

# **Design of a New Laboratory for Chemical Challenge Testing of Respirator Cartridges, Canisters, and Filters**

C.R. (Gus) Manning, PhD, CIH

# Chemical Challenge Testing Background

- Miller-Nelson, a leading independent Lab for 3 decades
  - Founded by Gary O. Nelson (Fellow AIHA)
- Miller-Nelson Lab acquired by Assay Technology (2004)
  - Incorporated into existing Analytical Lab facility
    - tasks performed are different from an Analytical Lab
- Eventually \*  
we would need to design a more appropriate Lab

---

\* 2009

# AT / Miller-Nelson Lab

## Typical Services

- **Respirator & Filter Testing** (Chemical Challenge)
  - Pre-Certification Test Data for APR Mfr
    - Submitted to NIOSH
  - 3<sup>rd</sup> Party QC Test
    - for Manufactured Respirator
  - Special Challenge Testing
    - Challenge Agents additional to those included in NIOSH certification testing
  - Special Projects
    - Filters and Adsorbents

---

APR = Air Purifying Respirator

# Chemical Challenge

## Respirator & Filter Testing

### Characteristics

- Flowing Toxic Stream with plumbing issues
  - Fume removal by hood
- Control Flow, Concentration, Humidity, Temp
  - Complex Work
- Continuous Monitoring with multiple Instruments
  - “Instrument Cluster”
- Lots of Utilities required
  - Power, Water, Nitrogen, Air, Compressed Gases

# Lab Design Considerations

## Preliminary

- Space
  - Perform 3 - 4 tests at one time
- Health & Safety
  - Prevent Exposures, Spills, and Explosions
- Quick Set-Up and Take -Down
  - Quick Changeover for Short Runs
- Testing
  - Accommodate Instrument Cluster
    - 5 or more Instruments used in 1 test
- Storage
  - Safe gas storage in or near Lab



# Assay Technology Facility

(Livermore, California)

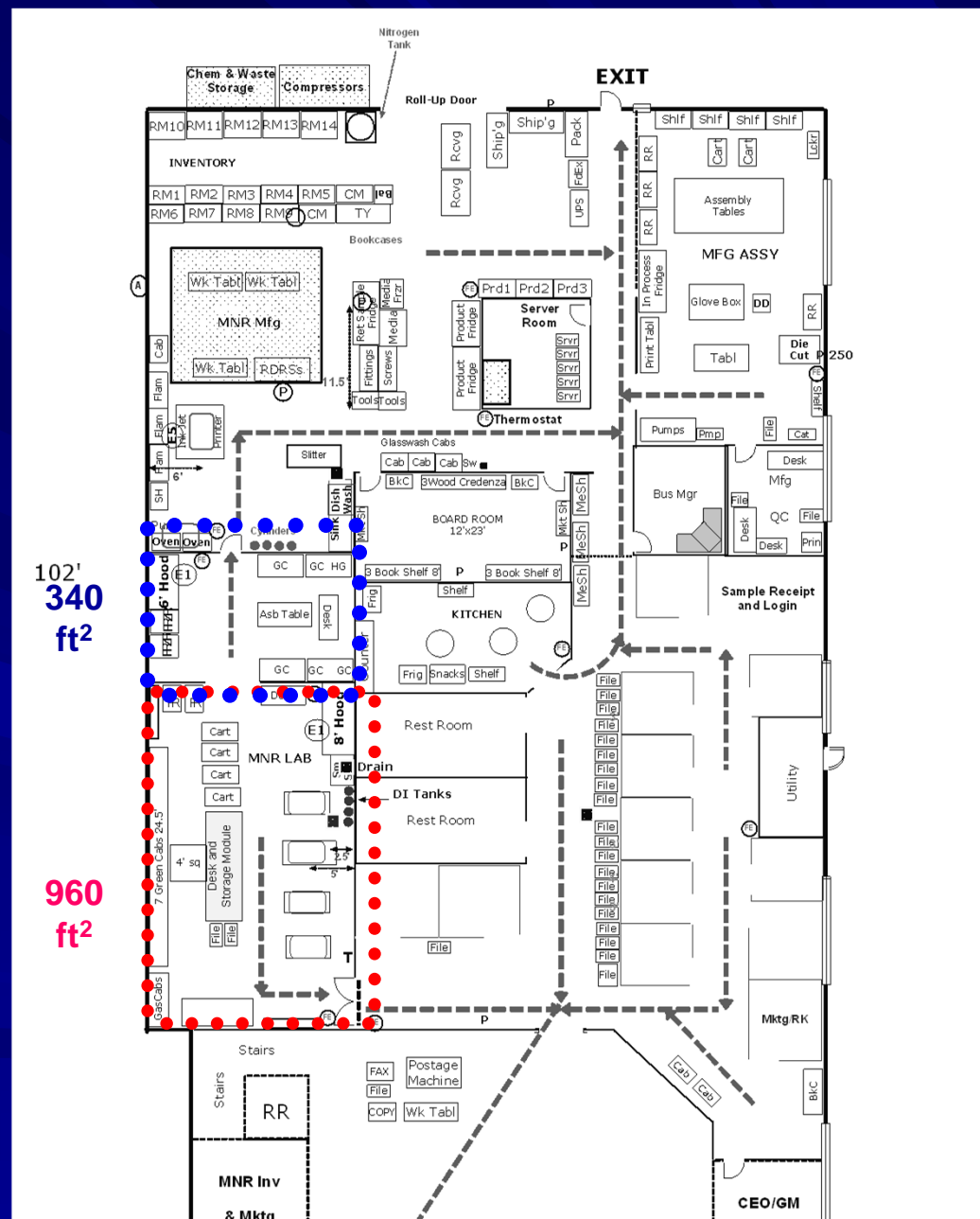


**10,550 sq. ft.**

# Entire Facility

1382 Stealth St  
Livermore, CA

10,550 Sq. ft.



# Components of the Instrument Cluster



# MNR Flow Generator HCS-401



# IR Spectrometer

(long path vapor cell)

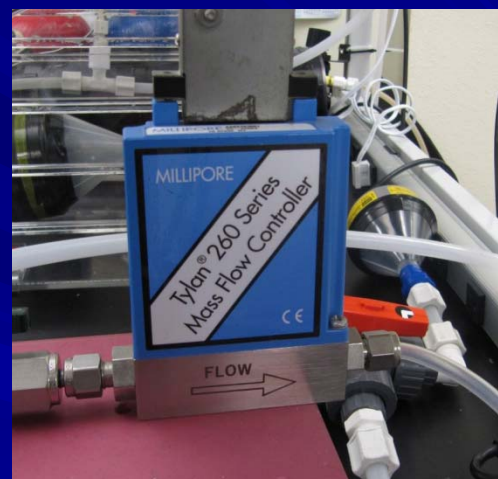


# Electrochemical Monitors





# Mass Flow Controller



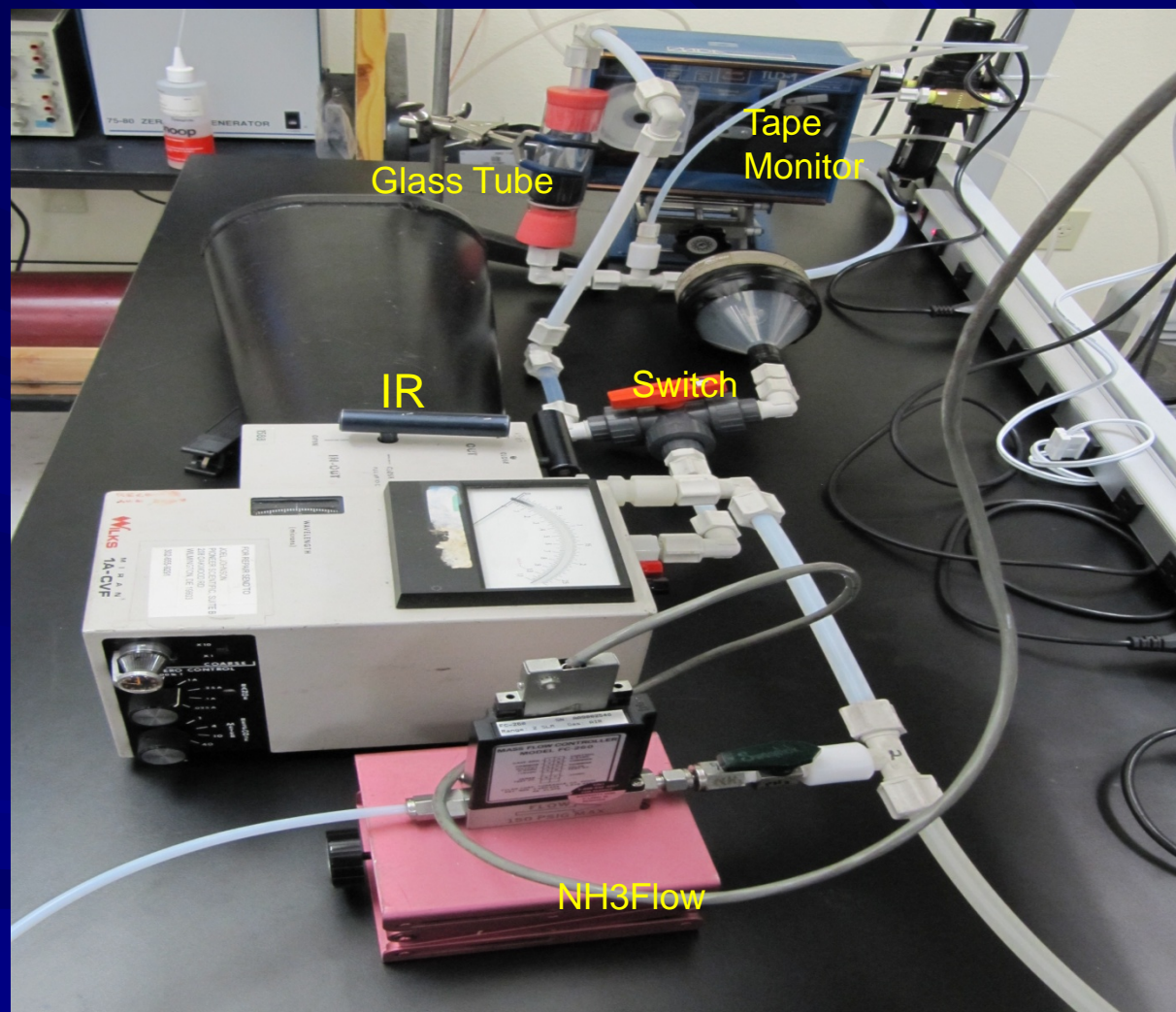
RH Vessel



Cal Vessel



# Schematic Set-Up for Test





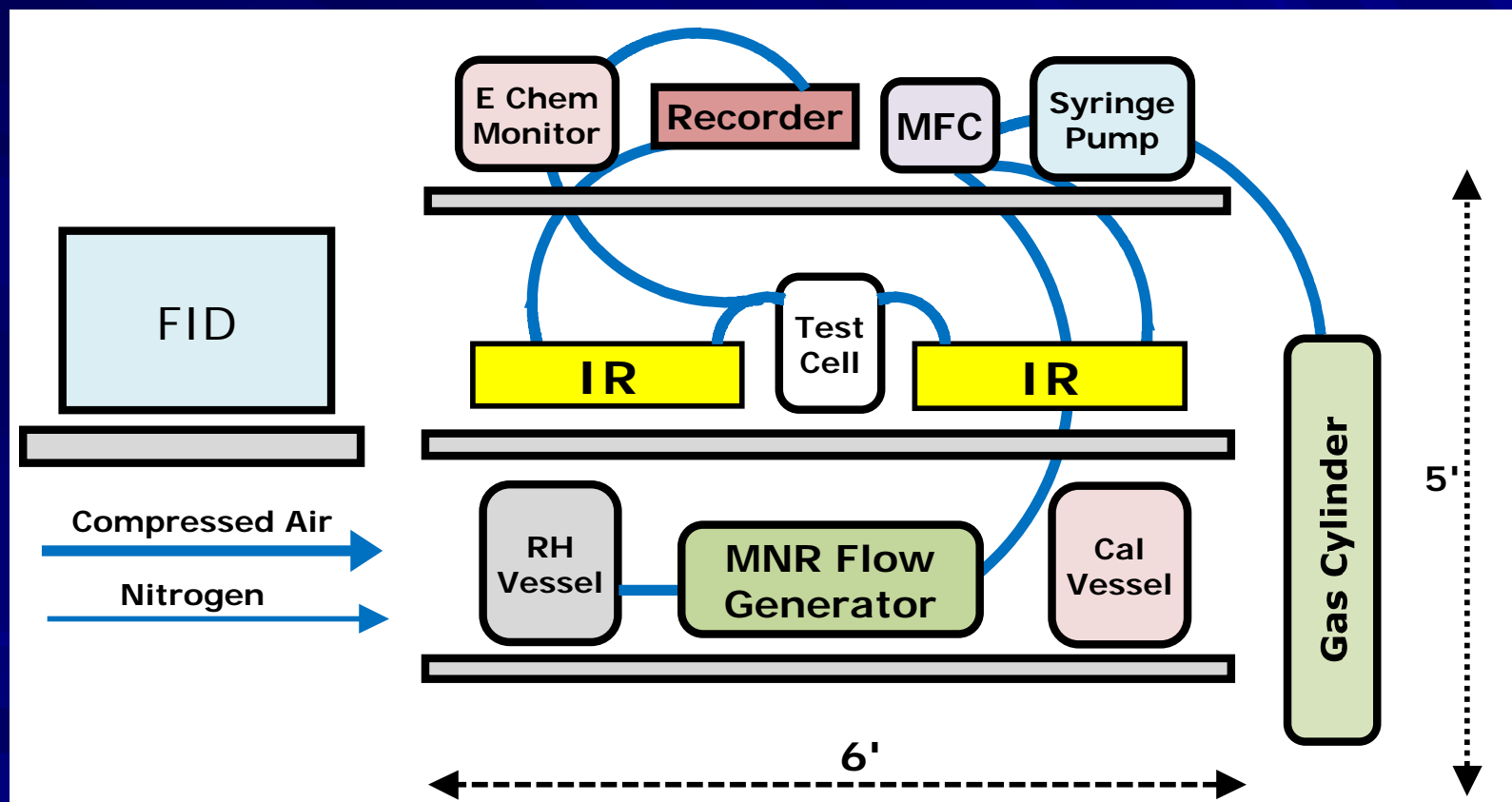
# Lab Bench Unit

(criteria)

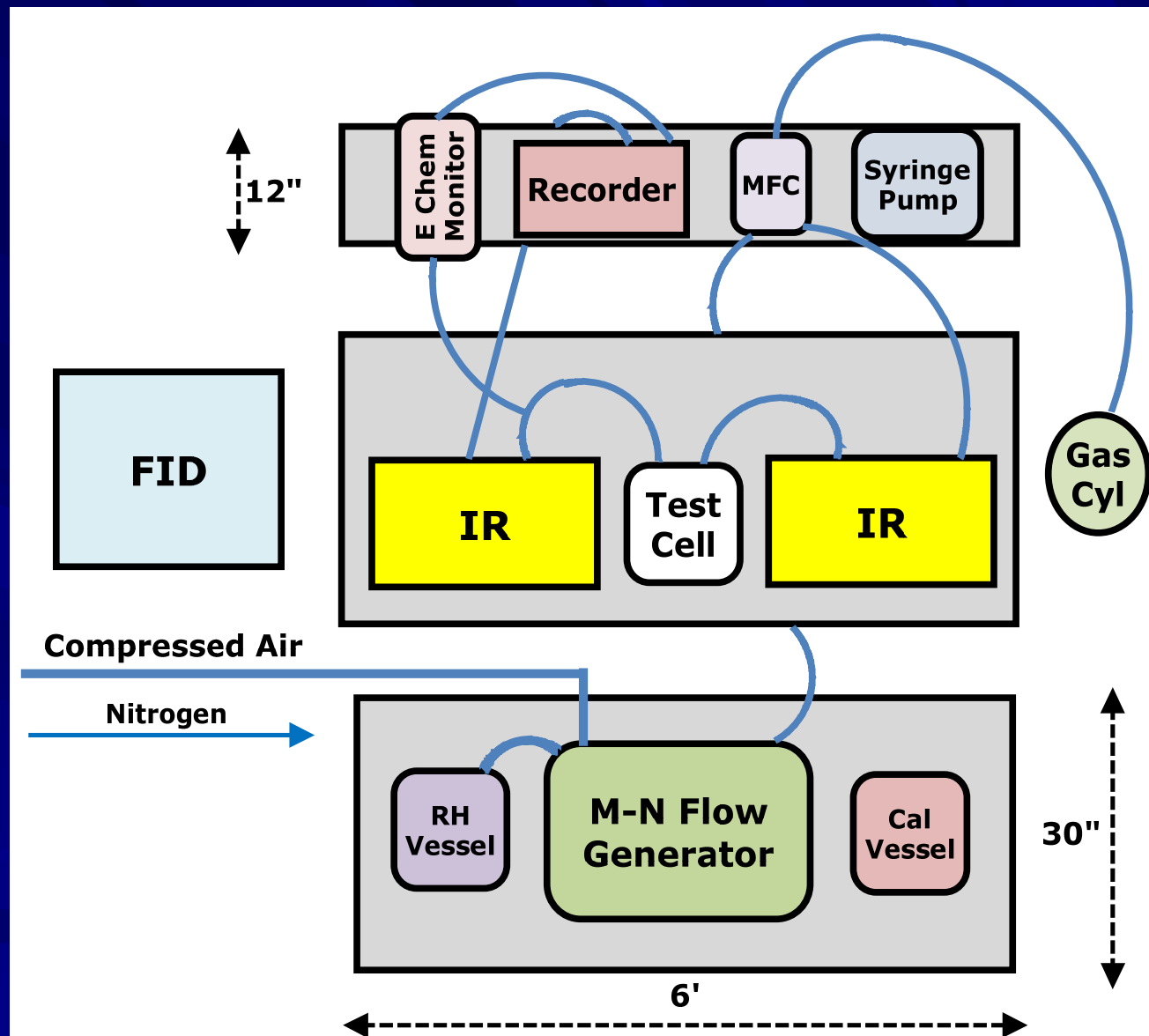
- **Within Fume Hood environment**
  - May leak toxic vapors
- **Can Contain “Instrument Cluster”**
  - Provides power, water, gas, & air
- **Rugged & Robust**
  - Physically & chemically
- **Semi-Portable**
  - Re-arrange for new experiments

# Lab Bench Layout

(Side View)



# Lab Bench Layout (Top View)



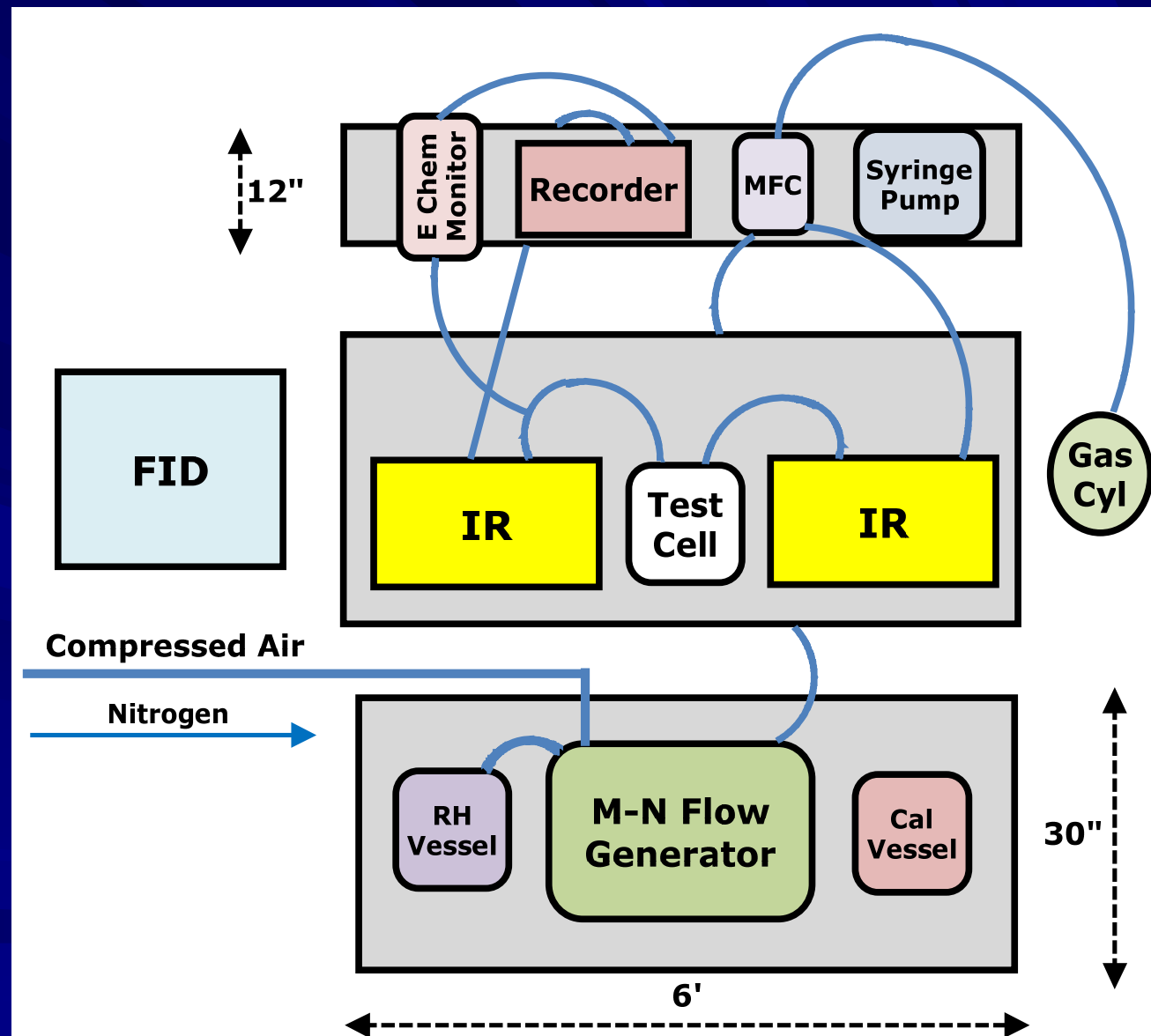
# Work Station (model)



# Work Station (example)



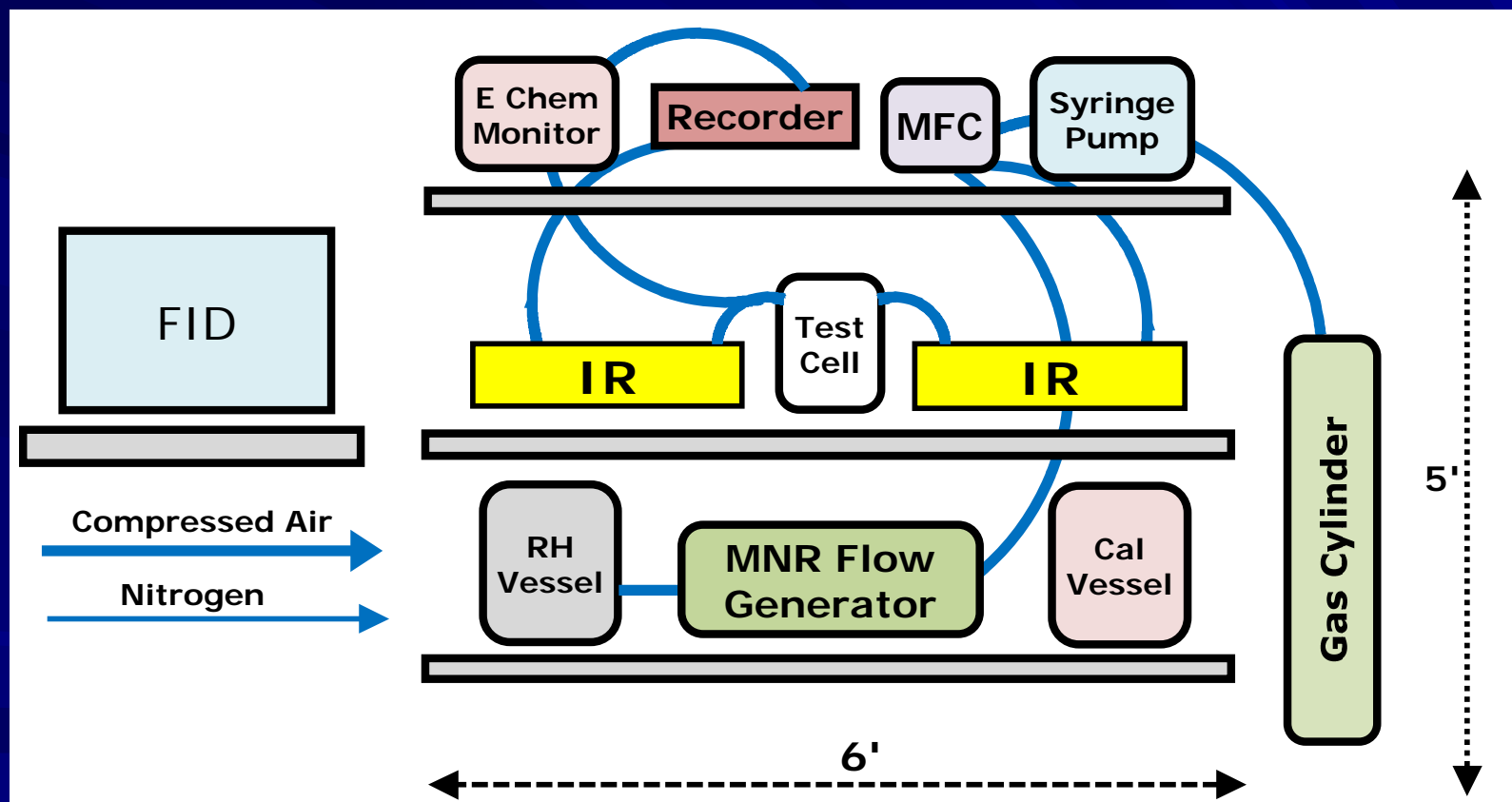
# Lab Bench Layout (Top View)



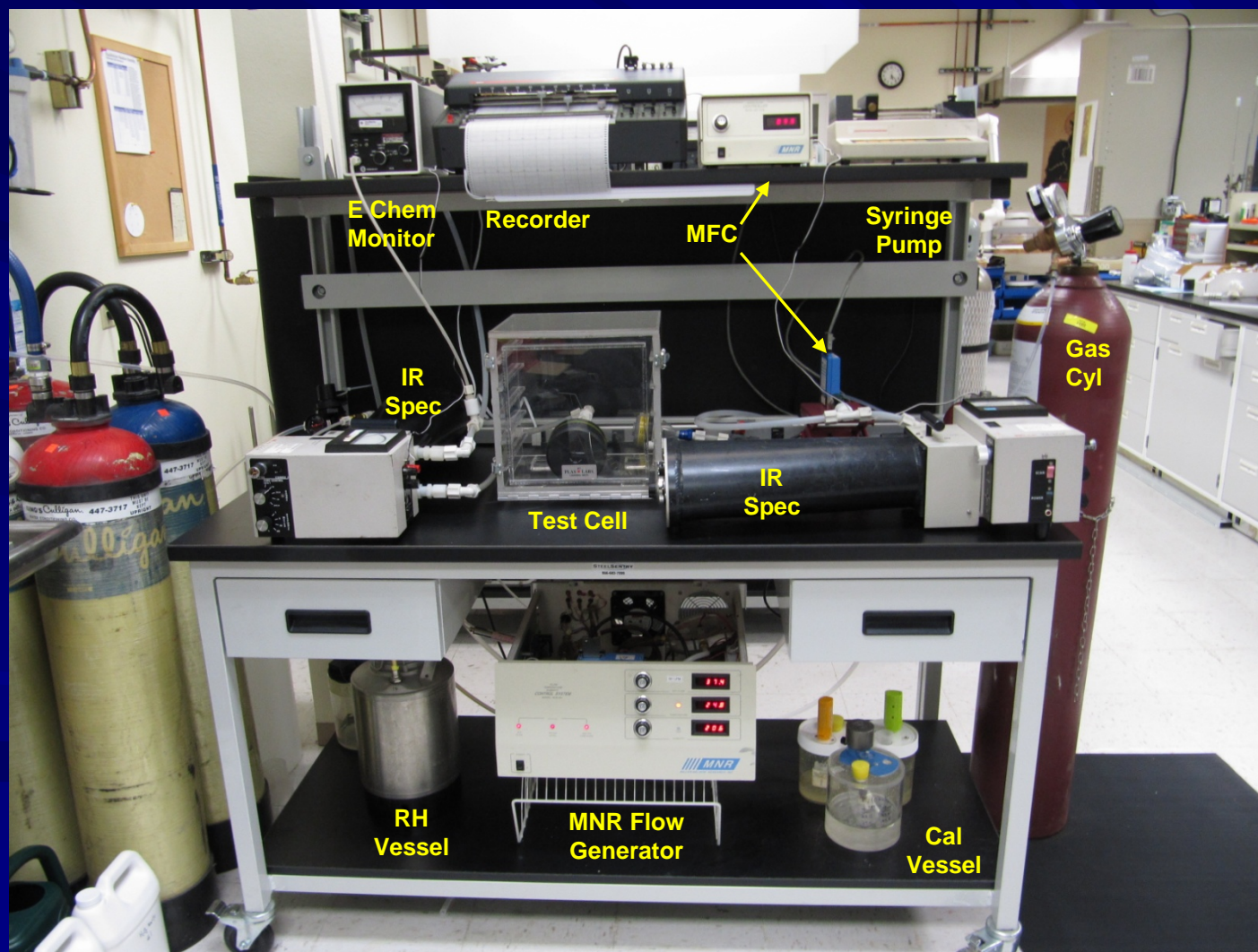


# Lab Bench Layout

(Side View)

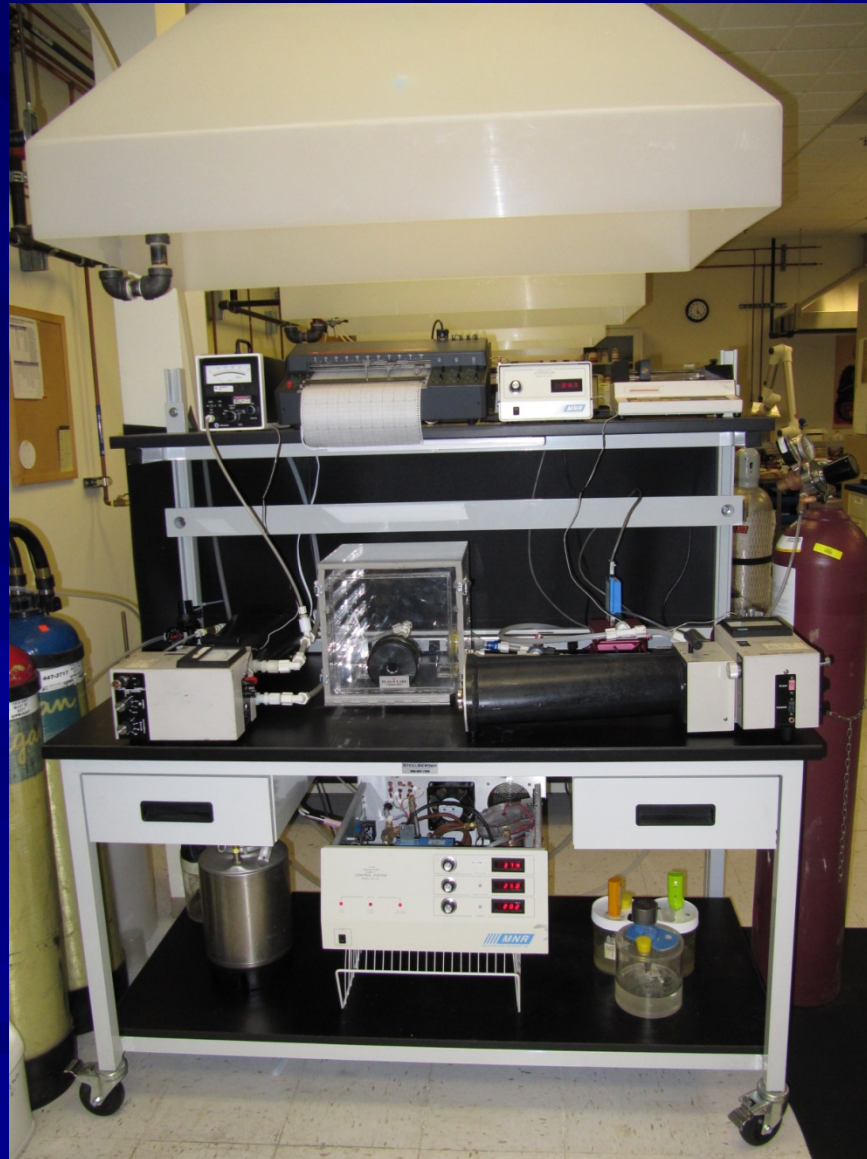


# Lab Bench (except for Hood)



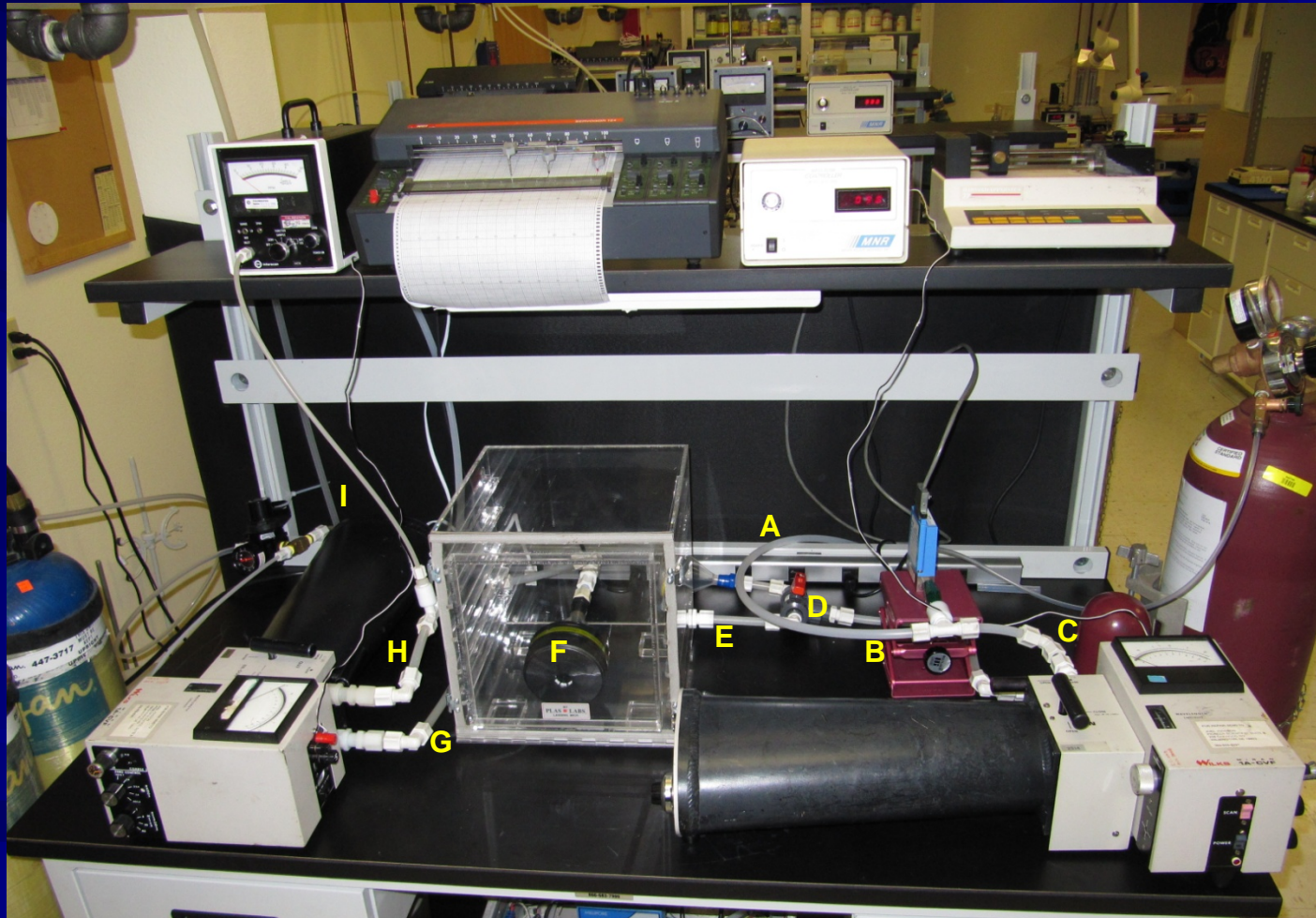
# Lab Bench

(complete view)





# Lab Bench (close-up)



# Overall Lab Arrangement

## (Integration of Bench Units)

- **Need 4-5 separate Test Benches**
  - 2-5 tests simultaneously
- **Comply with Air Handling Constraints**
  - Share Hood Ventilation Fans
- **Spaced as close as practical**
  - Limited to ca. 1,000 sq.ft
- **Open, Portable Layout**
  - Re-arrange for new experiments

# Lab Facility

1382 Stealth  
Livermore, CA

## AT MNR Lab

Rev 12-08-09

1,250 sq.ft.

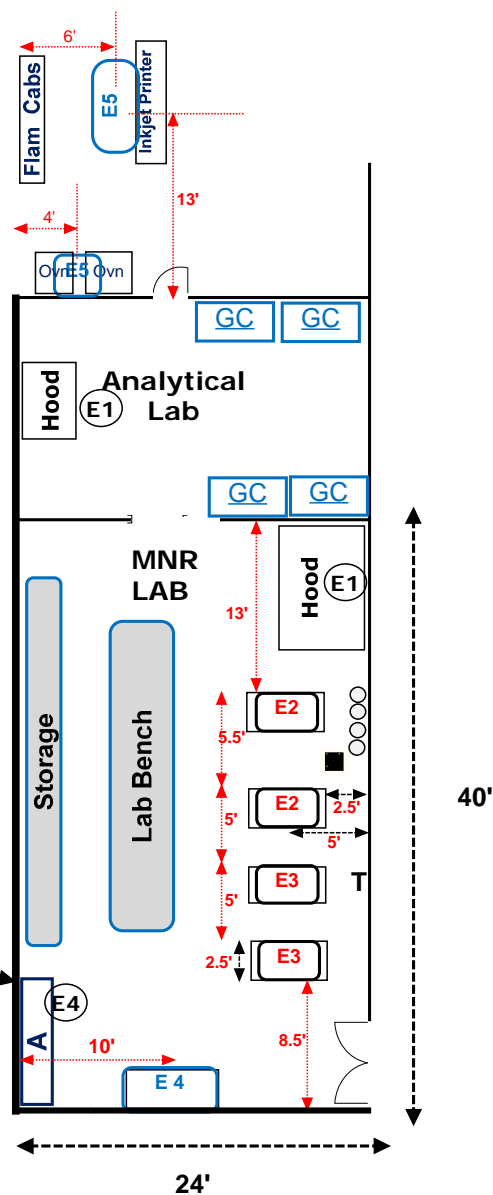
1382 Stealth St  
Livermore, CA

### Solvents

(1, 2, 4 L. bottles)  
Acetonitrile  
Dichloromethane  
Cyclohexane  
Methanol  
Ethanol  
Glycerol  
etc.

### Diluted Gas Cylinders

2% Hydrogen Cyanide  
1.5% Cyanogen Chloride  
0.9% Phosphine  
0.2% Phosgene  
7% Chlorine  
30% Carbon Monoxide  
7% Hydrogen Sulfide



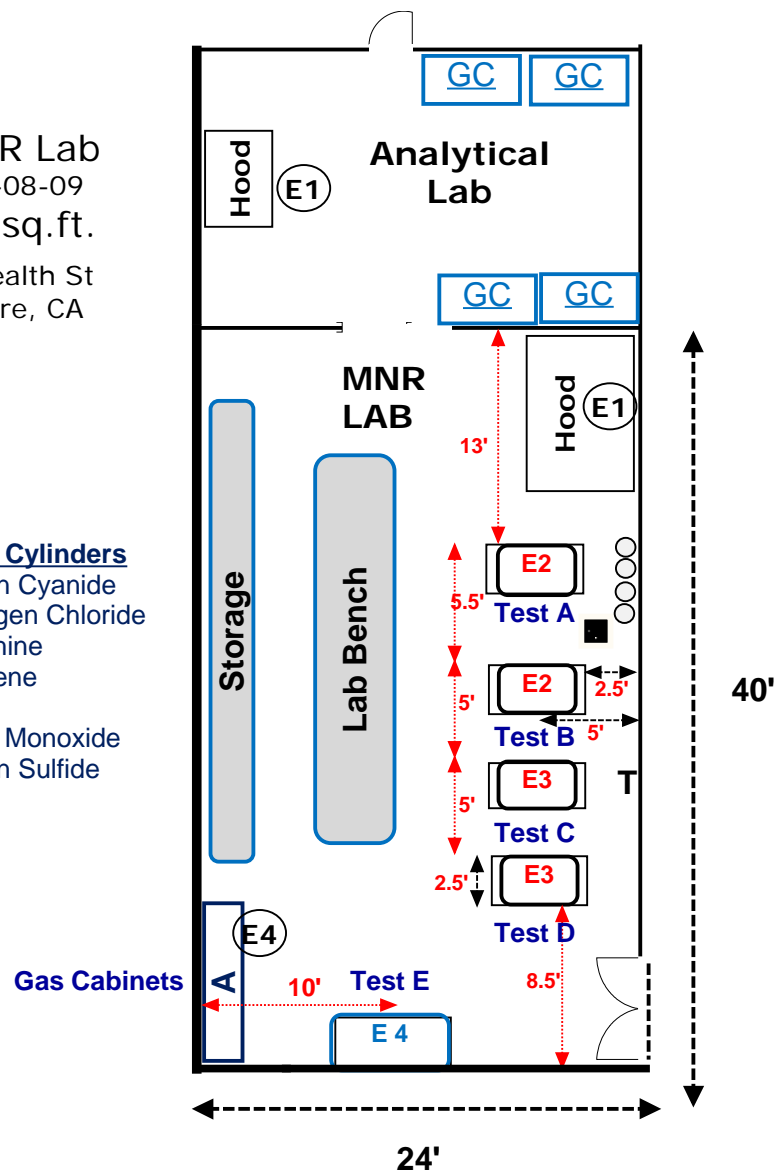


# MNR Lab

(close-up)

AT MNR Lab  
Rev 12-08-09  
1,250 sq.ft.  
1382 Stealth St  
Livermore, CA

Diluted Gas Cylinders  
2% Hydrogen Cyanide  
1.5% Cyanogen Chloride  
0.9% Phosphine  
0.2% Phosgene  
7% Chlorine  
30% Carbon Monoxide  
7% Hydrogen Sulfide



# AT Respirator and Filter Chemical Challenge Test Lab



# Chemical Challenge Testing Benches (+ Sink)





# Lab Center Aisle



# Set-Up Bench & Storage





# AT Respirator and Filter Chemical Challenge Test Lab





Finis

# Ammonia Testing

- **Challenge Level at 1000 mg/M3**
  - Same as some NIOSH tests
  - Monitor by IR
- **Breakthrough Monitoring at 17 mg/M3**
  - Monitor by Colorimetric Tape Method
- **Beyond Breakthrough (up to 170 mg/M3)**
  - Monitor by IR

# Dimethylmethylphosphonate (DMMP) Testing

- **Challenge Level at 3000 mg/M3**
  - There is no NIOSH test
  - Verify Gravimetrically & by FID
- **Breakthrough Monitoring (0.04 mg/M3)**
  - Monitor by Flame Photometric Detector \*
- **Beyond Breakthrough (0.4 mg/M3)**
  - Monitor by FID

---

(\*) We have only found FPD available as part of a GC-FPD  
(Need to purchase soon to complete tests on schedule.)

# Nitrogen Dioxide Testing

- **Challenge Level at 376 & 188 mg/M3**
  - 100 and 200 ppm
  - Similar to NIOSH tests
  - Verify by Titration or Monitor by IR
- **Breakthrough Monitoring**
  - 9 mg/M3 (as NO<sub>2</sub>) or 30 mg/M3 (as NO)
  - Monitor by Electrochemical Monitors
- **Beyond Breakthrough (9/30 mg/M3)**
  - Interrupt Challenge and Monitor by FID

# Hydrogen Cyanide Testing

- **Challenge Level at 4000 mg/M3**
  - Higher than NIOSH tests
  - Verify by Titration
- **Breakthrough Monitoring**
  - 5 mg/M3 HCN and 5 mg/M3 (CN)<sub>2</sub>
  - Monitor by Colorimetric Tape & FID
- **Beyond Breakthrough ( up to 50 mg/M3)**
  - Monitor by FID