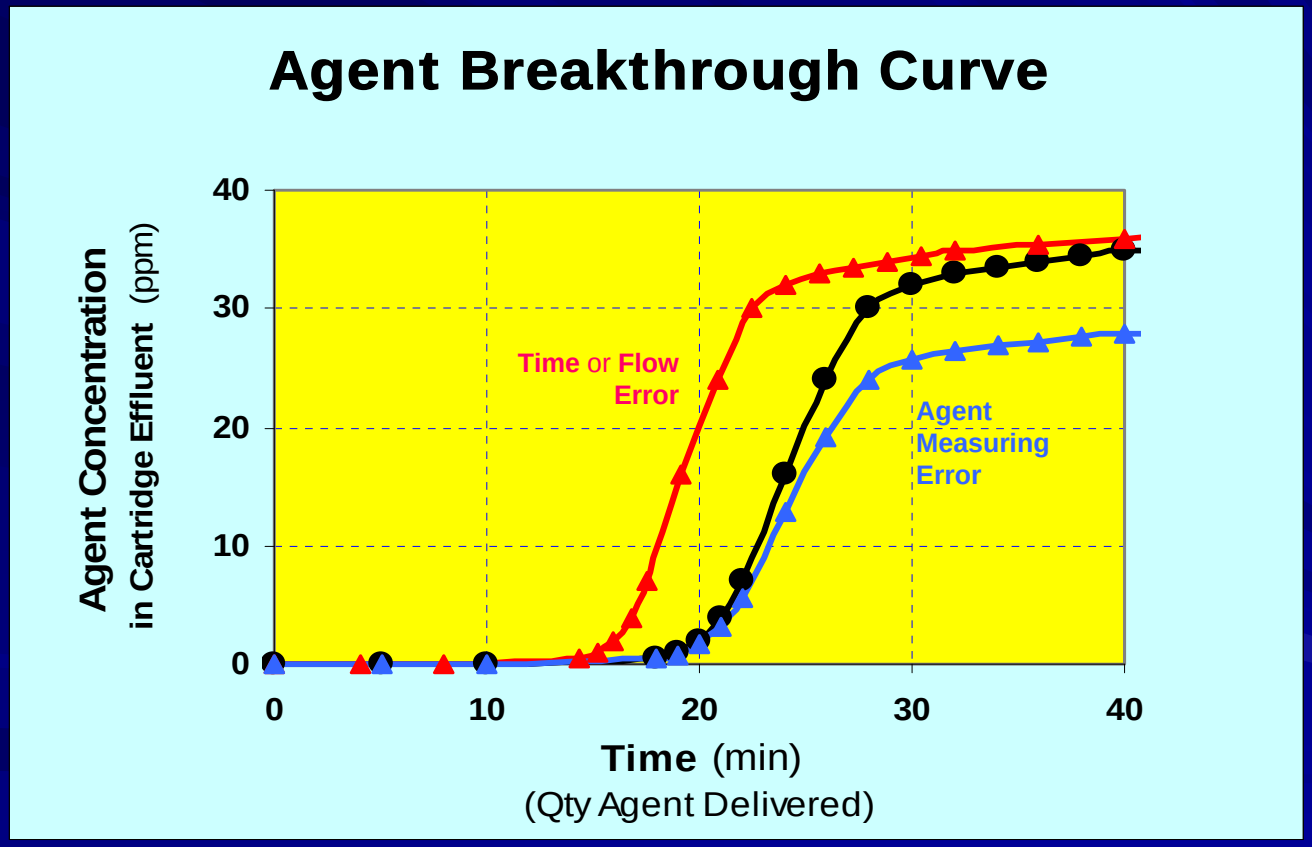


Breakthrough Time Error

induced by 20% variation in measurement of
Agent Concentration



Breakthrough Time Errors
(summary)



Test Parameters
(summary: effect of variations)

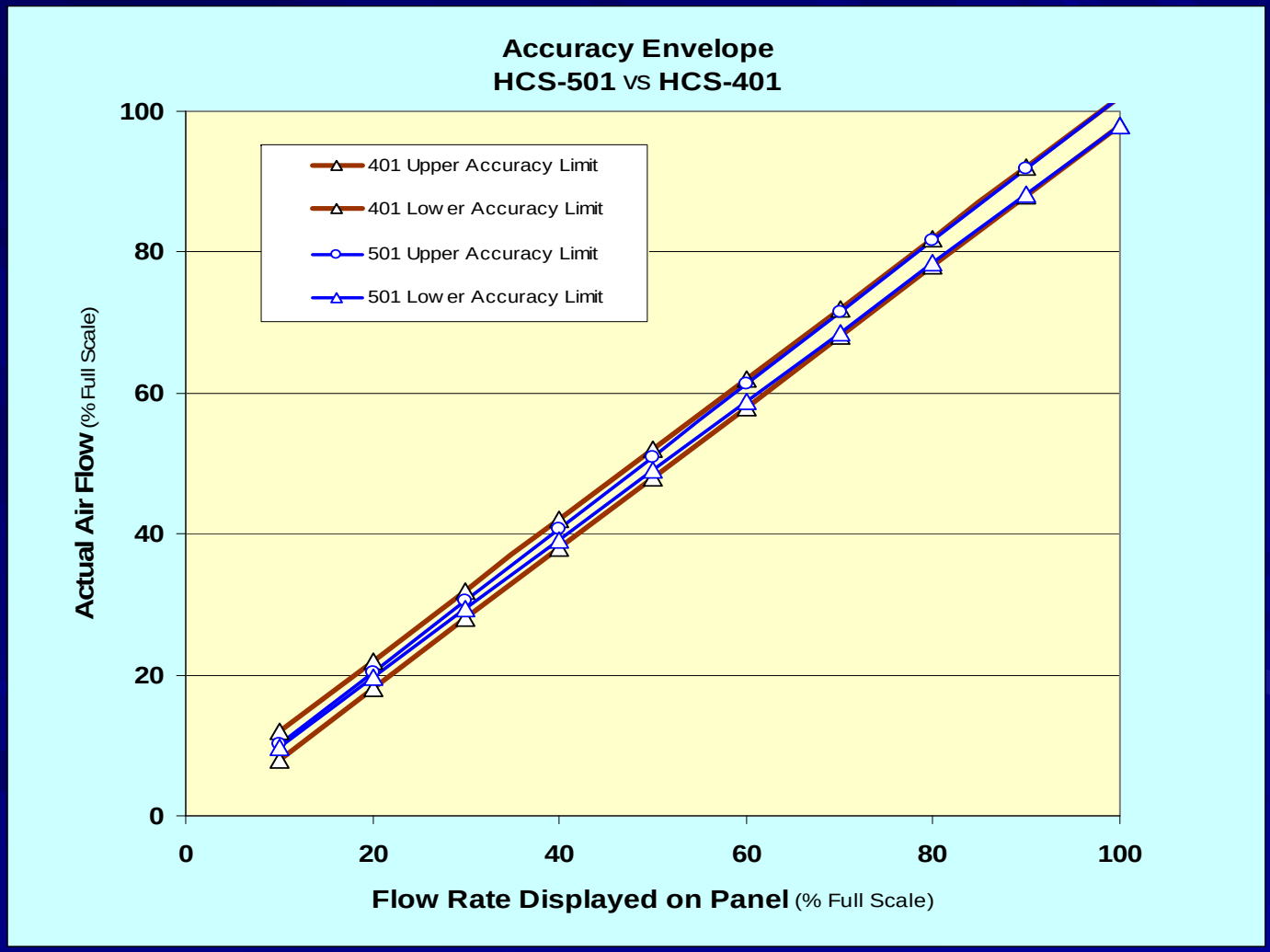
- FLOW (Mass of Agent applied *per time unit)*
  - Test Error proportional to Variation
    - Usually a 1:1 effect
- Temperature
  - Depends upon Isotherm
    - Usually < < 1:1 effect
    - But, occasionally > 1:1 effect
- RH Control (Mass of Water applied *per time unit)*
  - Competitive adsorption of agent vs water
    - Usually << 1:1 effect
    - But, occasionally >> 1:1 effect (CCl4)
- Effluent Monitor Accuracy
  - Depends on steepness of BT curve
    - Usually < < 1:1 effect

Atmosphere Generator Improvement Goals

- Performance Factors
  - Accuracy of Flow
    - Improved MFC
  - Accuracy of Humidity Control
    - Improved Calibration System
  - Reliability
    - Computer (PROM) Control

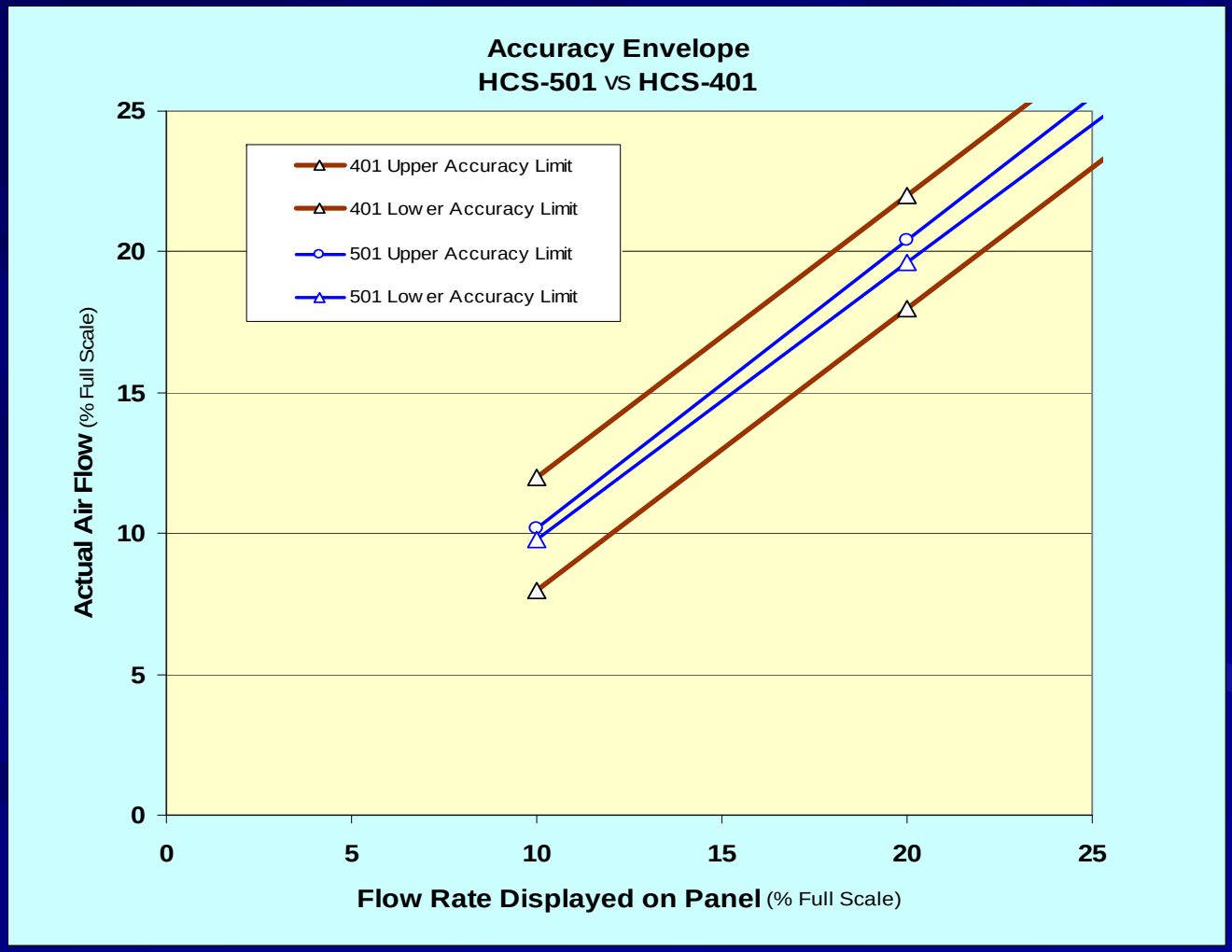
Improved Flow Accuracy

Digital Mass Flow Controller

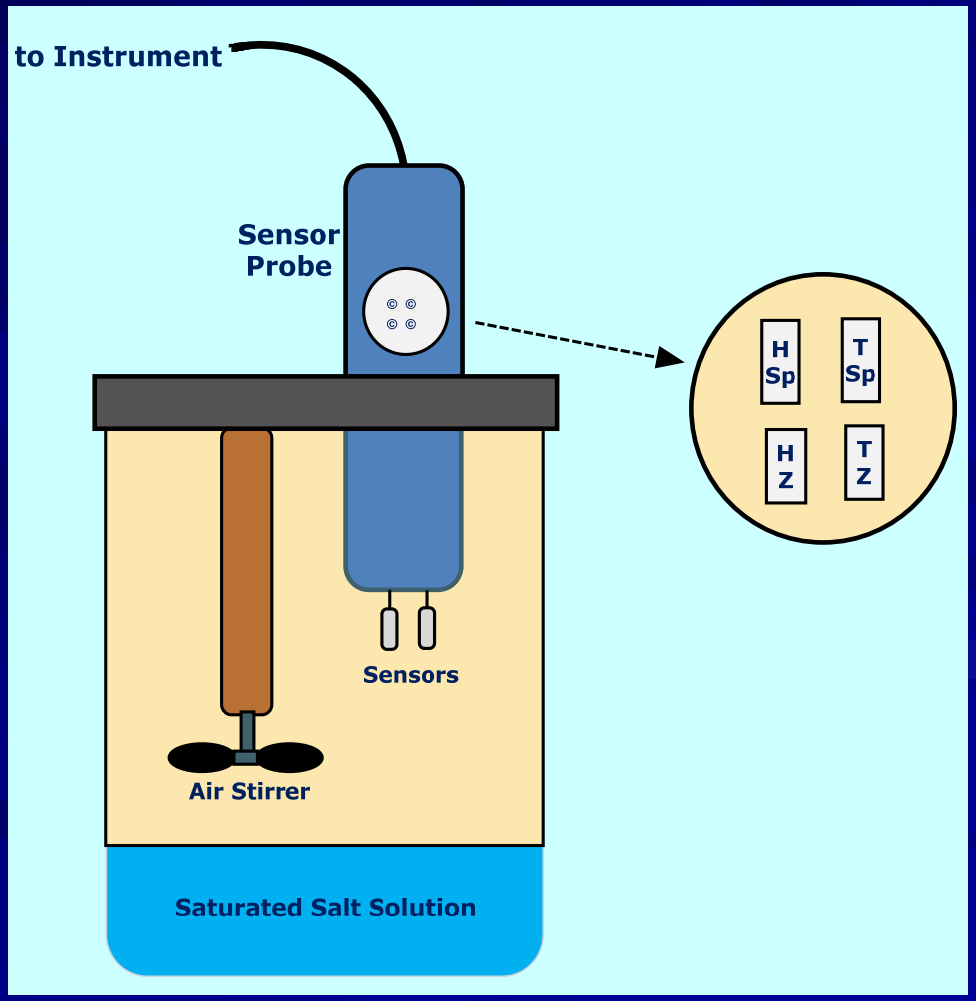


Improved Flow Accuracy

Digital Mass Flow Controller



RH Calibration System



RH Calibration System

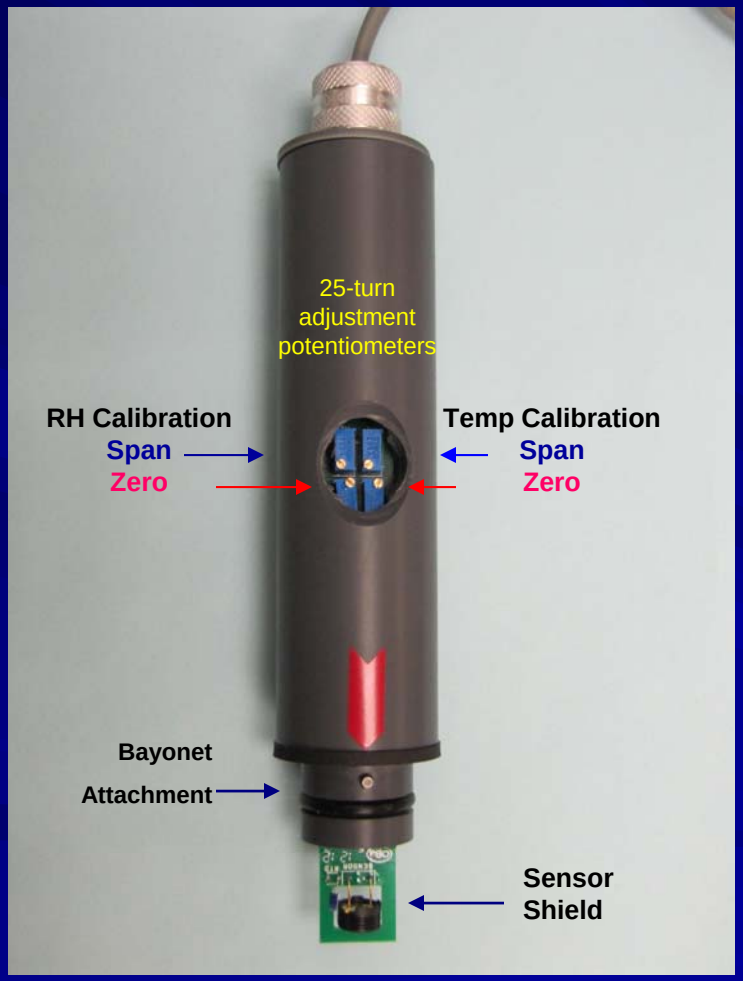
Calibration Materials

Head Space Above a Saturated Solution of:	%RH @ 20ºC	%RH @25ºC	%RH @30ºC
Lithium Chloride	11.3%	11.3%	11.3%
Potassium Acetate	23.1%	22.5%	21.6%
Magnesium Nitrate	54.4%	52.9%	51.4%
Potassium Chloride	85.1%	84.3%	83.6%

Temp/RH Probe Improvements

- Improved Adjustment Potentiometers
  - 25 turns instead of 10 turns
  - Larger screws - easier adjustment
  - Increased Lifetime - 5 times as many adjustments
- Protective Shield for Sensors
  - Protects Fragile Sensors from Harm
- Bayonet Attachment Mechanism
  - Quick/easy to Install & Remove
  - More Rugged
- Improved Electrical Plug to Instrument
  - Reduced electrical background noise
  - Easy to remove & install

Improved Humidity Control
(Quicker/Easier Calibration)



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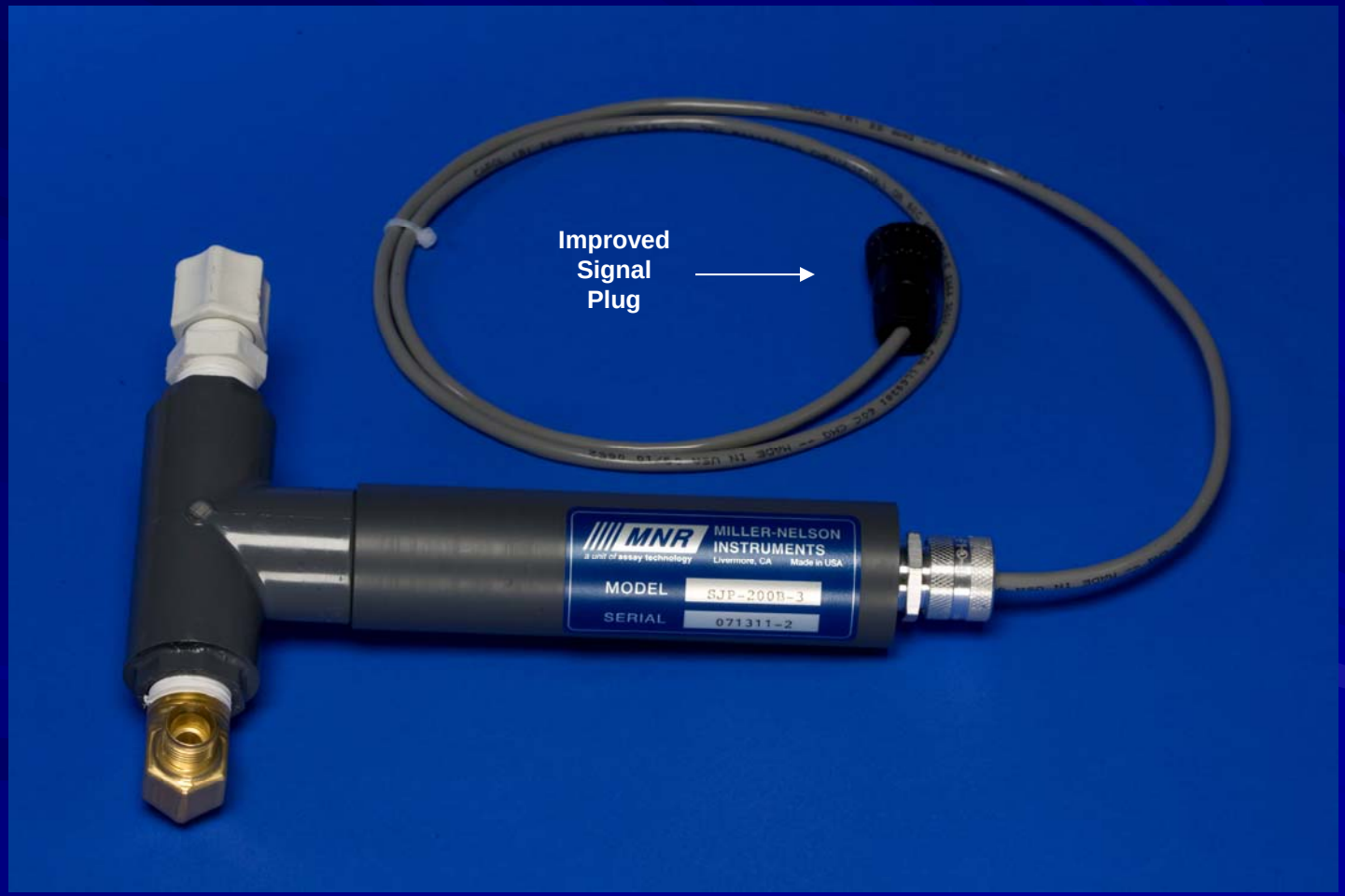

RH Calibration Chamber

Improved System Reliability
(Computer Control)

- Microprocessor Chip
  - Checks Reference Voltage
  - Queries Sensors
  - Follows Instructions
- Commands System
  - Maintains Electronic Calibration
  - Maintains Feedback Control

Atmosphere Generator Improvement Goals

- Efficiency Factors
  - Convenience
    - Ease of Calibration (previously discussed)
  - Avoid Crash & Burning
    - Alarms & Protective Systems
      - Water System (flooding)
      - Electrical System (burning)
  - Reduce Maintenance
    - Ease of Calibration (already discussed)
    - Computer (already discussed)

Alarms & Protective Systems

Under microprocessor control, the HCS-501 implements alarms and shut-down modes that protect the Instrument when faults are detected.

Water Pressure Alarm

If sensor signals insufficient water pressure, the System sounds an alarm and inactivates air and water heaters until water pressure is sufficient.

Inactivation of air and water heaters prevents overheating and consequent damage to the system.

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Water Level Alarm

If the sensor signals insufficient water level in the reservoir, the System calls for a water fill. If water level is still insufficient, System inactivates power preventing heating or further water filling.

Inactivation of power prevents subsequent overheating and/or flooding.

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If the sensor signals insufficient water level in the reservoir, the System calls for a water fill. If water level is still insufficient, System inactivates power preventing heating or further water filling.

Air Flow Alarm

If sensor signals insufficient air flow, the air and water heaters will not activate, protecting the Instrument from damage.

Continuous Improvement

- Instrument Controls, Alarms, & Protective Systems are now programmed into the microprocessor, therefore …
  - Future System Improvements will be able to be implemented by merely installing a newly programmed microprocessor.
  - Custom performance features may be made available by installing different programs in the microprocessor.

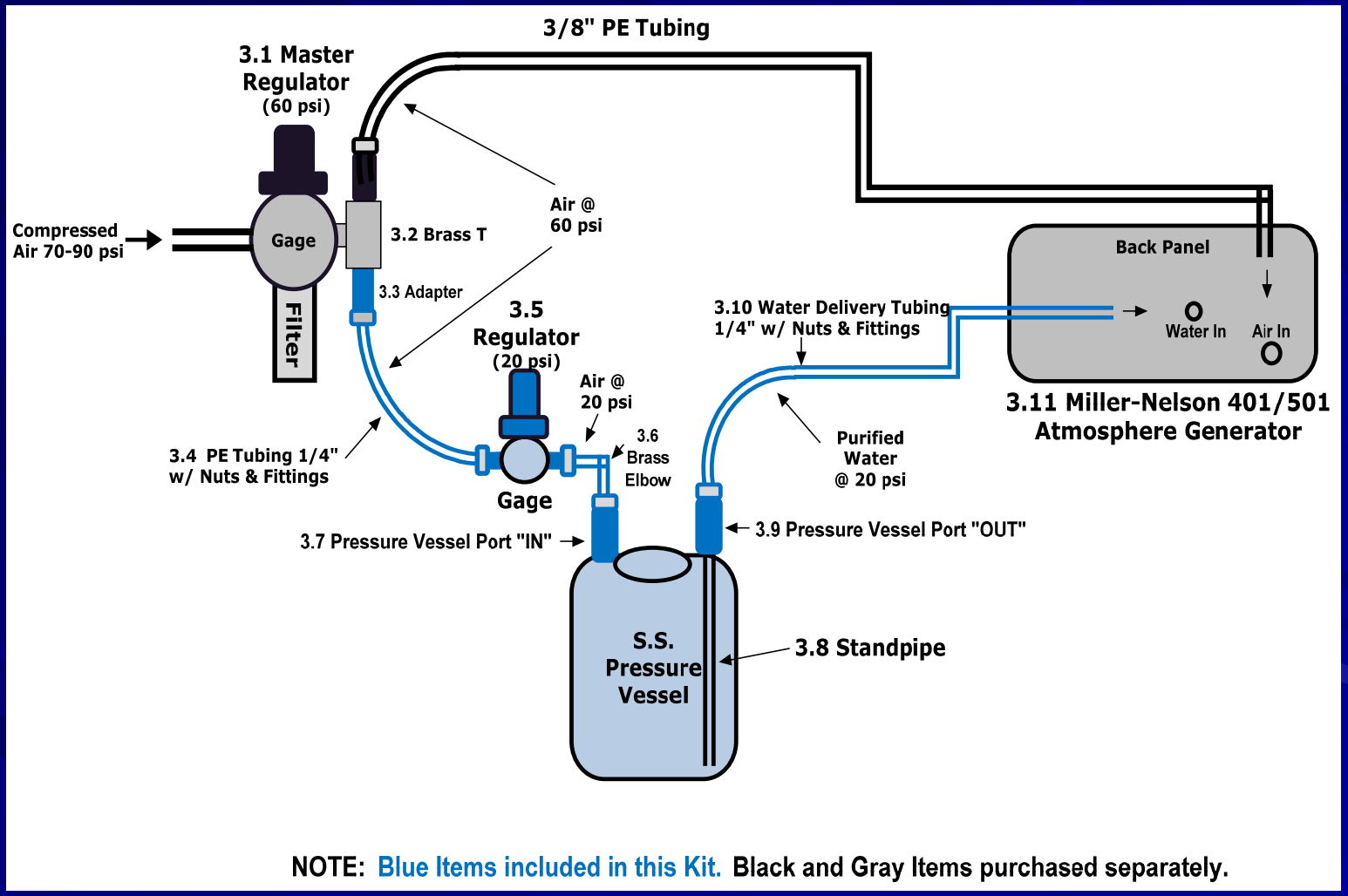
MNR Flow Generator

HCS-501

25” x 25” x 12”

Pressurized Water Source

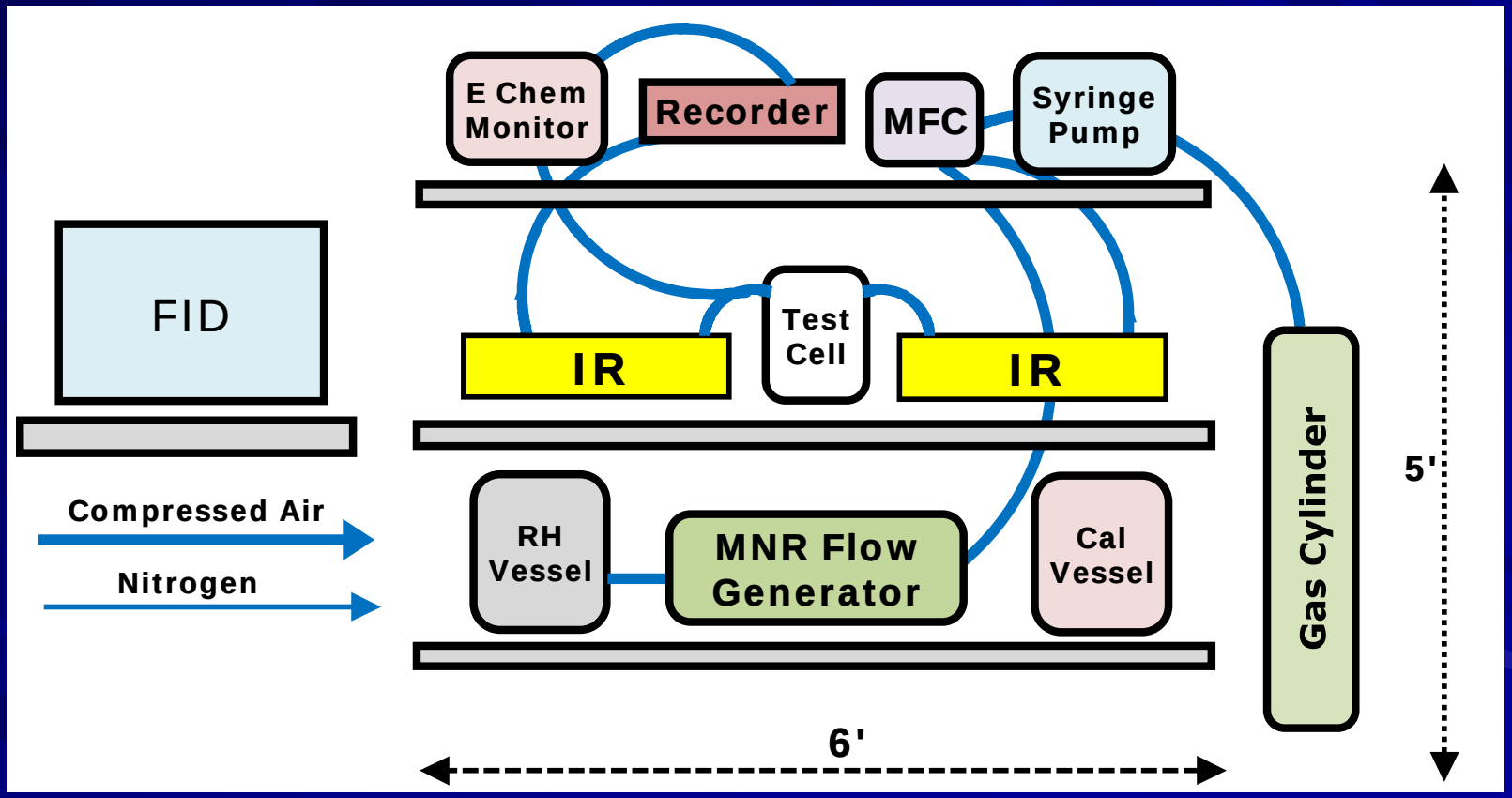
Pressurized Water Source (schematic)



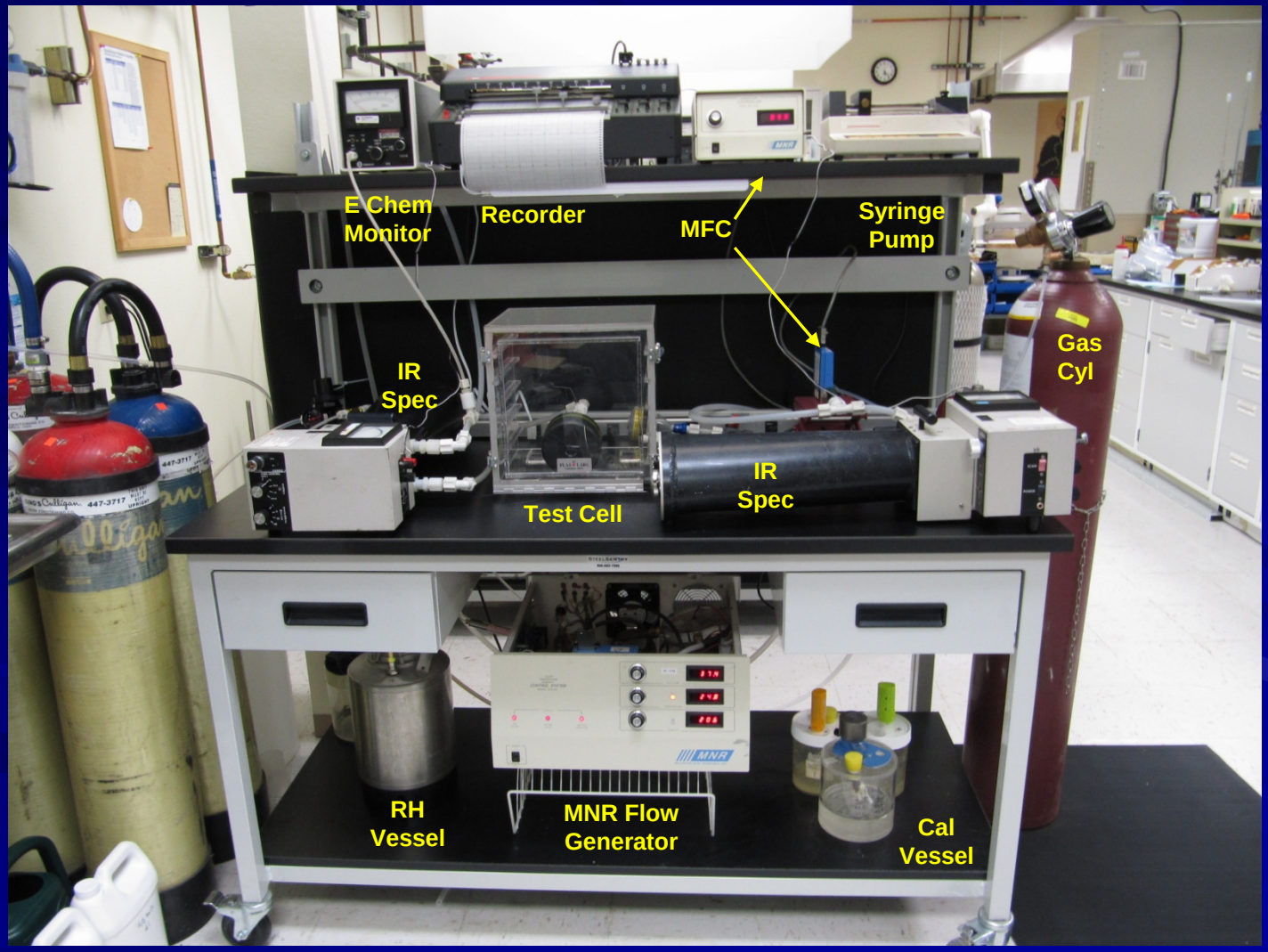
NOTE: Blue Items included in this Kit. Black and Gray Items purchased separately.

Lab Bench Layout

(Side View)



Lab Bench
(except for Hood)



AT Respirator and Filter Chemical Challenge Test Lab

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