

Generation of Vapor-Phase Hydrogen Peroxide Test Atmospheres for the Evaluation of Respirator Cartridges and Air Samplers

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Hydrogen Peroxide

Common substance with unusual properties

- I have a bottle in the bathroom.
- How bad can it be?

Hydrogen Peroxide

(VHP = Vapor Phase Hydrogen Peroxide)



Traditional Uses:

- Consumer Pharmaceutical
 - Antimicrobial
- Industrial
 - Oxidizing Agent
- Aerospace
 - Propellant (rocket fuel)

H₂O₂ Regulatory Concerns (formerly)

- Traditional Uses of H₂O₂
 - Used Low concentrations (3%)
 - Or, were well-contained
- Small number of exposed employees

H₂O₂ Regulatory Concerns (new)

New Application !

Medical Sterilizing Agent

Sterilizing Agent with lower risk profile than

Ethylene Oxide

Glutaraldehyde

Formaldehyde

H₂O₂ Regulatory Concerns (new)

Medical Sterilization performed in 1000's
of hospitals, surgical centers, and
medical mfg facilities

Sterilization generates high vapor levels
(100's of ppm)
> 25,000 employees exposed

REL = TLV = PEL = 1.0 ppm

Project Needs

- Evaluate Respirator Cartridges
 - Challenge with levels of VHP near IDLH
- Evaluate Personal Monitoring Methods
 - Expose to VHP Levels near PEL

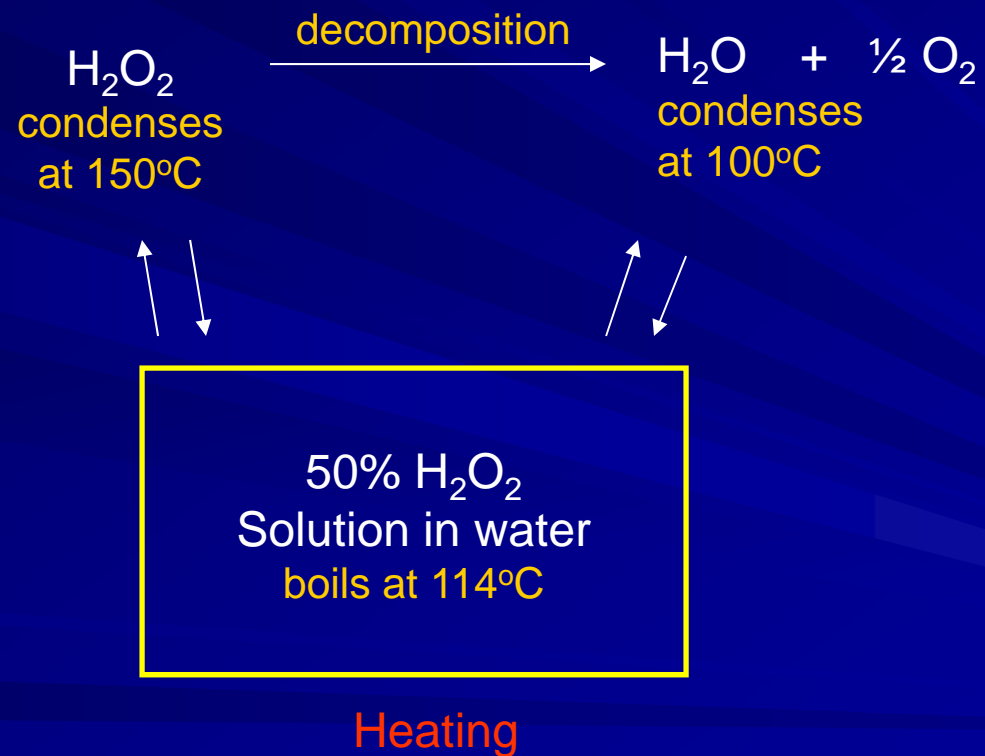
Goals of Study

- Generate VHP (vapor phase H_2O_2)
 - from PEL to IDLH or higher
 - PEL = 1 ppm IDLH = 75 ppm
- Detect and Measure H_2O_2
 - Direct Reading & Personal Sampling
 - 0.1 - 75 ppm

Generating H₂O₂ Vapor for Testing (issues)

- Not available in gaseous form
- Available as a 3-50% solution in water
 - Strongly attracted to water

Hydrogen Peroxide Interactions

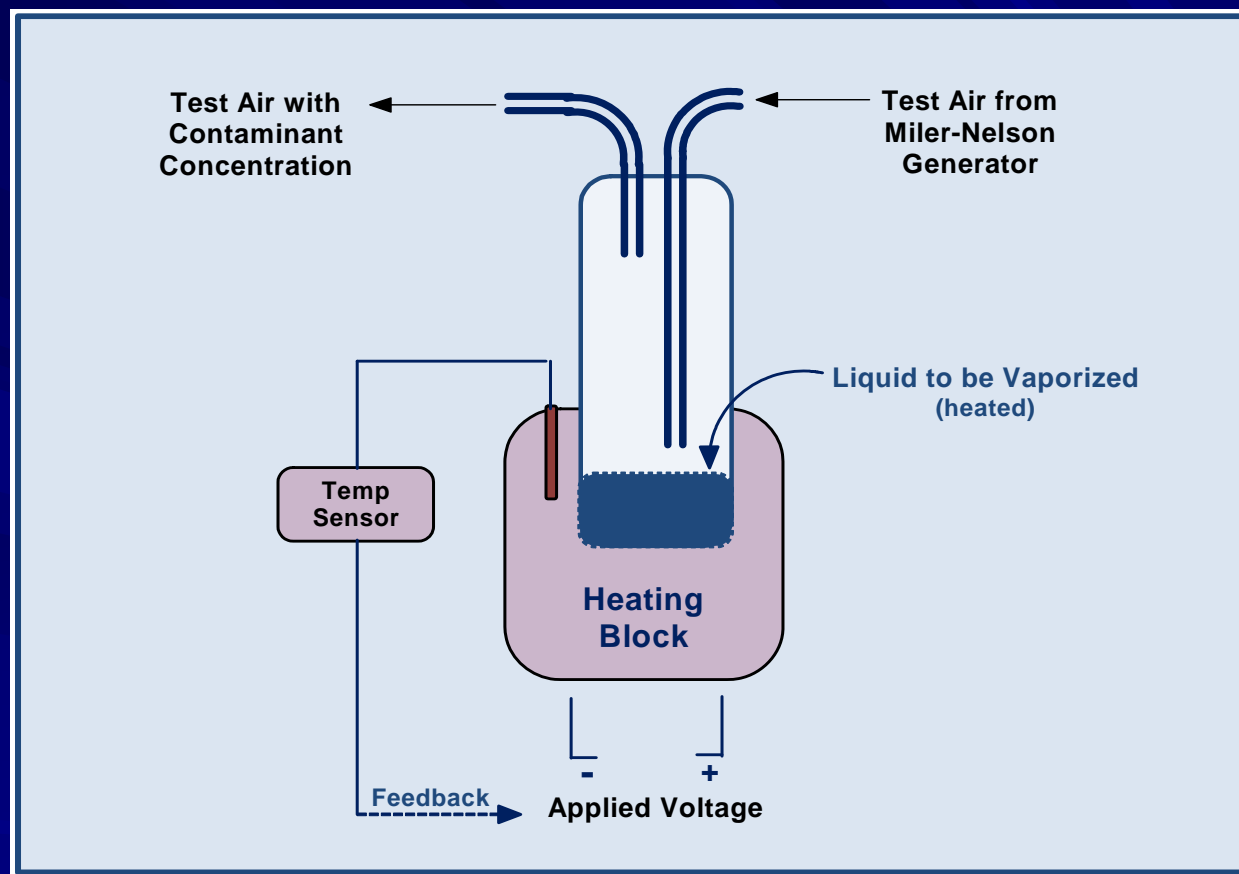


Vaporization Methods for Liquids

(3 attempted in this study)

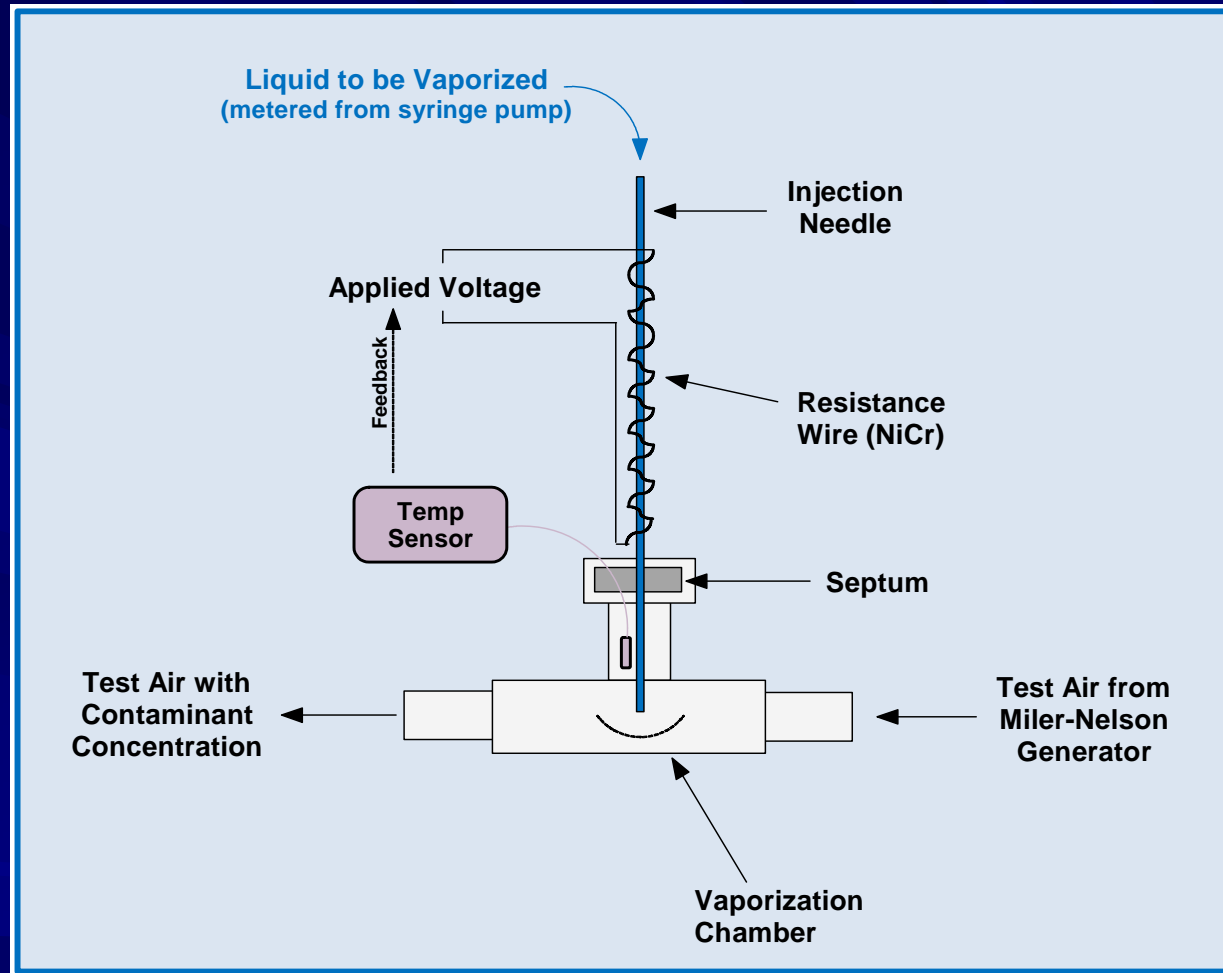
- **Equilibration with Heated Liquid**
 - Air or N₂ stream passes over heated liquid
- **Liquid Injection through Heated Needle**
 - directly into test air stream
- **Liquid Injection into Heated Chamber**
 - chamber located in test air stream

Test Air Passes Over Heated Liquid



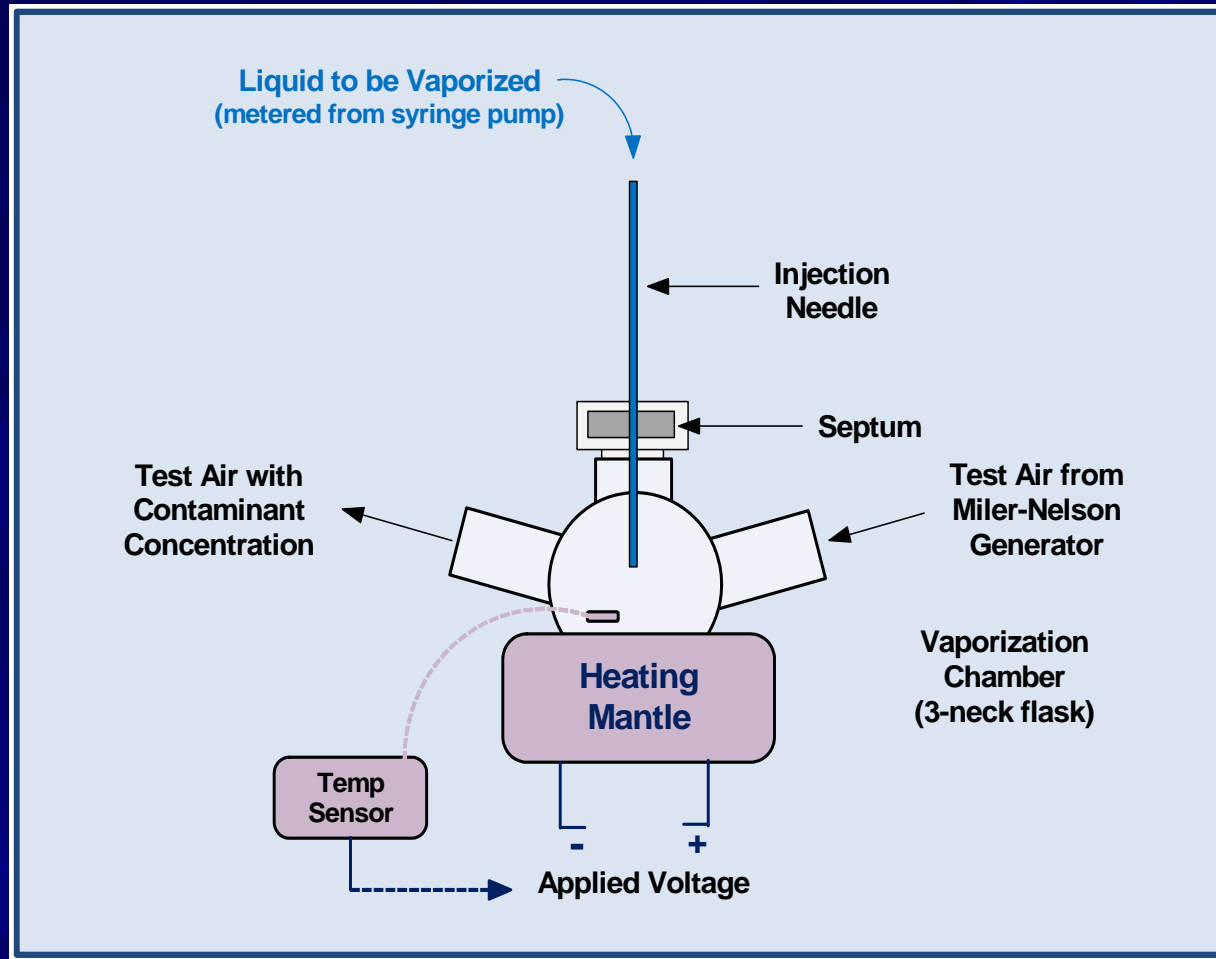
- Highest Concentration Attainment (> 1,000 ppm)
- Liquid components separate by volatility (boiling point)

Heated Needle Vaporization



- Vaporizes 100% of liquid (does not separates components)
- Lowest Concentration Attainment (1-50 ppm)

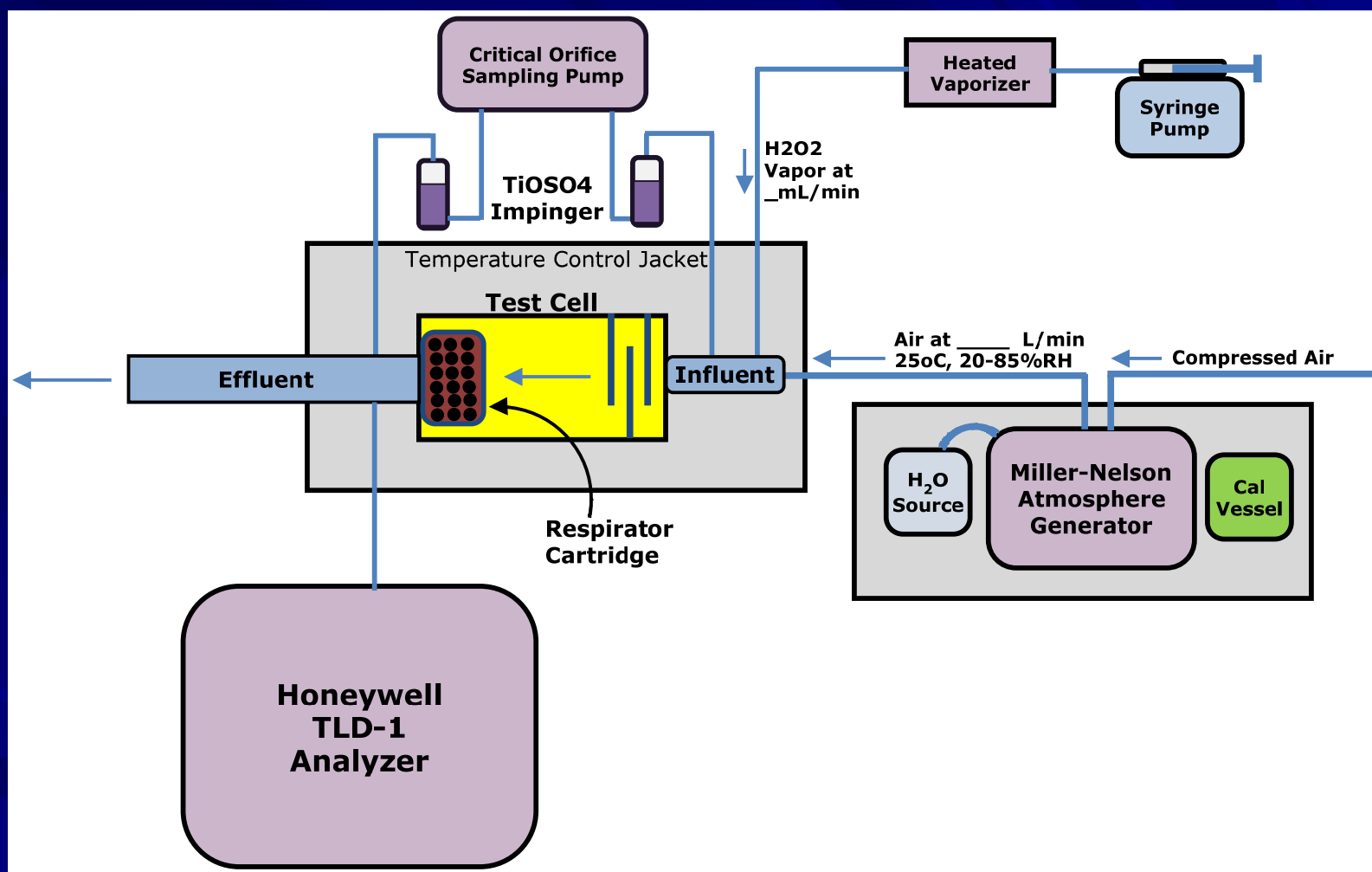
Heated Chamber Vaporization



- Higher Concentration Attainment than Heated Syringe (to 500 ppm)
- Does not separate liquid components (if careful)

Evaluating Respirator Cartridges

(Schematic)



VHP Sampling Methods

Hydrogen Peroxide Challenge Sampling Method

■ OSHA Method ID 006

– Impinger Containing TiOSO_4 Solution

■ TiOSO_4 Forms Yellow Complex with H_2O_2

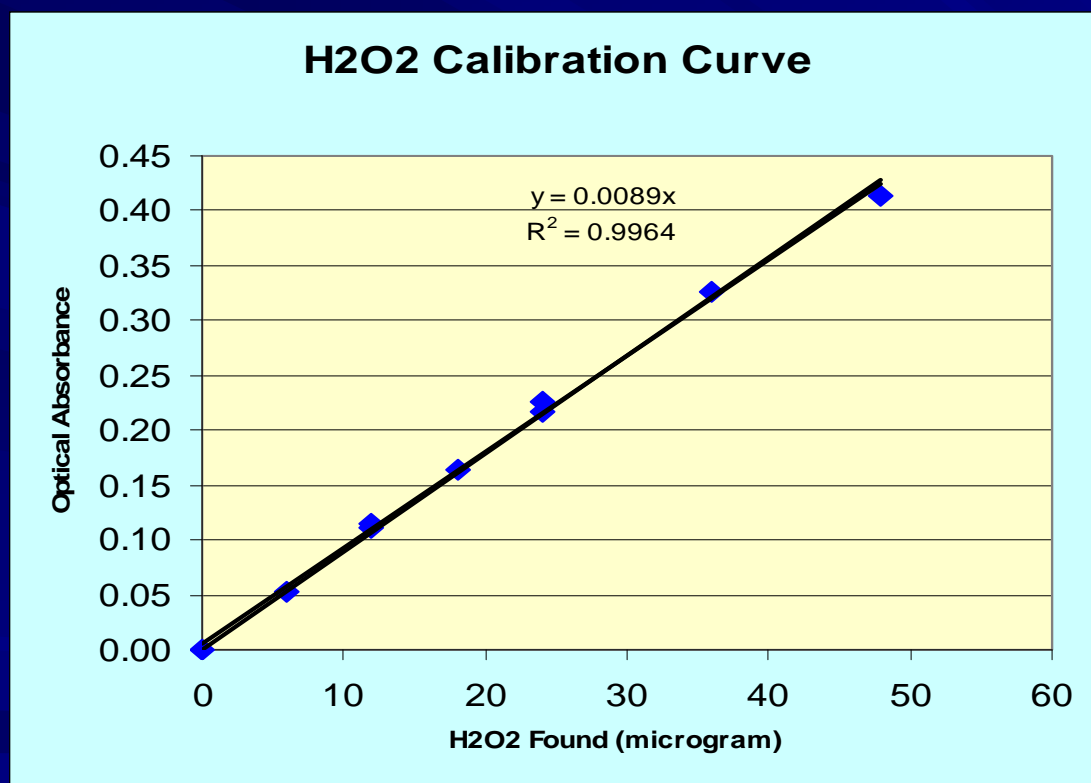
– Analysis by UV Spectrometer

– 0.1 – 150 ppm

■ by varying sampling time



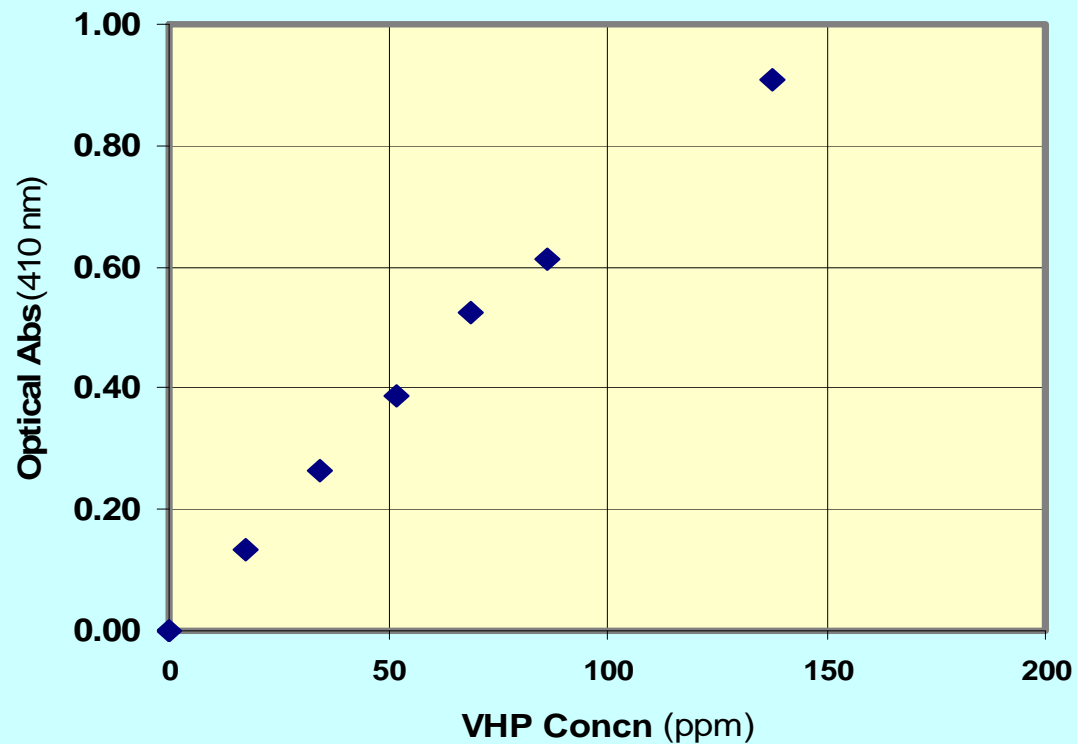
Analysis of H₂O₂ using OSHA ID 006



H₂O₂ Analysis (high levels)

OSHA ID 006 Impinger

Sampling Rate = 1 L/min; Sampling Time = 2 min



Hydrogen Peroxide

Breakthrough Sampling Methods

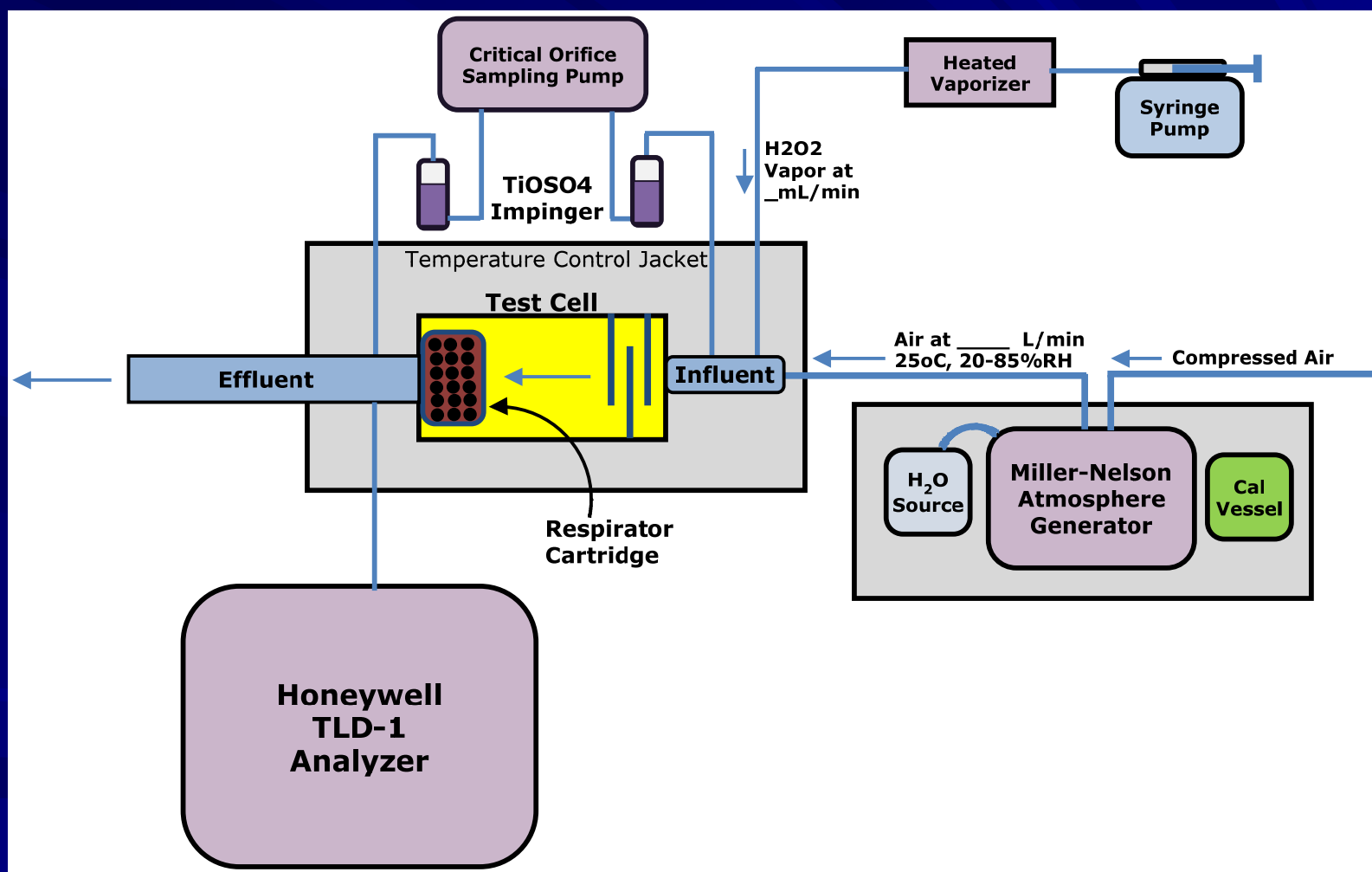
- Infra Red Spectrometry
 - Interference by Water
 - FTIR can avoid water interference
 - Cost = \$65,000

- Honeywell TLD-1 (Chem Key)
 - Paper tape reading device
 - Reagent forms color with H_2O_2
 - Measures 0.1-3ppm



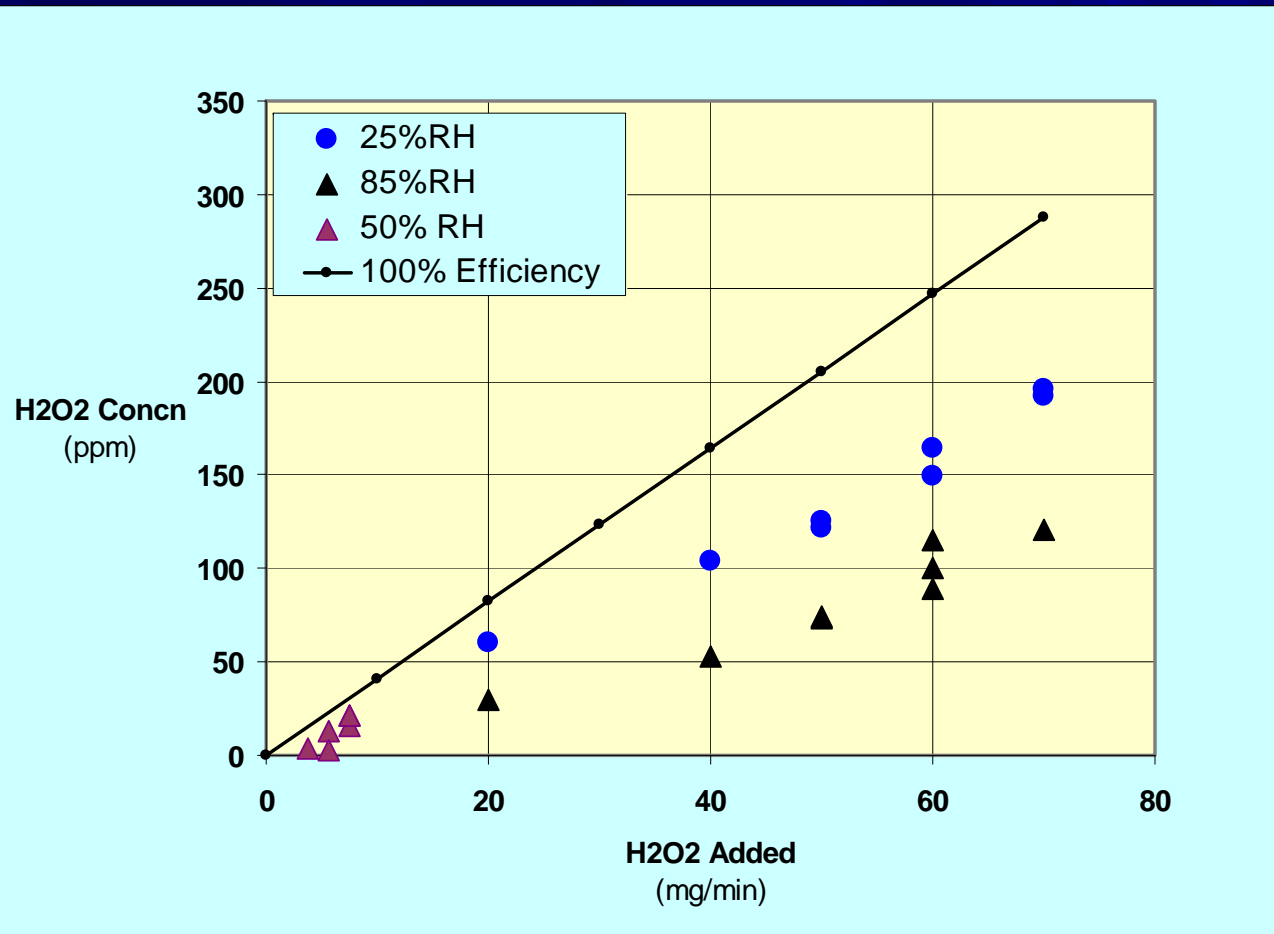
Evaluating Respirator Cartridges

(Schematic)

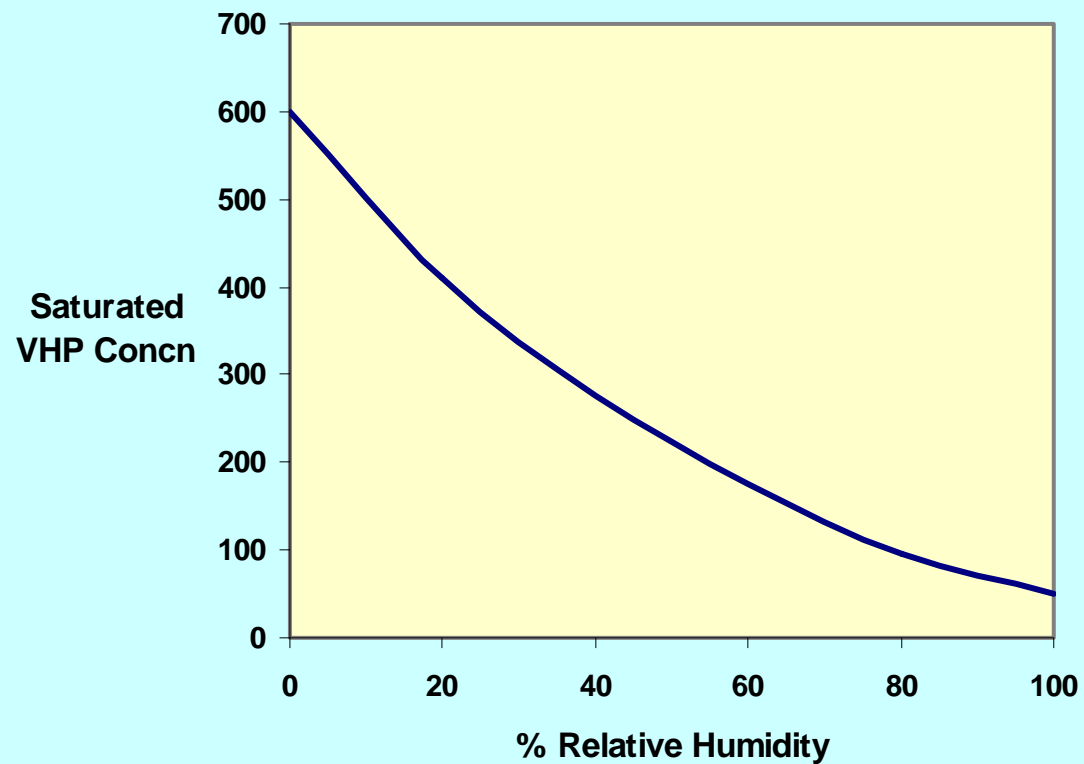


H₂O₂ Generation

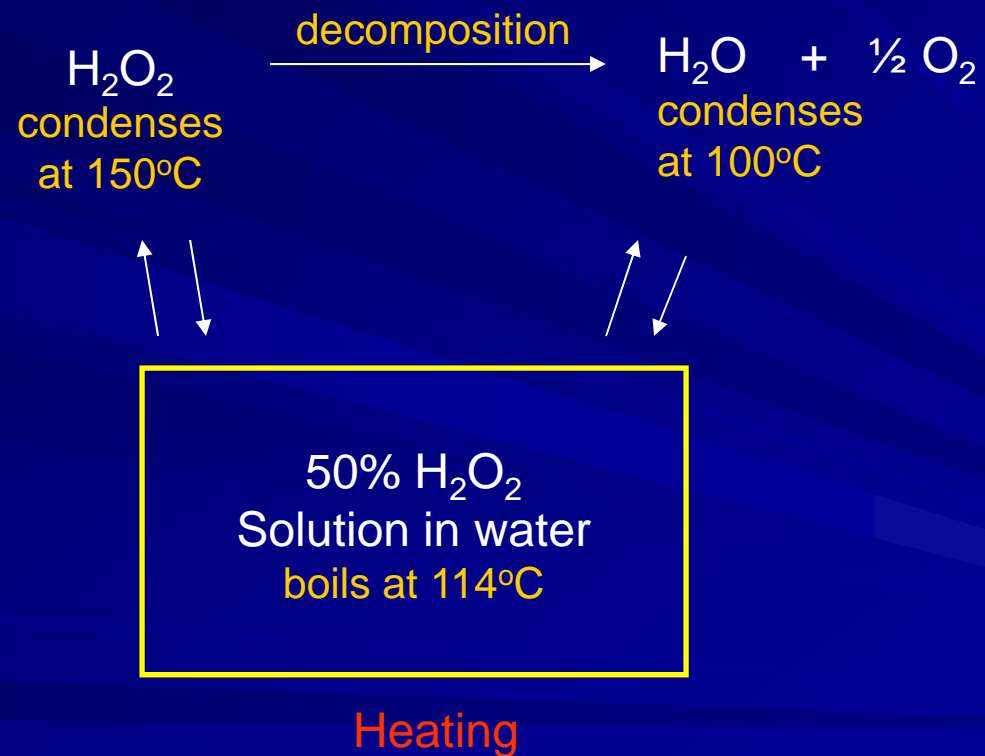
Humidity Effects



VHP Vapor Pressure is Limited at High Humidity

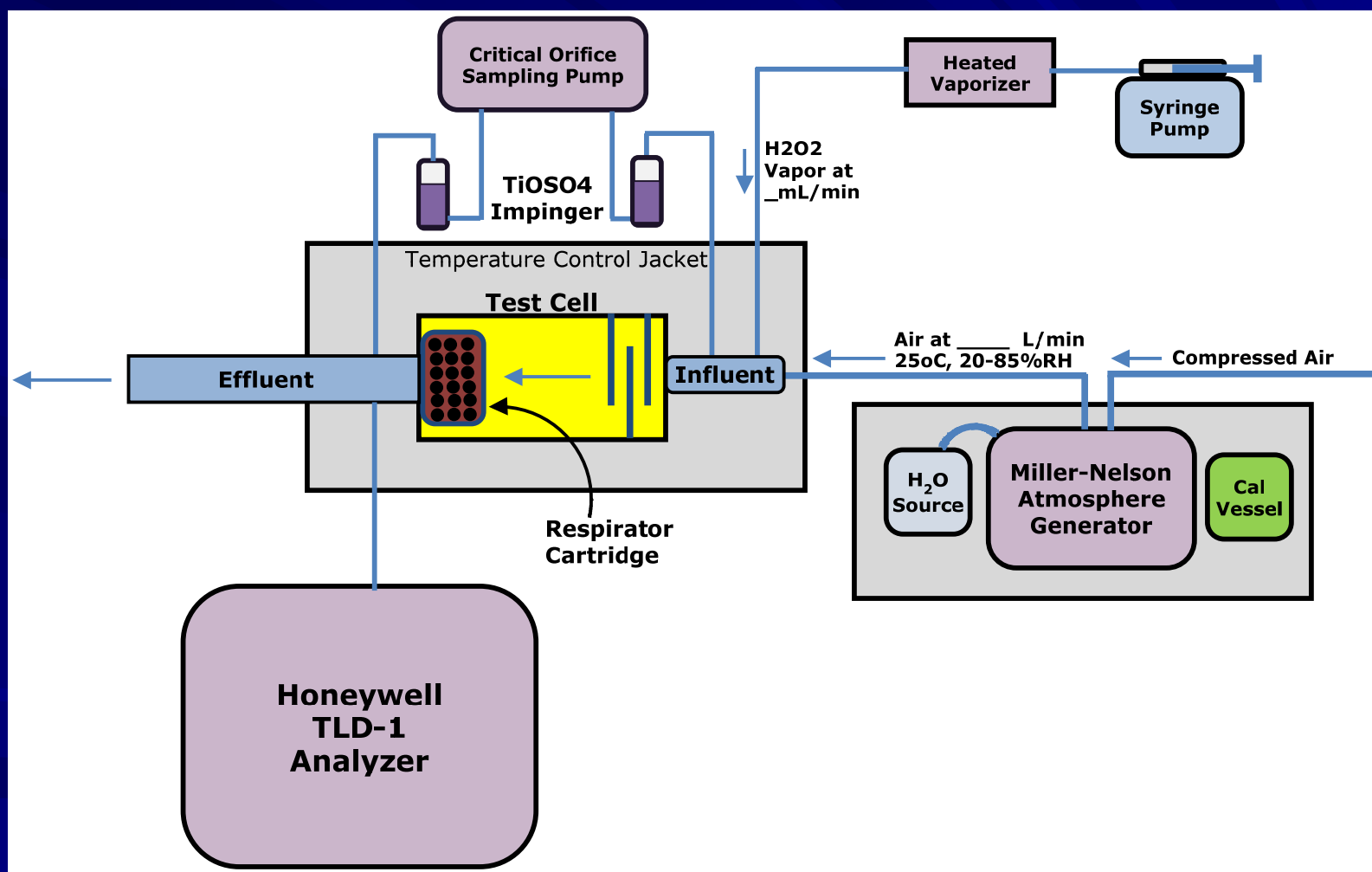


Hydrogen Peroxide Interactions



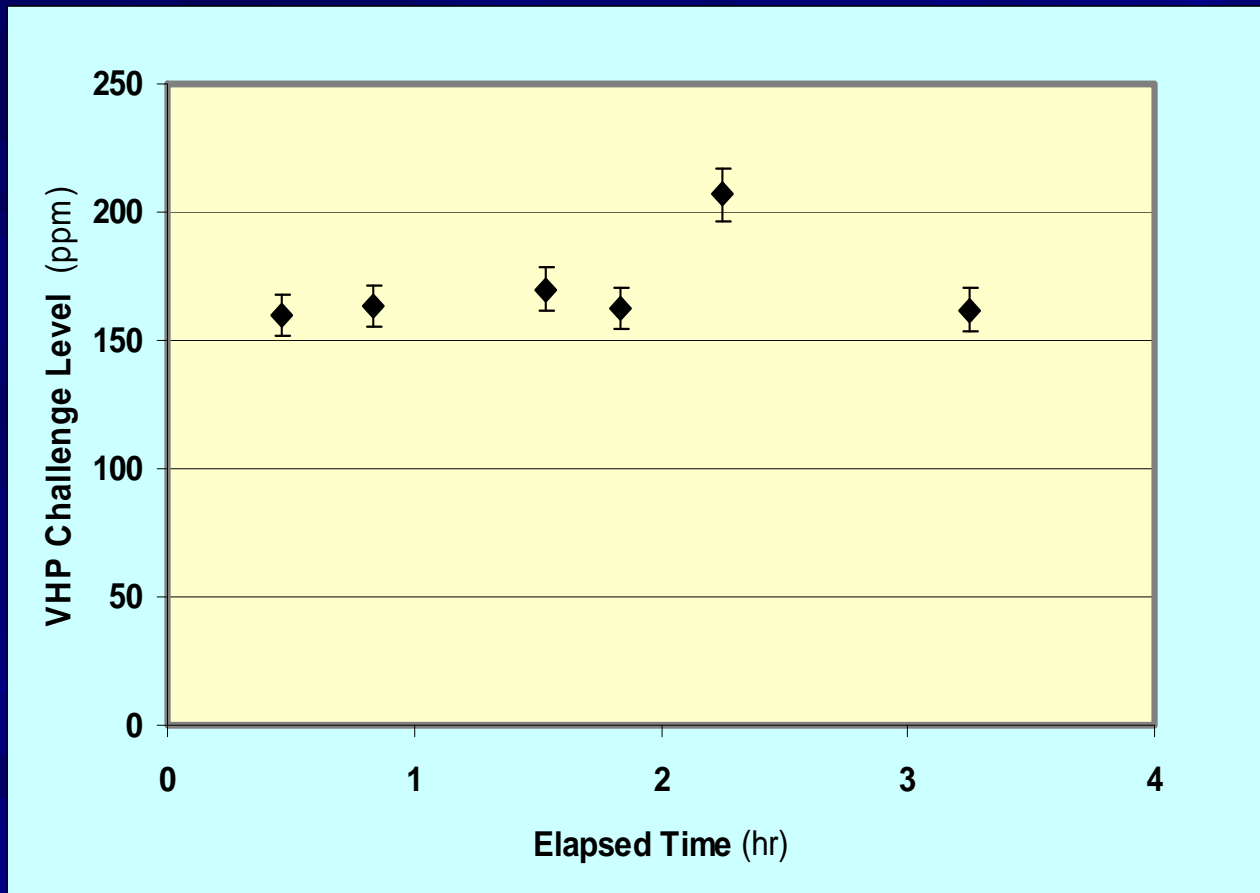
Evaluating Respirator Cartridges

(Schematic)



Accuracy of VHP Challenge

Challenge Level vs Testing Time



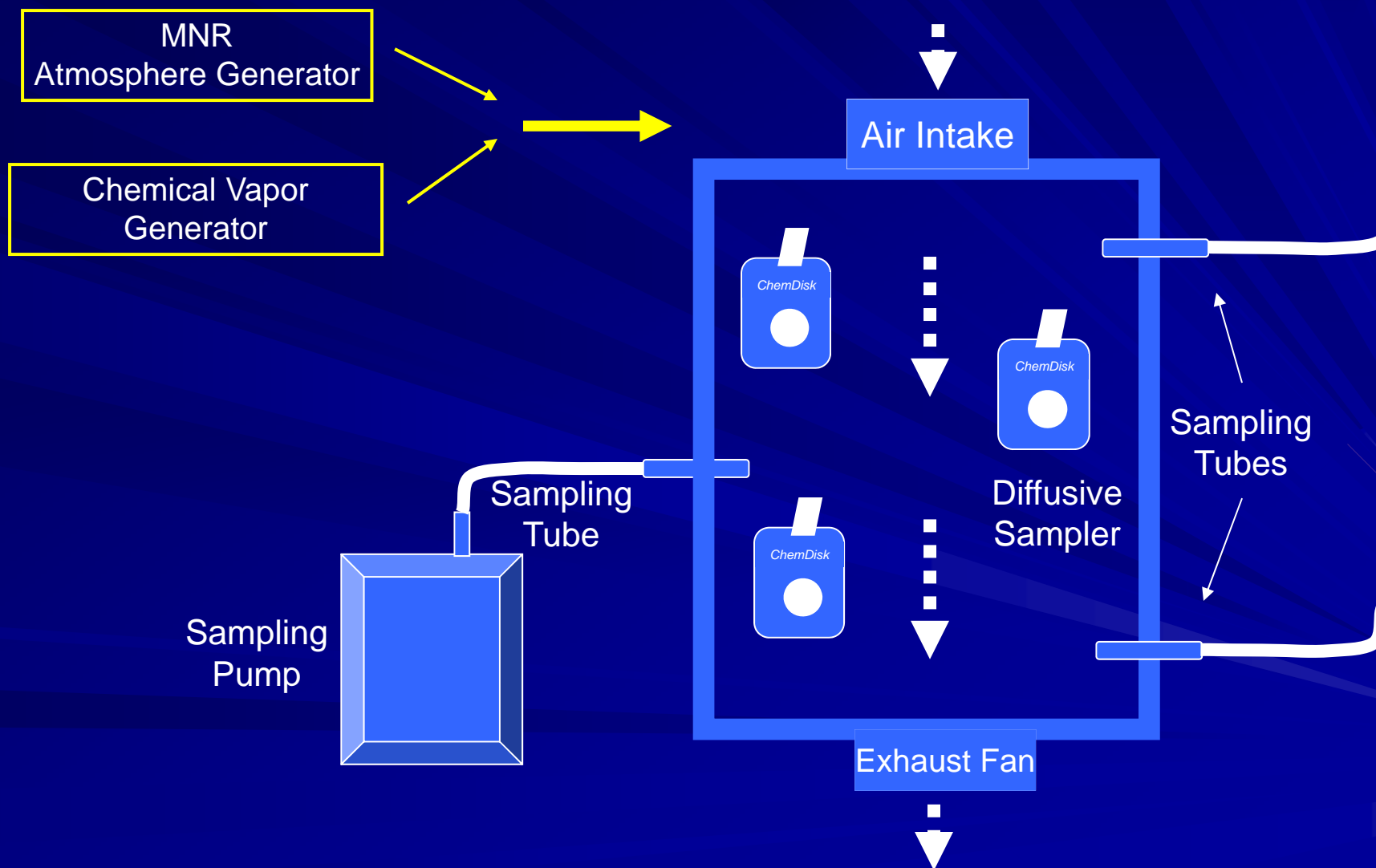
Conclusions

- Vapor Phase Hydrogen Peroxide (VHP) can be generated by injecting 50% aqueous H_2O_2 solution into a heated glass chamber with challenge air passing over.
 - Challenge Levels from 50 - 150 ppm
 - Flow Rates from 50 - 175 L/min
- Vaporization Efficiency decreases as %RH increases
 - 75 ppm (IDLH) can be generated at 85% RH
 - 150 ppm can only be generated with difficulty at higher RH
- Challenge Levels of VHP can be monitored using OSHA ID 006 utilizing TiOSO_4 reagent in a glass impinger.
 - Operating range 0.1 – 150 ppm
- Breakthrough Levels of VHP may be monitored using a Honeywell TLD-1 Analyzer.
 - Operating range 0.1 – 3ppm

Hydrogen Peroxide

- Evaluation of Personal Samplers

Concept of Side-by-Side Sampler Comparison

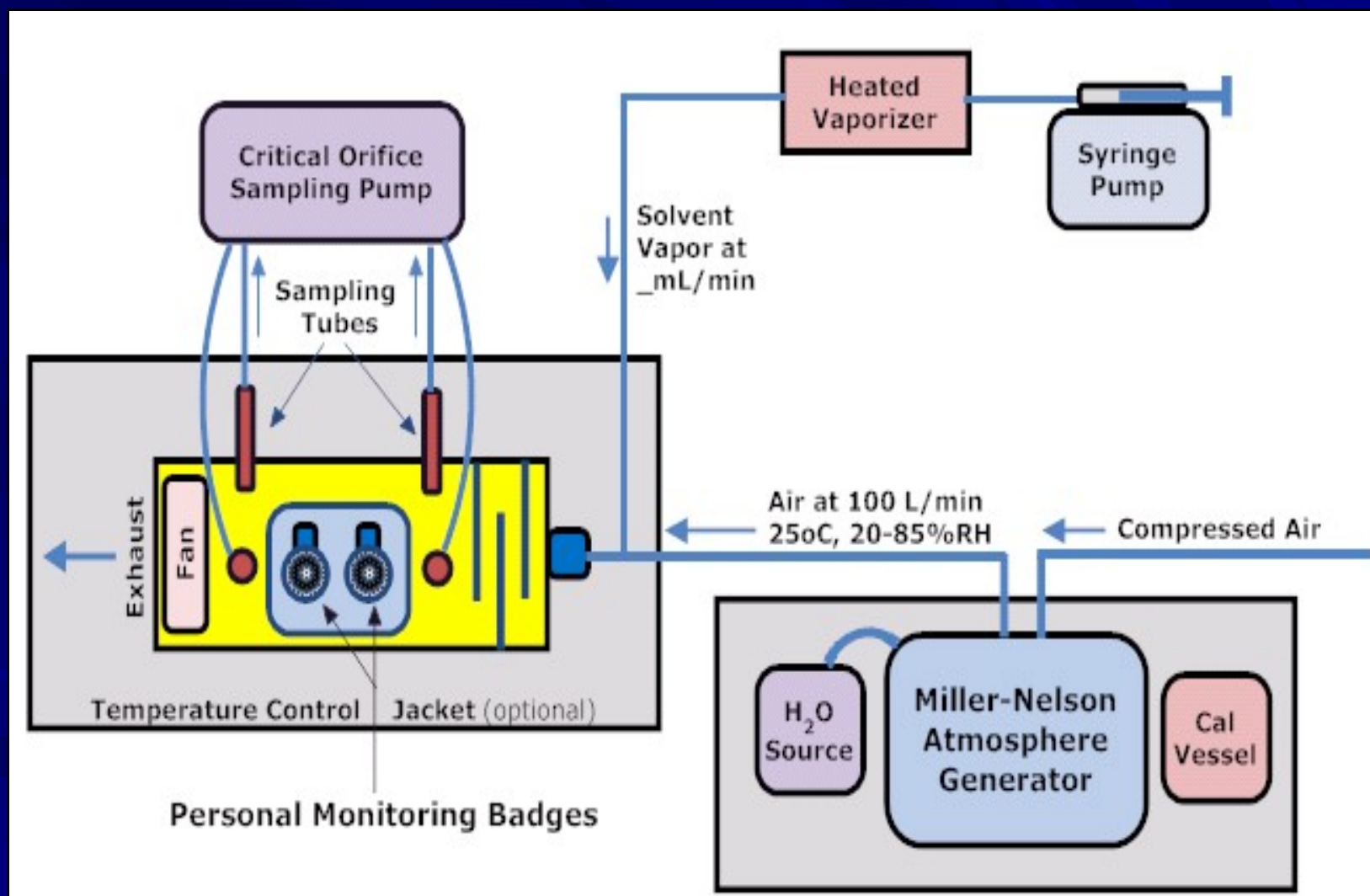


Comparison of Samplers

(Hydrogen Peroxide)



Evaluating Air Samplers (schematic)



Hydrogen Peroxide

Personal Sampling Methods

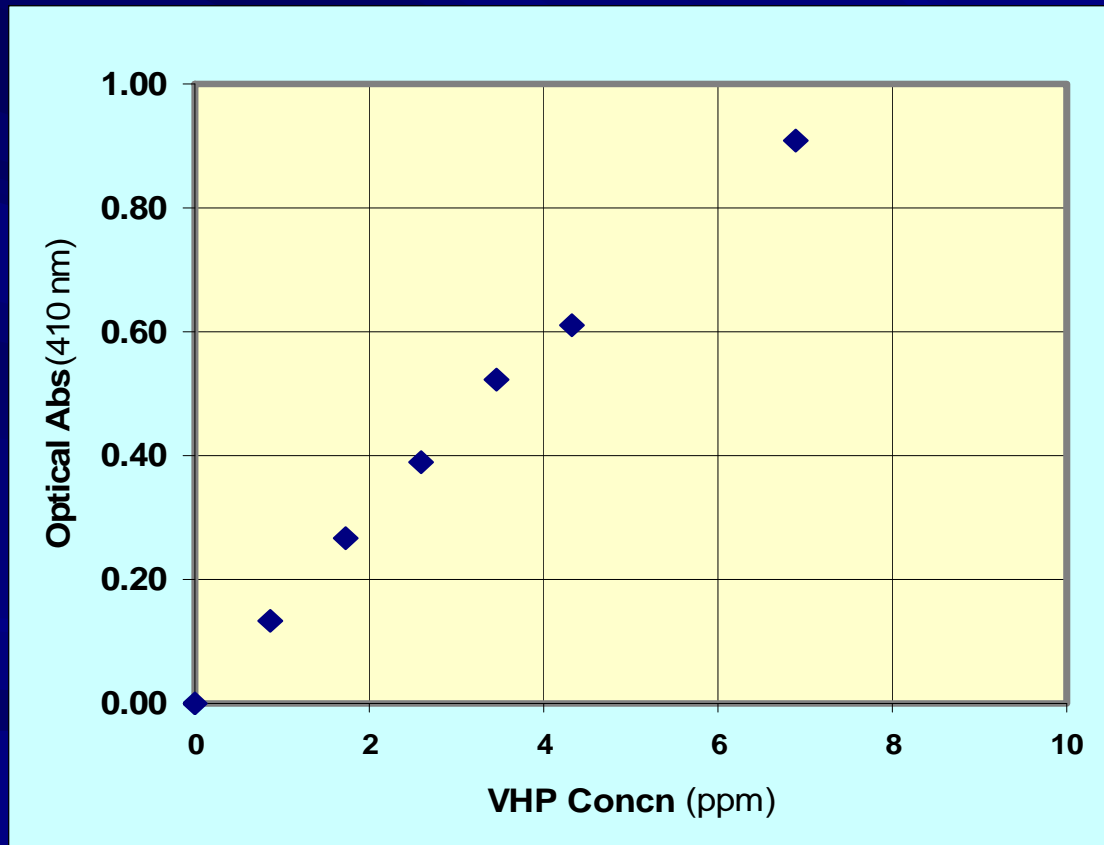
- OSHA Method ID 006 ✓
 - Impinger Containing TiOSO_4 Solution
 - TiOSO_4 Forms Yellow Complex with H_2O_2
 - Analysis by UV Spectrometer

- Diffusive Sampler (from OSHA Method) ✓
 - Personal Monitoring Badge Containing TiOSO_4
 - TiOSO_4 Forms Yellow Complex with H_2O_2
 - Analysis by UV Spectrometer

H₂O₂ Analysis (low levels)

OSHA ID 006 Impinger

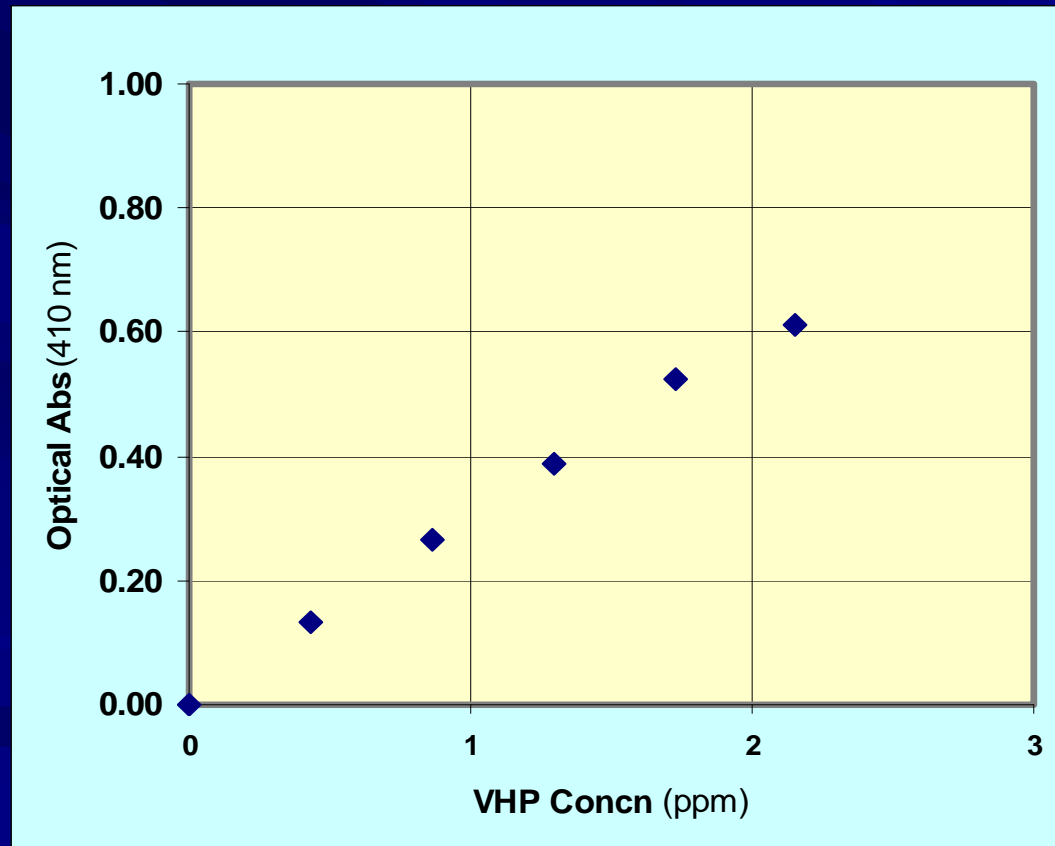
Sampling Rate = 1 L/min; Sampling Time = 40 min



H₂O₂ Analysis

Personal Monitoring Badge

Sampling Rate = 90 mL/min; Sampling Time = 4 hour



Conclusions

- Vapor Phase Hydrogen Peroxide (VHP) can be generated by injecting 50% aqueous H_2O_2 solution into a heated glass chamber with challenge air passing over.
 - Challenge Levels from 0.2 - 10 ppm
 - Flow Rates from 50 – 150 L/min
- Low Levels of Vapor Phase Hydrogen Peroxide (for TWA personal sampling) were monitored side-by-side using OSHA ID 006 and a Personal Monitoring Badge designed using similar chemistry.
 - Operating range 0.1 – 10 ppm

Conclusion

- Diffusive Samplers (Personal Monitoring Badges) based on TiOSO_4 chemistry perform similarly to the OSHA ID 006 method, but with increased convenience.
 - Eliminate need for Glass Impingers
 - Operating range 0.1 – 10 ppm

Finis