

This presentation should not be considered a final statement of NIOSH policy or of any agency or individual who was involved. This information is intended for use in advancing knowledge needed to protect workers.

National Personal Protective Technology Laboratory

Continued Discussions of Concepts for
Standards for Approval of Respirators for
Use Against Chemical, Biological,
Radiological and Nuclear Agents (CBRN)
and Concepts for Standards for
Industrial Powered Air Purifying
Respirators

Sheraton Station Square, Pittsburgh, PA

December 13, 2005



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

CBRN Respirator Standards

The findings and conclusions in this presentation have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

Agenda – December 13, 2005

9:00 – 9:15	Administrative Remarks	Jon Szalajda, NIOSH
9:15 – 9:30	Welcome and NPPTL Overview	Les Boord, NIOSH
9:30 – 10:15	CBRN PAPR Strategy *Step 1 Concept *Retrofit	Jon Szalajda, NIOSH Bill Hoffman, NIOSH
10:15- 10:30	Break	
10:30- 11:30	PAPR Strategy *CBRN Step 2 *Industrial Standard	Jon Szalajda, NIOSH Bill Hoffman, NIOSH
11:30- 12:00	PAPR Benchmark Testing	Terry Thornton, NIOSH Rich Vojtko, EG&G Jeff Palcic, EG&G

Agenda – December 13, 2005

12:00 - 1:10	Lunch	
1:10 – 2:15	PAPR Benchmark Testing (Continued)	
2:15 – 2:30	Break	
2:30 – 3:00	Facial Leakage Study	Kathryn Butler, NIST
3:00 – 4:30	CBRN Closed Circuit SCBA	Jon Szalajda, NIOSH John Kovac, NIOSH Frank Palya, NIOSH Tim Rehak, NIOSH
4:30 – 5:00	Open Comment Period	
5:00	Wrap-up and Adjourn	Jon Szalajda, NIOSH



Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

Meeting Logistics

Sign in sheets

Please silence cell phones and pagers

Meeting recorded and transcribed verbatim for docket

Presentation in accordance with the agenda

Q & A period after each presentation

- Comment at microphone; identify name and affiliation
- Additional presentations – sign up at registration desk

Information Docket CBRN PAPR

- **Mail:**
NIOSH Docket Office
Robert A. Taft Laboratories, M/S C 34
PAPR – NIOSH 010
4676 Columbia Parkway
Cincinnati, OH 45226
- **Email:** niocindocket@cdc.gov
- **Fax:** (513) 533-8285
- **Phone:** (513) 533-8303
- **NPPTL Web Site:** <http://www.cdc.gov/niosh/npptl>

Information Docket Industrial PAPR

- **Mail:**
NIOSH Docket Office
Robert A. Taft Laboratories, M/S C 34
PAPR – NIOSH 008
4676 Columbia Parkway
Cincinnati, OH 45226
- **Email:** niocindocket@cdc.gov
- **Fax:** (513) 533-8285
- **Phone:** (513) 533-8303
- **NPPTL Web Site:** <http://www.cdc.gov/niosh/npptl>

Information Docket CBRN CC SCBA

- **Mail:**
NIOSH Docket Office
Robert A. Taft Laboratories, M/S C 34
PAPR – NIOSH 039
4676 Columbia Parkway
Cincinnati, OH 45226
- **Email:** niocindocket@cdc.gov
- **Fax:** (513) 533-8285
- **Phone:** (513) 533-8303
- **NPPTL Web Site:** <http://www.cdc.gov/niosh/npptl>

National Institute for Occupational Safety and Health (NIOSH) / National Personal Protective Technology Laboratory (NPPTL)

CBRN Respirator
Standards Public
Meeting

December 13, 2005

Les Boord



NORA / NIOSH Program Sectors

- Agriculture, forestry, and fishing
- Construction
- Healthcare and social assistance
- Mining
- Manufacturing
- Services
- Transportation, warehousing, and utilities
- Wholesale and retail trade



NIOSH Cross-Sector Programs

- Authoritative Recommendations Development
- Cancer, reproductive, cardiovascular, neurologic & renal diseases
- Communications and information dissemination
- Emergency preparedness/response
- Global collaborations
- Health hazard evaluation (HHE)
- Hearing loss prevention
- Immune, dermal and infectious diseases
- Musculoskeletal disorders
- **Personal protective technology**
- Radiation dose reconstruction
- Respiratory diseases
- Training grants
- Traumatic injury
- Work organization and stress-related disorders

NIOSH Coordinated Emphasis Areas

- **Economics**
- **Exposure assessment**
- **Engineering controls**
- **Work life initiative**
- **Occupational health disparities**
- **Small business assistance and outreach**
- **Surveillance**



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

NORA Town Hall Meetings

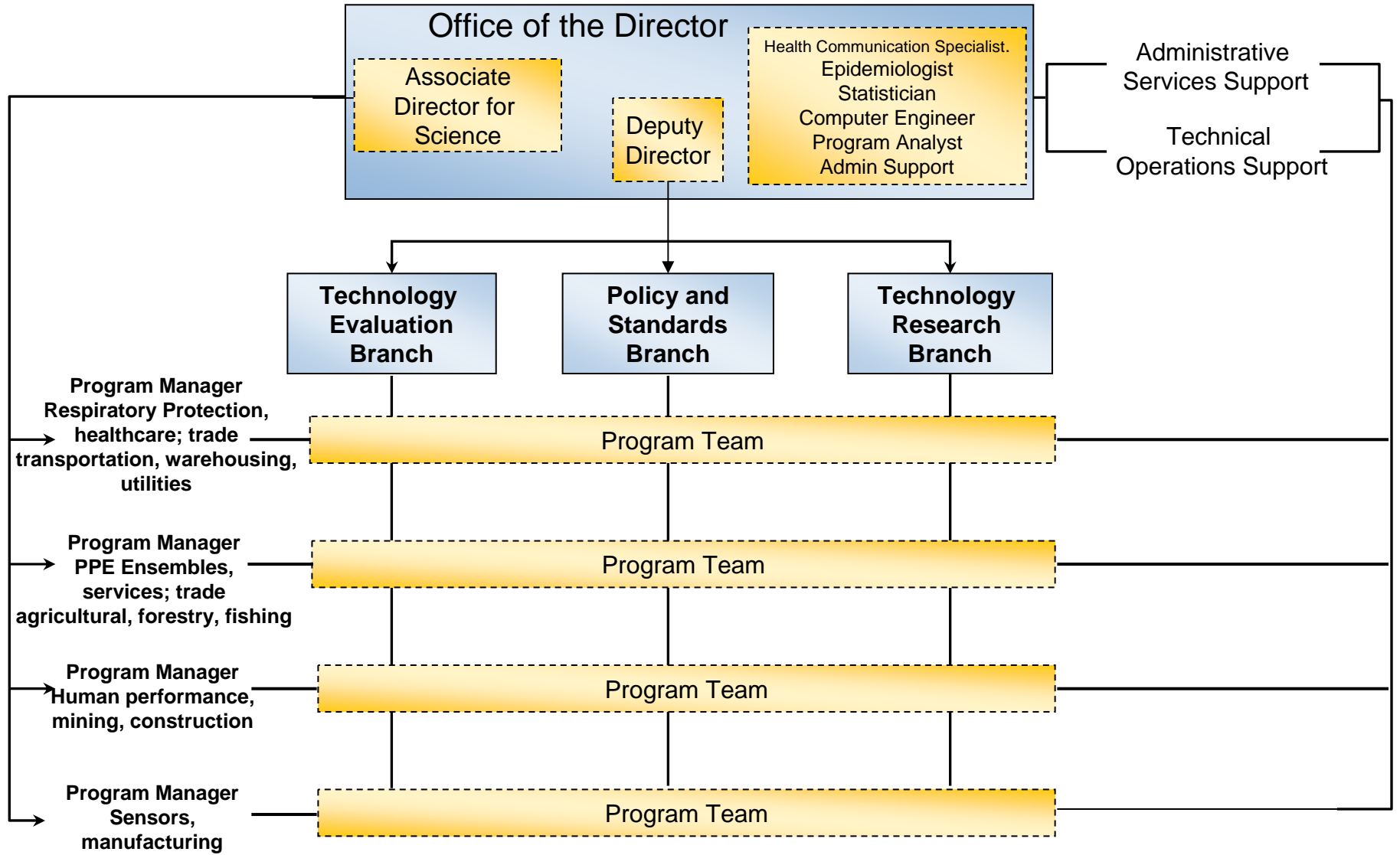
<u>Date</u>	<u>Location</u>	<u>Sector</u>
<u>December 5</u>	College Park, Maryland	Transportation, Warehousing and Utilities
<u>December 19</u>	Chicago	Construction
<u>January 17</u>	Seattle	Agriculture, Forestry and Fishing
<u>January 23</u>	Houston	Healthcare & Social Assistance
January 30	Jackson, Mississippi	Regional meeting
February 13	Tampa	Wholesale and Retail Trade
February 17	Iowa	Regional Meeting
February 21	Los Angeles	Public and Private Services
February 27	Salt Lake City	Mining
March 6	Troy , Ohio	Manufacturing
March 13	Washington D.C.	Wrap-Up

NIOSH



- Office of the Director, NIOSH
- Office of Extramural Programs
- Pittsburgh Research Laboratory (PRL)
- **National Personal Protective Technology Laboratory (NPPTL)**
- Division of Respiratory Disease Studies (DRDS)
- Division of Safety Research (DSR)
- Health Effects Laboratory Division (HELD)
- Education and Information Division (EID)
- Division of Applied Research and Technology (DART)
- Division of Surveillance Hazard Evaluation and Field Studies (DSHEFS)
- Office of Compensation Analysis and Support (OCAS)
- Research to Practice (R2P)
- Spokane Research Laboratory

NPPTL Organizational Chart



NPPTL Organizational Chart

- Associate Director for Science: M. D'Alessandro
- Deputy Director: Ken Williams
- Technology Evaluation Branch Chief: Heinz Ahlers
- Policy & Standards Branch Chief: Jon Szalajda
- Technology Research Branch Chief: Ron Shaffer
- Respiratory Protection PM: Roland Berryann
- Sensor Technology PM: George Bockosh
- Human Performance PM: John Kovac
- Ensemble PM: Bill Haskell

CBRN Respirator Certification

- **CBRN SCBA: 41 approvals issued to 6 manufacturers**
- **CBRN SCBA Upgrade: 11 approvals (retrofit) issued to 2 manufacturers**
- **CBRN APR:**
 - 6 approvals issued to 4 manufacturers
 - Additional approvals pending
- **CBRN Escape:**
 - 2 approvals issued to 2 manufacturers



Customer Relationships and Satisfaction

- **National Academies Involvement in NPPTL**

- *Committee on PPE for the Workforce (COPPE)*
- *Review of Anthropometrics Survey and Respirator Panel Modifications*
 - *Next Meeting Feb 9, 2006 Irvine, CA*
- *Review of BLS Survey of Respirator Use*

- **Customer surveys**

- *Customer Satisfaction Survey (CSS)*
- *Point of Service (POS) Surveys*

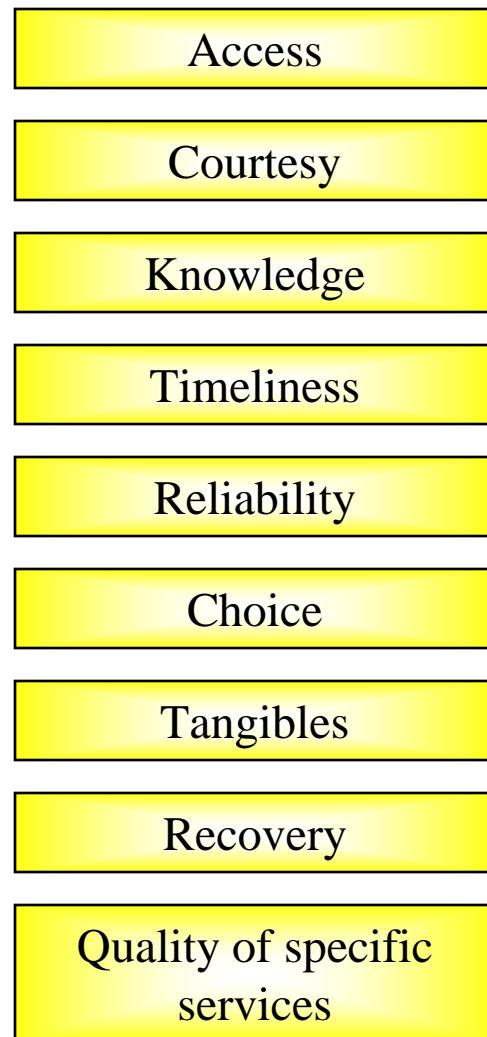
- **Customer Satisfaction Council**

- *Council of 9 – 10 Customers*
- *Council Coordinator: Tom Pouchot*
- *Meet 3 times annually*
- *First Meeting Spring 2006*

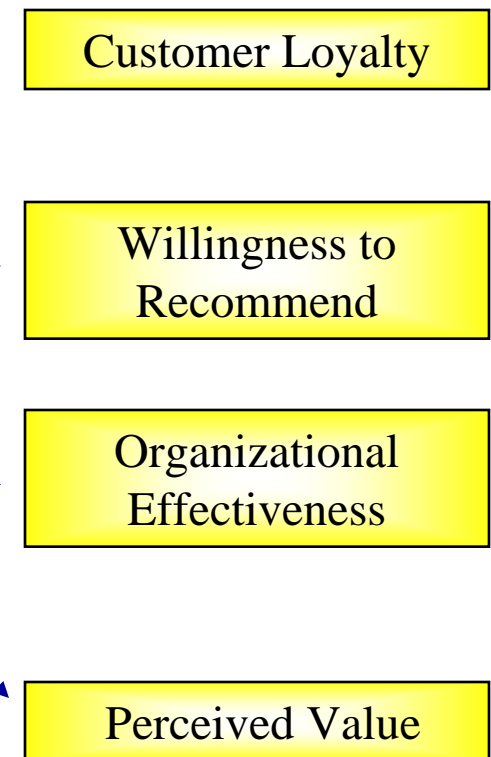
**Deliberate
and
Systematic
Activities
Proactive vs
Reactive**

Customer Service Dimensions and Outcomes

Service Dimensions



Organizational Outcomes



Quality Partnerships Enhance Worker Safety & Health



Visit Us at: <http://www.cdc.gov/niosh/npptl/default.html>

Thank you

National Personal Protective Technology Laboratory

CBRN PAPR Standard Development Overview and Step 1 Concept

Sheraton Station Square

Pittsburgh, PA

Jonathan Szalajda

December 13, 2005



Workplace
Safety and Health



NPPTL Research to Practice
through Partnerships

Why we are here: Continuing Threat of Terrorism

Major attacks Since 1999:

1999-- Russian Apartment Bombings

2000-- USS Cole

2001 – 9/11, Moscow Metro, Anthrax

2002 – Beltway sniper; Moscow Theater

2003 – Riyadh Compound

2004 – Madrid

2005 – London

2006 -- ?



Source:http://en.wikipedia.org/wiki/Terrorist_attack#2000



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

Purpose of the Meeting

To continue discussions of:

(1) Concepts for standards and testing processes for PAPR and Closed Circuit SCBA suitable for respiratory protection against CBRN agents

(2) Conceptual discussions for establishing Industrial PAPR requirements



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

Quality Partnerships Enhance Safety and Health



CBRN Respirator Standards Impact

- **NIOSH CBRN Respirator Standards have been recognized and adopted by:**
 - **The DOD/DHS InterAgency Board**
 - **DHS, as the first CBRN standards used for issuing grants to responder organizations**
 - **NFPA in their protective ensemble standards**
- **British Standards Institute (BSI) is patterning new standards and tests based on NIOSH CBRN standards**

CBRN Respirator Standards

Standards Completed

SCBA – January 2002

SCBA upgrades – March 2003

Gas masks – March 2003

Escape sets – October 2003

Standards in Development

PAPRs

Closed-circuit SCBA

Combination SCBA/PAPR or SCBA/APR

SAR

CBRN Self Contained Breathing Apparatus (SCBA)

Open Circuit CBRN SCBA

Three Tiers of Requirements:

- 42 CFR, Part 84 (NIOSH)
- NFPA 1981, Current Edition
- Special CBRN Requirements:
 - CW Agents (GB & HD)
 - Respirator Fit

Standard Announced December 2001 and Implemented
January 2002

CBRN-SCBA Retrofit Announced March 2003

CBRN Air Purifying Respirator (APR)

Full Facepiece CBRN APR

Three Tiers of Requirements:

- 42 CFR, Part 84 applicable sections
- Enhanced Requirements (Other Standards)
- Special CBRN Requirements:
 - CW Agents (GB & HD)
 - Respirator Fit

Standard Announced and Implemented March 2003

CBRN APR Retrofit in Development

CBRN Escape Respirator

CBRN escape respirator

- CBRN air-purifying escape
- CBRN self-contained escape

Three Tiers of Requirements

- 42 CFR, Part 84, applicable sections
- Requirements derived from others standards
- Special CBRN Requirements:
 - CW Agents (GB & HD)
 - Respirator Fit

Standards Announced September 2003

CBRN Respirator Certification

CBRN SCBA: multiple approvals issued to 6 manufacturers

CBRN SCBA Upgrade: multiple approvals (retrofit) issued to 3 manufacturers

CBRN APR:

- **Multiple approvals issued to 5 manufacturers**
- **Additional approvals pending**

CBRN Escape:

- **2 approvals issued to 2 manufacturers**

CBRN Respirator Standards Program

- Continue CBRN Respirator Certification
- Complete CBRN PAPR standard
- Continue Standards Development Efforts for Remaining Classes of Respirators (CC SCBA, SAR, Combination Units SCBA/PAPR, SCBA/APR)
 - Public Process
- Provide clarifications to Existing CBRN Standards (SCBA, APR, APER, SCER) based upon lessons learned over the past four years
 - Document Clarifications, Not Revisions to Requirements
 - Post Clarifications to Web Site by 2Q FY 2006
 - 30 day Public Review and Comment Period
 - Post Updates by 3Q FY 2006

CBRN PAPR Standard Development Docket and Meeting Comments

Public meetings

October 2003

May 2004

December 2004

July 2005

December 13, 2005

Docket

22 Formal submissions



Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

CBRN PAPR Respirator Concept Docket and Meeting Comments

- **Comments provided through various sources**
 - **Formal Docket submissions**
 - **Public Meeting Feedback**
 - **Informal Stakeholder Meetings**
- **Comments are accepted in total or in part as part of standards development process**
- **Comments are rejected for technical / programmatic reasons**
- **Some Comments remain under consideration, pending completion of benchmark testing**

CBRN PAPR

Program Issues

- **Technical -- High Flow Aerosol Test Technology**
 - Two high flow testers from two manufacturers
 - Complete equipment verification during 2006
- **Competing Stakeholder Needs**
 - Department of Homeland Security and responder community want CBRN capable PAPR soon
 - Manufacturers want common platform in Part 84 industrial requirements and CBRN requirements
- **Draft OSHA Receiver PAPR guidance**



CBRN PAPR Implementation

Considerations for the implementation process:

- Project focus is to provide the user community with required protection through equipment availability as quickly as possible
- Project needs to verify standard test procedures prior to implementation of the standard
- Implementation options are through policy provisions or through rulemaking processes

CBRN PAPR Implementation

- Previous CBRN Respirator Standards have been implemented using a voluntary approval program pursuant to 42 CFR Parts 84.60(b) and 84.63(c).
- These sections provide NIOSH with the authority to issue approvals for respirators not specifically addressed in Part 84 and to develop additional requirements that the agency determines are "necessary to establish the quality, effectiveness and safety of any respirator used as protection against hazardous atmospheres."
- Using Policy Provisions result in a projected implementation goal of the CBRN PAPR standard release by the end of 2Q FY2006

CBRN PAPR

NIOSH implementation concept repackages the standard requirements into a two step approach for the CBRN PAPR:

Step 1

- Implement CBRN PAPR via regulatory authorities 2Q FY 2006
- Limited elements of new technology (4 additional tests) combined with existing 42 CFR Part 84 requirements

Step 2

- Implement a PAPR 42 CFR Part 84 module via rulemaking processes that begins in late 2006 with implementation during 2008
- CBRN requirements would be a type of PAPR under the new 42 CFR Part 84 module
- Technology advancements addressed through the rulemaking process

CBRN PAPR Step 1 Requirements

Approval under NIOSH 42 CFR Part 84

Special tests under NIOSH 42 CFR Part 84.63(c)

- Durability conditioning
- Chemical agent permeation and penetration resistance against Distilled Sulfur Mustard (HD) and Sarin (GB)
- Laboratory Respirator Protection Level (LRPL)
- Canister test challenge and test breakthrough concentrations



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

CBRN PAPR Step 1 Requirements: Approval under NIOSH 42 CFR Part 84

Test #	Title
1	Initial DOP -- HE protection (if applicable)
3	Exhalation resistance, blower off (tight-fitting)
4	Exhalation valve leakage (if applicable)
5/5A/6	IAA fit test
7 fitting)	Inhalation resistance with blower off (tight-
12	PAPR Air Flow*
25	Silica Dust+
30	Sound Level (if applicable)
33-48 or 62	Gas and Vapor (as applicable)
60	ESLI visibility (if applicable)
61	ESLI damage resistance (if applicable)

*115 Lpm for tight-fitting, 170 Lpm for loose-fitting

+CBRN Canister evaluated for HE particulate and Silica Dust



Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

CBRN PAPR Step 1 Requirements: Special tests under NIOSH 42 CFR Part 84.63(c)

**Durability conditioning - CBRN tight-fitting PAPR only
(Reference STP CBRN-0311)**

Purpose of Tests:

To perform environmental storage, transportation shock and drop tests on the CBRN tight-fitting PAPR to qualify durability and to detect any initial life cycle failures that may occur from typical use.

Goal:

To ensure CBRN tight-fitting PAPR provides adequate respiratory protection after being subjected to normal environmental storage, transportation and rough handling conditions by the user.

Durability Test Matrix

Test	Test Method	Test Conditions	Duration	Notes
Hot Diurnal	Mil-Std-810F 501.4	(35°C/ 95°F) to (71°C/ 160°F), 24 Hour cycle	3 Weeks Diurnal Cycle	PAPR, Battery and Canisters
Cold Constant	Mil-Std-810F 502.4	Basic Cold, -32°C (-24°F), Constant	3 Days	
Humidity	Mil-Std-810E 507.3	Realistic, Natural Cycle Humidity Profiles in the U.S. (range 88°F @ 88%RH– 05°F @ 59%RH, 24 hr period)	5 Days “quick look” Mil-Std-810E Table 507.3-II	Batteries in MPC as indicated by Users Instructions. Gas Service Life, Filtration (P100) and Filtration After OV Gas Life
Transportation Vibration	Mil-Std-810F 514.5	U. S. Roadway Vibration, Unrestrained	12 hours/axis, 3 Axes Total duration = 36 hours = 12,000 miles	
Drop Test: In Minimum Packaging Configuration	Canisters Only	1 drop per filter (on one of the 3 axis)	Height of 3 feet	

CBRN PAPR Step 1 Requirements: Special tests under NIOSH 42 CFR Part 84.63(c)

Chemical Agent Permeation and Penetration Resistance against Distilled Sulfur Mustard (HD) and Sarin (GB) Agent Requirement - (Reference STPs CBRN - 0550 and 0551)

- Blower is running and including all components and accessories except for the battery (or batteries),
- Resists the permeation and penetration of distilled sulfur mustard (HD) and Sarin (GB) chemical agents
- Breathing machine operating at an airflow rate of 40 L/min, 36 respirations per minute, 1.1 liters tidal volume.
- Testing performed on four PAPR (two for HD and two for GB) following the durability conditioning.
- QLAT performed on two PAPR (one for HD, one for GB)

CBRN PAPR Step 1 Requirements: Special tests under NIOSH 42 CFR Part 84.63(c)

Laboratory Respiratory Protection Level (LRPL) Test Requirement – (all Respirators, Reference STP CBRN 0552)

- The measured LRPL for each powered, air-purifying respirator shall be 10,000 for $\geq 95\%$ trials with the blower operating (blower on mode).
- The measured LRPL for each tight-fitting powered, air-purifying respirator shall be 2,000 for $\geq 95\%$ trials with the blower not operating (Blower Off mode)
- All sampling will be performed in the breathing zone of the respirator. The respirator is tested in an atmosphere containing 20–40 mg/m³ corn oil aerosol of a mass median aerodynamic diameter of 0.4–0.6 μm .
- Discussions with OSHA regarding LRPL testing of 10,000 (provides a safety factor of 10 for a potential 1000 PAPR APF)

CBRN PAPR Step 1 Requirements: Special tests under NIOSH 42 CFR Part 84.63(c)

Canister Test Challenge and Test Breakthrough Concentrations—
Reference STPs CBRN – 0501, 0502, 0503, 0504, 0505, 0506, 0507,
0508, 0509, 0510)

- Canister capacity tests will be performed at room temperature, $25\text{ }^{\circ}\text{C} \pm 2.5\text{ degree C}$; and at $25\% \pm 2.5\%$ relative humidity and $80\% \pm 2.5\%$ relative humidity
- Three canisters will be tested at each specified humidity
- Canister test time is fifteen minutes
- Canister capacity testing for the tight-fitting systems will be tested at a flow rate of 115 Lpm divided by the least number of canisters used on the system for which approval is sought
- Canister capacity testing for the loose-fitting systems will be tested at a flow rate of 170 Lpm divided by the least number of canisters used on the system for which approval is sought
- Canister capacity testing shall be performed following the durability conditioning.

CBRN PAPR Step 1 Requirements: Special tests under NIOSH 42 CFR Part 84.63(c)

Tight - Fitting Canister test challenge and test breakthrough concentrations

Test Representative Agent (TRA)	Test Concentration (ppm)	Breakthrough Concentration (ppm)
Ammonia	2500	12.5
Cyanogen chloride	300	2
Cyclohexane	2600	10
Formaldehyde	500	1
Hydrogen cyanide	940	4.7*
Hydrogen sulfide	1000	5.0
Nitrogen Dioxide	200	1 ppm NO ₂ or 25 ppm NO ⁺
Phosgene	250	1.25
Phosphine	300	0.3
Sulfur dioxide	1500	5



CBRN PAPR Step 1 Requirements: Special tests under NIOSH 42 CFR Part 84.63(c)

Loose - Fitting Cartridge test challenge and test breakthrough concentrations

Test Representative Agent (TRA)	Test Concentration (ppm)	Breakthrough Concentration (ppm)
Ammonia	1250	12.5
Cyanogen chloride	150	2
Cyclohexane	1300	10
Formaldehyde	250	1
Hydrogen cyanide	470	4.7*
Hydrogen sulfide	500	5.0
Nitrogen Dioxide	100	1 ppm NO ₂ or 25 ppm NO [†]
Phosgene	125	1.25
Phosphine	150	0.3
Sulfur dioxide	750	5

CBRN PAPR Step 1 Requirements: Special tests under NIOSH 42 CFR Part 84.63(c)

Particulate/aerosol testing:

- The canister shall meet the requirements of 99.97% particulate filter efficiency
- Canister particulate testing for the system will be tested at a flow rate of 170 Lpm divided by the least number of canisters used on the loose-fitting system
- Canister particulate testing for the tight-fitting system will be tested at a flow rate of 115 Lpm divided by the least number of canisters used on the system
- Current test technology limits flow rate testing to 95 Lpm. When test equipment has been validated to test at higher flows, single filter elements will be able to be evaluated

CBRN PAPR Cautions and Limitations

Units will have two labels: One for 42 CFR Part 84 and one for CBRN Rating

Units will include appropriate cautions and limitations:

- Industrial 14 G (tight-fitting) or 23 C (loose-fitting) requirements
- Previously identified CBRN cautions and limitations
- CBRN Loose-Fitting PAPR unique cautions and limitations

Cautions and Limitations from 42 CFR Part 84

For respirators approved under 30 CFR Part 11 & 42 CFR Part 84:

- Not evaluated as an ignition source in flammable or explosive atmospheres by MSHA/NIOSH.
- Not for use in atmospheres containing less than 19.5 percent oxygen.
- Not for use in atmospheres immediately dangerous to life or health.
- Tight-fitting facepiece: Do not use if airflow is less than four cubic feet per minute.
- Loose-fitting facepiece: Do not use if airflow is less than six cubic feet per minute.
- In making renewals and repairs, parts identical with those furnished by the manufacturer under the pertinent approval shall be maintained.
- Refer to approval label and instruction and maintenance manuals for additional information on use and maintenance of the respirators.
- Follow the manufacturer's instructions for changing filters, cartridges, and/or canisters.
- This respirator shall be selected, fitted, used and maintained in accordance with Mine Safety and Health Administration and other applicable regulations.

Cautions and Limitations from 42 CFR Part 84

For respirators approved under 30 CFR Part 18:

- Not evaluated as an ignition source in flammable or explosive atmospheres by MSHA/NIOSH, except evaluated under Part 18 for use in methane air atmosphere.

Additional limitations under 42 CFR Part 84:

- Do not use powered air-purifying respirators if airflow is less than four cfm (115 lpm) for tight-fitting facepieces or six cfm (170 lpm) for hoods and/or helmets.
- Contains electrical parts which have not been evaluated as an ignition source in flammable or explosive atmospheres by MSHA/NIOSH

Cautions and Limitations from 42 CFR Part 84

General Limitations - All Gas Masks (14G):

- Not for use in atmospheres immediately dangerous to life or health.
- Not for use in atmospheres containing less than 19.5 percent oxygen.
- Refer to approval label, and instruction and maintenance manuals, for additional information on use and maintenance of these respirators.
- In making renewals and repairs, parts identical with those furnished by the manufacturer under the pertinent approval shall be maintained.
- Approval may include protection against particulates and multiple gases and vapors. The type of additional approval is listed in the approval record under the approval number.
- Follow the manufacturer's instructions for changing canisters.
- Do not wear for protection against gases or vapors with poor warning properties or those which generate high heats of reaction with sorbent materials in the canister.
- Respirators shall be selected, fitted, used and maintained in accordance with Mine Safety and Health Administration and other applicable regulations.

Cautions and Limitations from 42 CFR Part 84

General Limitations - All 23 C Chemical Cartridges:

- Not for use in atmospheres containing less than 19.5 percent oxygen.
- Not for use in atmospheres immediately dangerous to life or health.
- Do not exceed maximum use concentrations established by regulatory standards.
- Air-line respirators can be used only when the respirators are supplied with respirable air meeting the requirements of CGA G-7.1 Grade D or higher quality.
- Use only the pressure ranges and hose lengths specified in the User's Instructions.
- Do not use powered air-purifying respirators if airflow is less than four cfm (115 lpm) for tight-fitting facepieces or six cfm (170 lpm) for hoods and/or helmets.
- If airflow is cut off, switch to filter and/or cartridge and immediately exit to clean air.
- Do not wear for protection against organic vapors with poor warning properties or those which generate high heats of reaction with sorbent.



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

Cautions and Limitations from 42 CFR Part 84

General Limitations - All 23 C Chemical Cartridges (cont.)

- Contains electrical parts which have not been evaluated as an ignition source in flammable or explosive atmospheres by MSHA/NIOSH.
- Failure to properly use and maintain this product could result in injury or death.
- The Occupational Safety and Health Administration regulations require gas-proof goggles to be worn with this respirator when used against formaldehyde.
- Follow the manufacturer's User's Instructions for changing cartridges and/or filters.
- All approved respirators shall be selected, fitted, used, and maintained in accordance with MSHA, OSHA, and other applicable regulations.
- Never substitute, modify, add, or omit parts. Use only exact replacement parts in the configuration as specified by the manufacturer.
- Refer to User's Instructions, and/or maintenance manuals, for information on use and maintenance of these respirators.
- Special or critical User's Instructions and/or specific use limitations apply. Refer to User's Instructions for donning

CBRN APR Cautions and Limitations

- Not for use in atmospheres containing less than 19.5 percent oxygen.
- Not for use in atmospheres immediately dangerous to life and health or where hazards have not been fully characterized.
- When used at defined occupational exposure limits, the rated service time cannot be exceeded. Follow established canister change schedules or observes End of Service Life Indicators to ensure that canisters are replaced before breakthrough occurs.
- Failure to properly use and maintain this product could result in injury or death.
- Follow the manufacturer's User's Instructions for changing canisters.
- All approved respirators shall be selected, fitted, used, and maintained in accordance with MSHA, OSHA, and other applicable regulations.
- Use replacement parts in the configuration as specified by the applicable regulations and guidance.
- Refer to User's Instructions and/or maintenance manuals for information on use and maintenance of these respirators.
- Consult manufacturer's User's Instructions for information on the use, storage, and maintenance of these respirators at various temperatures.

CBRN APR Cautions and Limitations (continued)

- This respirator provides respiratory protection against inhalation of radiological and nuclear dust particles. Procedures for monitoring radiation exposure and full radiation protection must be followed.
- If during use an unexpected hazard is encountered such as a secondary CBRN device, pockets of entrapped hazard or any unforeseen hazard, immediately leave the area for clean air.
- Use in conjunction with personal protective ensembles that provide appropriate levels of protection against dermal hazard. Failure to do so may result in personal injury even when the respirator is properly fitted, used, and maintained.
- Some CBRN agents may not present immediate effects from exposure, but can result in delayed impairment, illness, or death.
- Direct contact with CBRN agents requires proper handling of the respirator after each use and between multiple entries during the same use. Decontamination and disposal procedures must be followed. If contaminated with liquid chemical warfare agents, dispose of the respirator after decontamination.
- The respirator should not be used beyond eight (8) hours after initial exposure to chemical warfare agents to avoid possibility of agent permeation. If liquid exposure is encountered, the respirator should not be used for more than two (2) hours.
- These limitations are not all inclusive. The respirator manufacturer may also identify further cautions and limitations for their respirators. In addition, regulatory agencies may also place a limit on the use of respirators in their standards.

CBRN PAPR Unique Cautions and Limitations

- The CBRN loose-fitting PAPR should not be used in emergency response (fire service, law enforcement, emergency medical technician) applications where high physiological demand is expected
- Use in conjunction with personal protective ensembles that provide appropriate levels of protection against dermal hazard. Failure to do so may result in personal injury even when the respirator is properly fitted, used, and maintained. Appropriate dermal protection for use with CBRN loose-fitting PAPR should include a shroud that provides dermal protection to the head and upper torso
- The CBRN loose-fitting PAPR should not be used for escape purposes

CBRN PAPR Step 1

Anticipated Certification Fees

• 42 CFR Part 84	\$ 1,250
• Durability Conditioning (NIOSH)	\$21,900
• CWA Testing	\$18,960
• LRPL	\$18,156
• Gas/Vapor/Particulate (averaged @ \$990/gas)	\$ 9,900
• NPPTL processing cost	\$ 1,000
• RDECOM processing cost	\$ 6,000
Total	\$77,166

Additional testing, if needed, charged on a per-test basis.

Fees calculations based on RDECOM 2005 fees.



Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

CBRN PAPR Step 1 Advantages

- Supports CBRN respirator standards development three tier approach by using the current 42 CFR Part 84 requirements for the first tier of performance
- Provides for equipment availability in the near term
- Provides a Safety and Health Benefit through addressing Draft OSHA First Receiver Guidance recommendations for PAPR with an APF of 1000

Information Docket CBRN PAPR

- **Mail:**

NIOSH Docket Office
Robert A. Taft Laboratories, M/S C 34
PAPR – NIOSH 010
4676 Columbia Parkway
Cincinnati, OH 45226

- **Email: niocindocket@cdc.gov**

- **Fax: (513) 533-8285**

- **Phone: (513) 533-8303**

- **NPPTL Web Site: <http://www.cdc.gov/niosh/npptl>**

National Personal Protective Technology Laboratory

CBRN PAPR Retrofit Concept

Sheraton Station Square
Pittsburgh, PA

Bill Hoffman

December 13, 2005



Workplace
Safety and Health



NPPTL Research to Practice
through Partnerships

National Personal Protective Technology Laboratory

Prerequisites

- Part 84 approval
- CBRN approval
- Field deployed units available



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

National Personal Protective Technology Laboratory

Hardware Requirements

- 4 units from field in use 1-5 years

2 light use

2 heavy use



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

National Personal Protective Technology Laboratory

Testing Requirements

- Units fitted with retrofit kit by factory representative
- Testing will consist of Mustard (HD) and Sarin (GB)
- Other tests may be required as deemed necessary

National Personal Protective Technology Laboratory

Documentation Requirements

- Complete Standard Application Procedure (SAP)
- Information describing criteria for determining retrofit-eligible PAPR
- User Instructions addressing the retrofit
- Method of recording which units have been retrofitted
- Retrofit labeling



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

National Personal Protective Technology Laboratory

Additional details being addressed:

- Fees
- Additional QA requirements
- Performance differences between industrial and CBRN



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

National Personal Protective Technology Laboratory

Questions?



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

National Personal Protective Technology Laboratory

Industrial PAPR/CBRN Step 2 Concepts

Sheraton Station Square
Pittsburgh, PA

Jon Szalajda
Bill Hoffman

December 13, 2005



Workplace
Safety and Health



NPPTL Research to Practice
through Partnerships

Industrial PAPR Concepts

- The module must be flexible enough to cover a potential wide range of applications while providing the desired respiratory protection to the user
- The module must also have the flexibility to provide for specific tests associated with specific applications (like CBRN or Mining)
- One size fits all approach may be too restrictive for some applications and not protective enough for others

Industrial PAPR Concepts

Concept for consideration: Develop PAPR performance requirements using categorization techniques

Base Requirements – Performance requirements that all PAPR exhibit

Enhanced User Requirements – Performance requirements based on the type of system being evaluated

Advanced Specific Requirements – Performance requirements based on the workplace use of the system

Industrial PAPR Concepts

Base Requirements – Performance requirements that all PAPR exhibit

Examples:

- **Maintain positive pressure in the breathing zone**
- **Inhalation/Exhalation Resistance**
- **Low pressure indicator**

Industrial PAPR Concepts

Enhanced User Requirements – Performance requirements based on the type of system being evaluated

Examples:

- Field of View
- Lens Abrasion
- Low Temperature

Industrial PAPR Concepts

Advanced Specific Requirements – Performance requirements based on the workplace use of the system

Examples:

- **CBRN**
- **Mining**
- **Healthcare**



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

Industrial PAPR / CBRN Step 2 Implementation

- Much of the Technical Work developed in the CBRN PAPR project can be applied in the Industrial Standard
- CBRN Step 2 will be an Advanced Specific Requirement in the new Industrial PAPR Standard
- Will use Concept Paper format up to the initiation of Rulemaking
- Next edition of the Concept paper during 2QFY06 will expand on categorization
- Additional public meeting late spring 2006
- Formal Rulemaking Process –
 - **Follow administrative procedures and staffing requirements**
 - **Target date to begin rulemaking process by end of 2006**
 - **18 to 21 months to implementation following initiation of rulemaking processes**

Current Industrial PAPR Concept

**Place all PAPR requirements in one
subpart of 42 CFR
(unchanged from 7/05)**

- **Clarify/update/consolidate requirements**
- **Incorporate requirements for breath response and constant flow units**
- **Keep existing general categories (Subparts A-G)**
- **Provide provisions for positive pressure units**



Workplace
Safety and Health



NPPTL Research to Practice
through Partnerships

Current Industrial PAPR Concept

Design Consideration Areas (unchanged from 7/05)

- Accessible switches
- Harness design (unit and head)
- Marked containers
- Lens impact resistance
- Low pressure- real time indicator
- Battery charge indicator
- Noise limitations

Current Industrial PAPR Concept

Specific Performance Consideration Areas (revised from 7/05)

- All considered Positive pressure
- 3 Flow ratings

Low: remains positive @ 14.5 res/min @ 10.5 lpm

Moderate: remains positive @ 24 res/min @ 40 lpm

High: remains positive @ 30 res/min @ 86 lpm

& 30 res/min @ 103 lpm for 5 min

Current Industrial PAPR Concept

Filter

(Unchanged from 7/05)

- PAPR95- 95% initial filter efficiency when tested against DOP
- PAPR100- 99.97% efficiency when loaded with DOP as the test challenge
- Test at highest flow rate of system divided by number of filters



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

Current Industrial PAPR Concept

Canister/Cartridge

(revised from 7/05)

- Cartridges tested same as Part 84 except eliminate the one-half minimum life test times
- Canisters tested same as CBRN
- Flow is highest flow rate specified by manufacturer divided by number of units



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

Current Industrial PAPR Concept

Other Testing (Revised from 7/05)

CO2 machine test

14.5 res/min 10.5 lpm, 5% CO2 ex., $\leq 0.5\%$ in.

- Breathing gas human subject test

Stand then walk at 3.5 mph

O2 $\geq 19.5\%$

CO2 $\leq 2\%$

- LRPL

**PF $\geq 2,000$ or $10,000$ for $\geq 95\%$ of trials
as requested by applicant**

Current Industrial PAPR Concept

Questions?



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

National Personal Protective Technology Laboratory

*Continued Discussions of Concepts for Standards for
Approval of Respirators for Use Against Chemical,
Biological, Radiological and Nuclear Agents (CBRN) and
Concepts for Standards for Industrial Powered Air
Purifying Respirators*



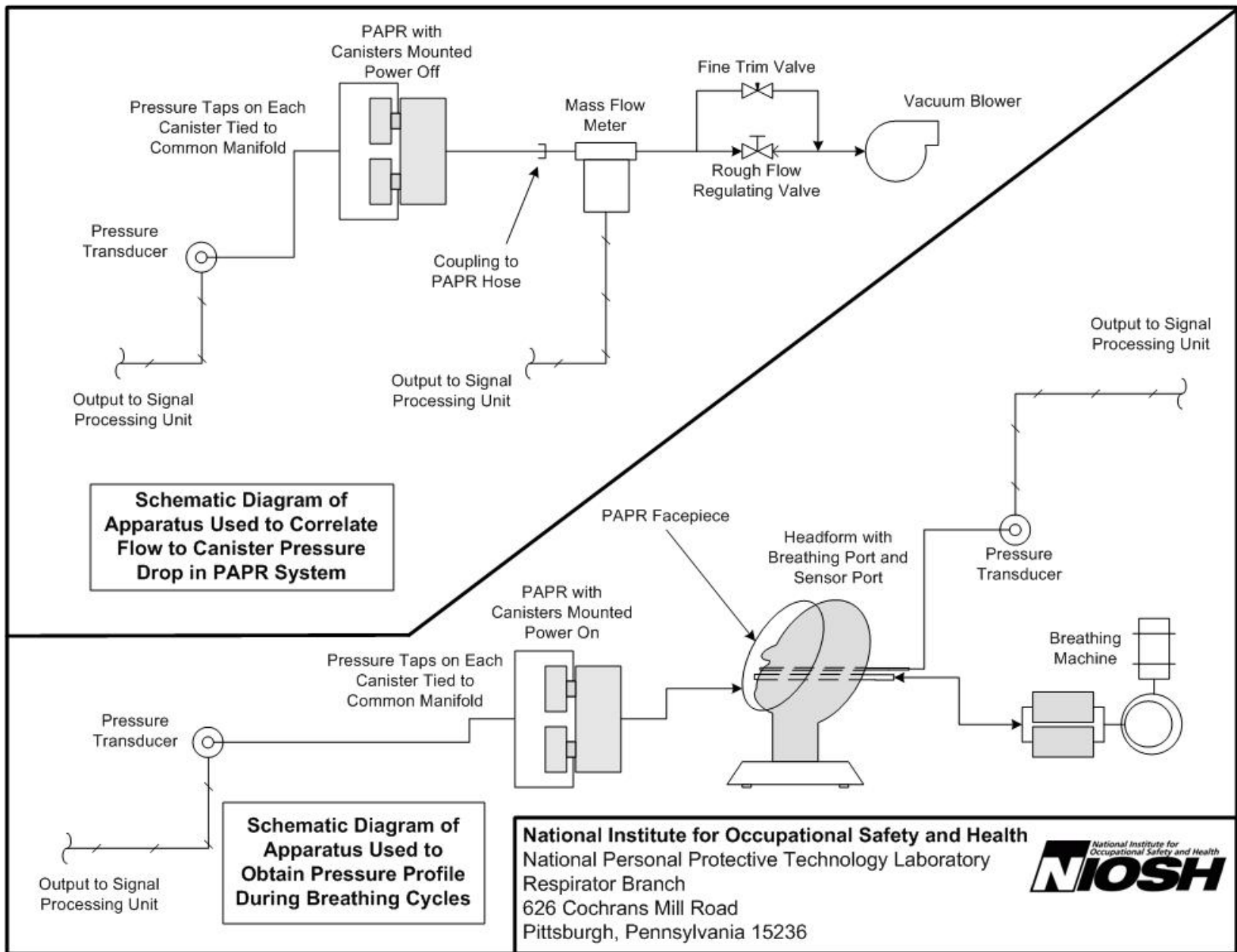
Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

Review of PAPR Air Flow Measurement Technique Discussed at the July '05 Public Meeting



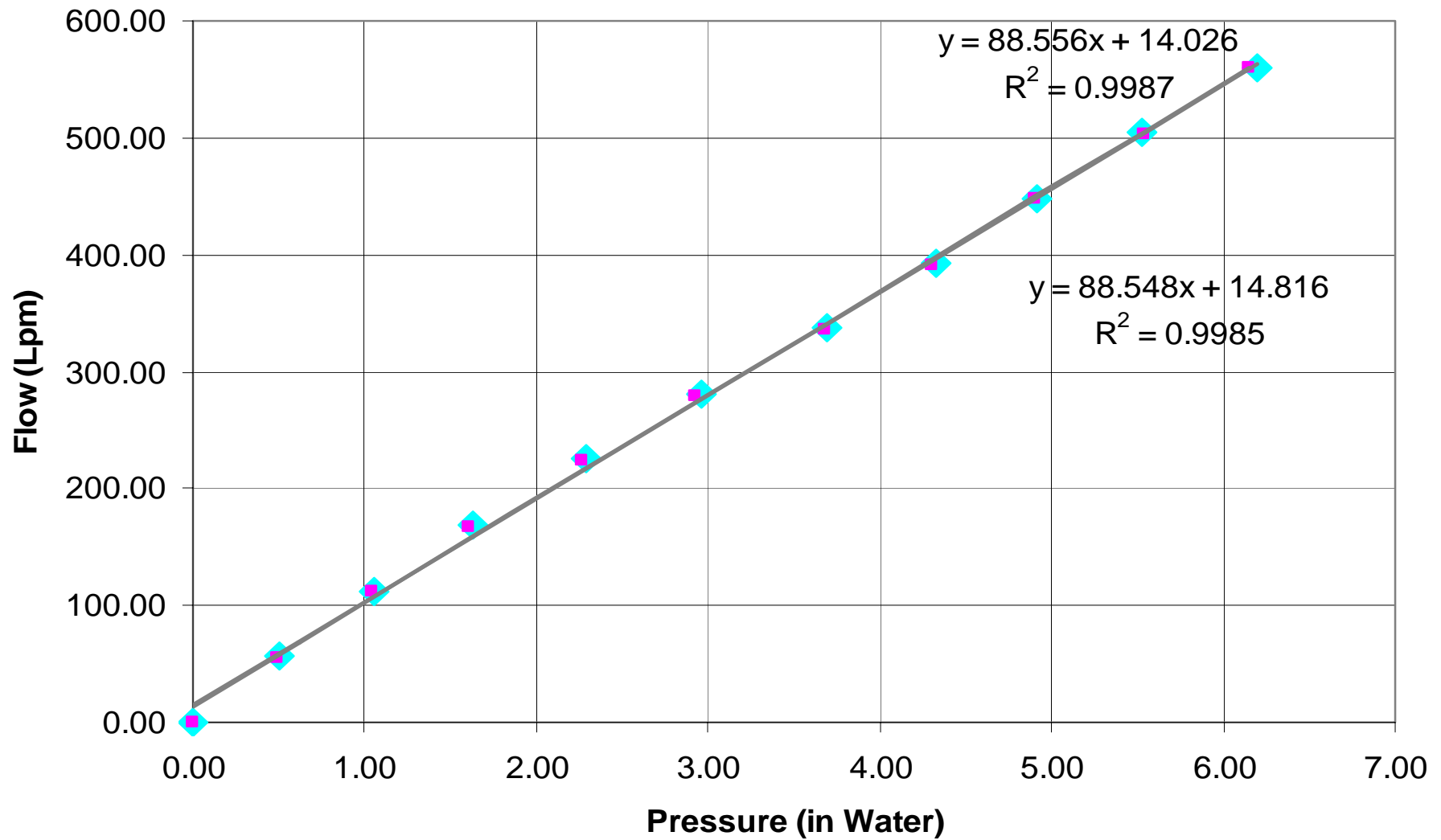


Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

Filter Calibration Chart - Tests 1 & 2 (Linear Curve Fit)

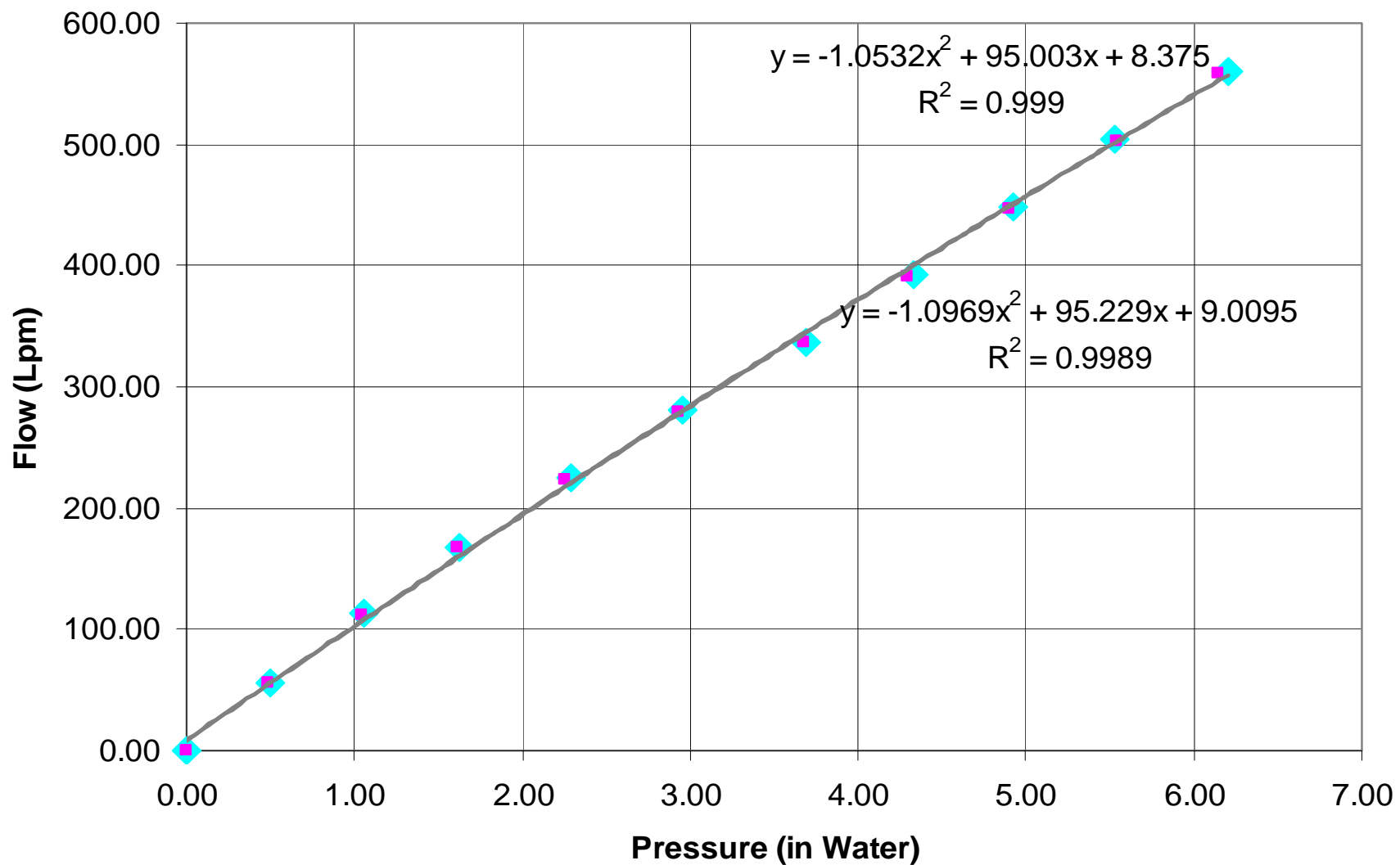


Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

Filter Calibration Chart - Tests 1 & 2 (Polynomial Curve Fit)



Breathing Machines

Variable

Fixed



National Personal Protective Technology Laboratory

PAPR Benchmark Testing

*Sheraton Station Square
Pittsburgh, PA*

*Terry Thornton, Chemist
Rich Vojtko, EG&G, Engineer
Jeff Palcic, EG&G, Engineer*

December 13, 2005

National Personal Protective Technology Laboratory

PAPR Benchmark Testing

1. *High Flow Particulate Tests*
2. *Service Life Tests*
3. *Air Flow Measurements*
4. *Alarms*



Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

National Personal Protective Technology Laboratory

PAPR Benchmark Tests

*High Flow
Particulate Testers*



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

High Flow Particulate Tests

- **Two High Flow Particulate Testers located in bldg 104; modified ATI Model TDA 100P and TSI 3120.**
- **High flow testers are custom built to test at flows of 100 – 500 Lpm following the P100 specification written in 42 CFR Part 84.**
- **Both testers have been powered up and preliminary studies started. DOP has been generated for gravimetric tests.**

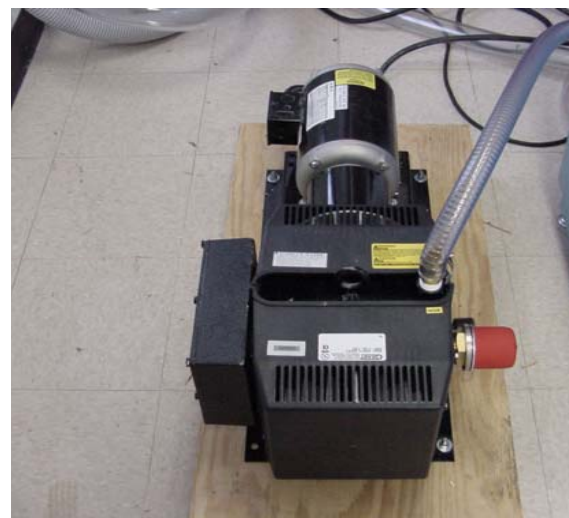
High Flow Particulate Tests

Set Up Experiences

- High flow testers need large vacuum pumps to run. High noise level in the laboratory.
- In a new location vacuum pumps will be in separate location.
- Discharge of DOP into air handling units
- High flow during gravimetric testing causes filter medium to tear. Solution is thick paper or multiple sheets.

High Flow Particulate Tester

- TSI 3120 High Flow Tester with external vacuum pump
- Same frame as TSI 8130
- Gravimetric test shows at 100 Lpm testing, 200 mg of DOP deposited on filter approximately 12- 14 minutes
- TSI 8130 takes approximately 23 – 30 minutes for 85 Lpm



High Flow Particulate Tester

- **ATI TDA 100P_{mod} High Flow Tester with external vacuum pump**
- **Gravimetric test shows at 100 Lpm testing, 200 mg of DOP deposited on filter approximately 27 – 30 minutes**
- **TSI 8130 takes approximately 23 – 30 minutes for 85 Lpm**



High Flow Particulate Tests

Next Steps for Validation

1. Run particle sizer on testers to verify particle size distribution count median diameter of 0.185 ± 0.020 micrometers with a geometric standard deviation not exceeding 1.6.
2. Verification of consistent gravimetric tests at various flows (100,115, 170 Lpm)
3. Correlation studies between high flow testers and TSI 8130s (100 to 110 Lpm)
4. Sufficient filter elements run at various flows that gives consistent penetration results.
5. Purchase additional tester from each manufacture for consistent penetration results

High Flow Particulate Tests

Questions?



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

National Personal Protective Technology Laboratory

PAPR Benchmark Tests

Service Life Tests



Workplace
Safety and Health



NPPTL Research to Practice
through Partnerships

Service Life Benchmark Tests

Experiences at High Flow Service Life Testing

- Higher flows cause increased pressure in system
- Pressure needs to be as close to atmosphere as possible
- Pressure will affect the humidity values
- Pressure can be reduced by using 1 ¼ " piping
- Single canister is easier for laboratory testing
- Dual and Single Miller Nelson Controllers have been used for establishing flows

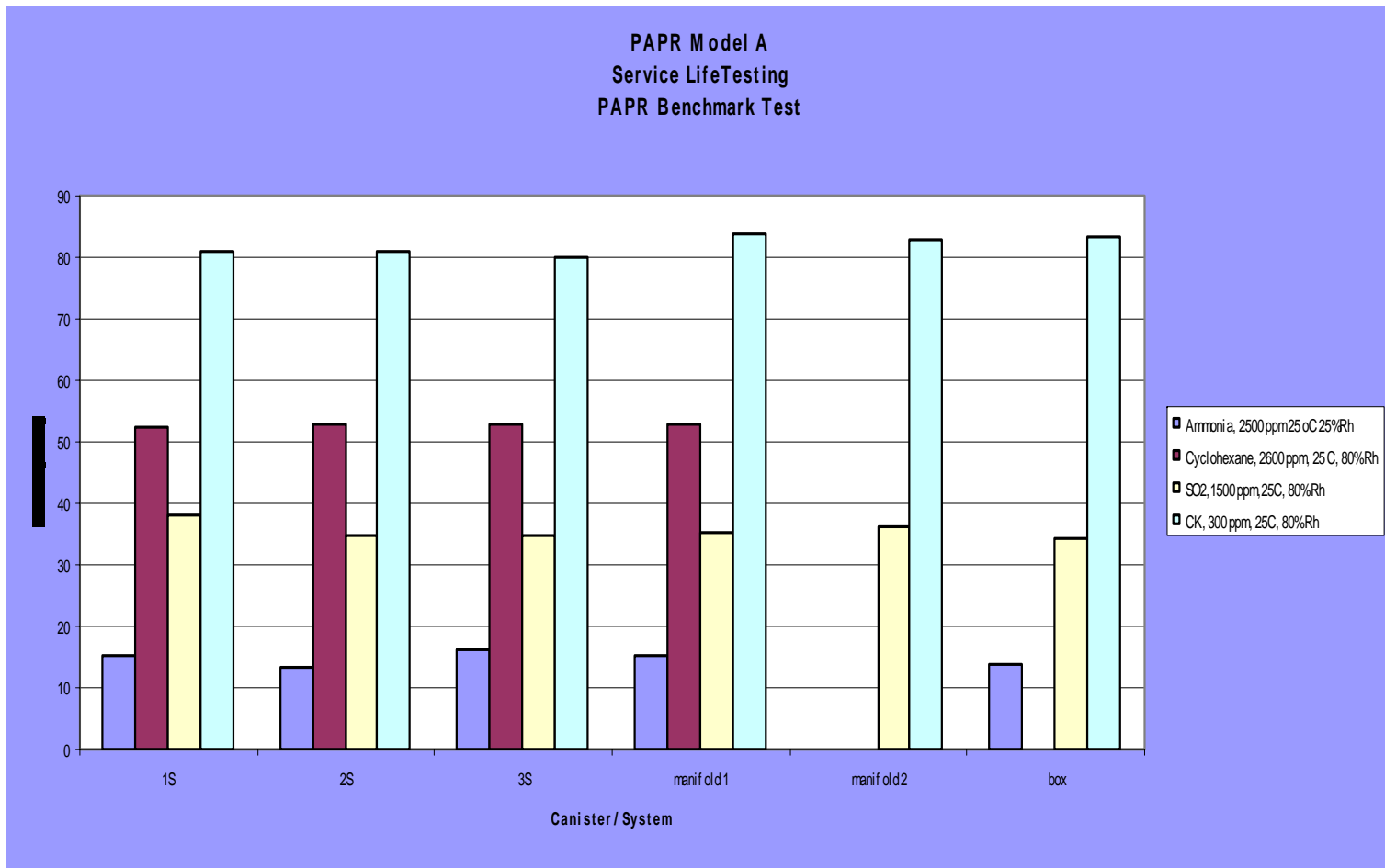
Service Life Benchmark Testing

- **Benchmark data was collected using tight fitting PAPR units that have NIOSH approval and can be purchased on the market**
- **Both constant flow units and demand responsive units were used**
- **All units have 2 or 3 canisters each and were a “first responder” type of canister.**

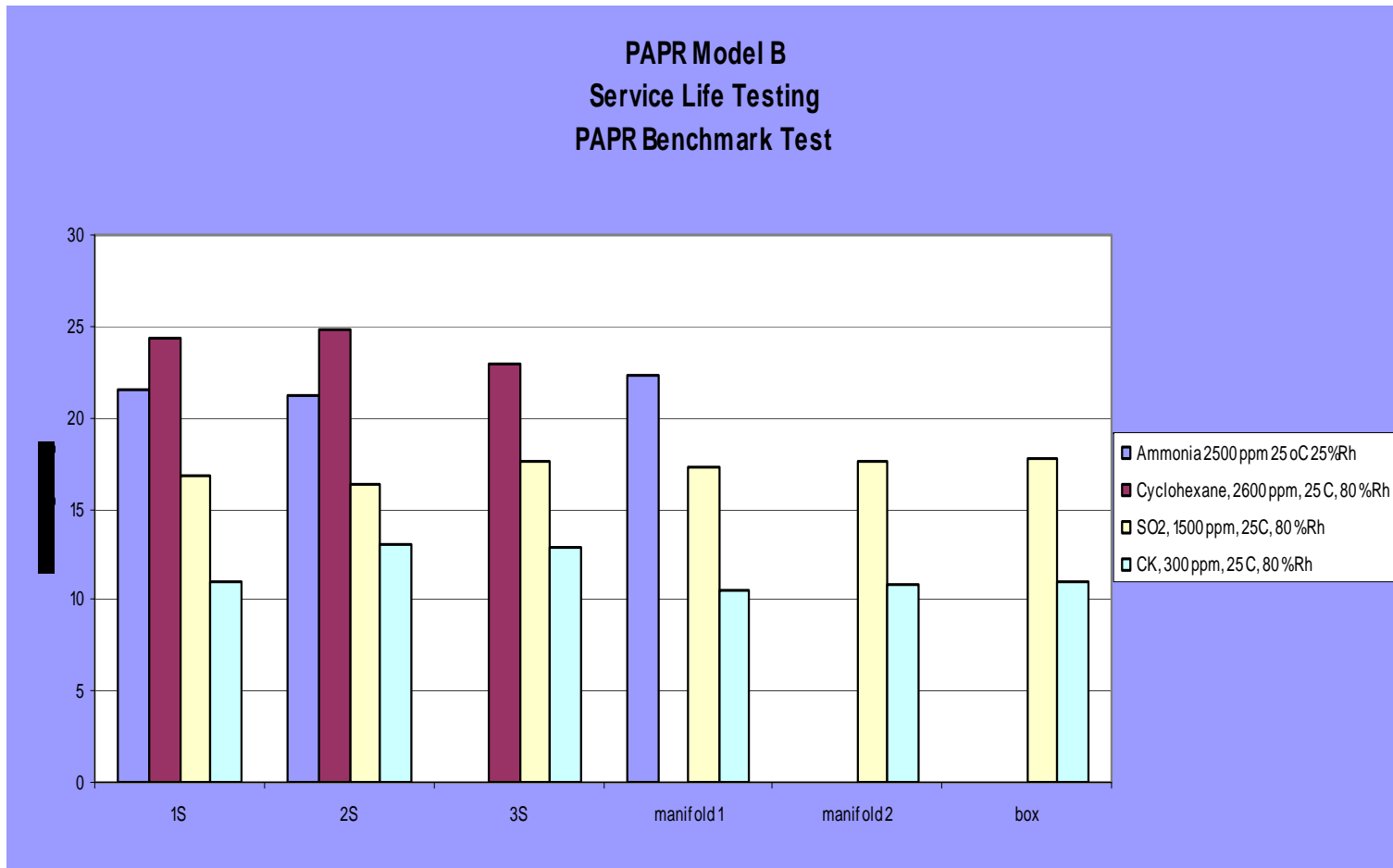
Service Life Benchmark Testing

- For “Constant Flow” units the performance air flow was measured using current NIOSH test procedures.
- For “Demand Responsive” units the airflow used was 300 Lpm
- Manifold with canisters were evaluated at the previously discussed airflows
- Single canisters were evaluated at the airflow divided by the number of canisters on the unit
- The test chamber with 2 or more canisters were used in addition or in place of the units manifold

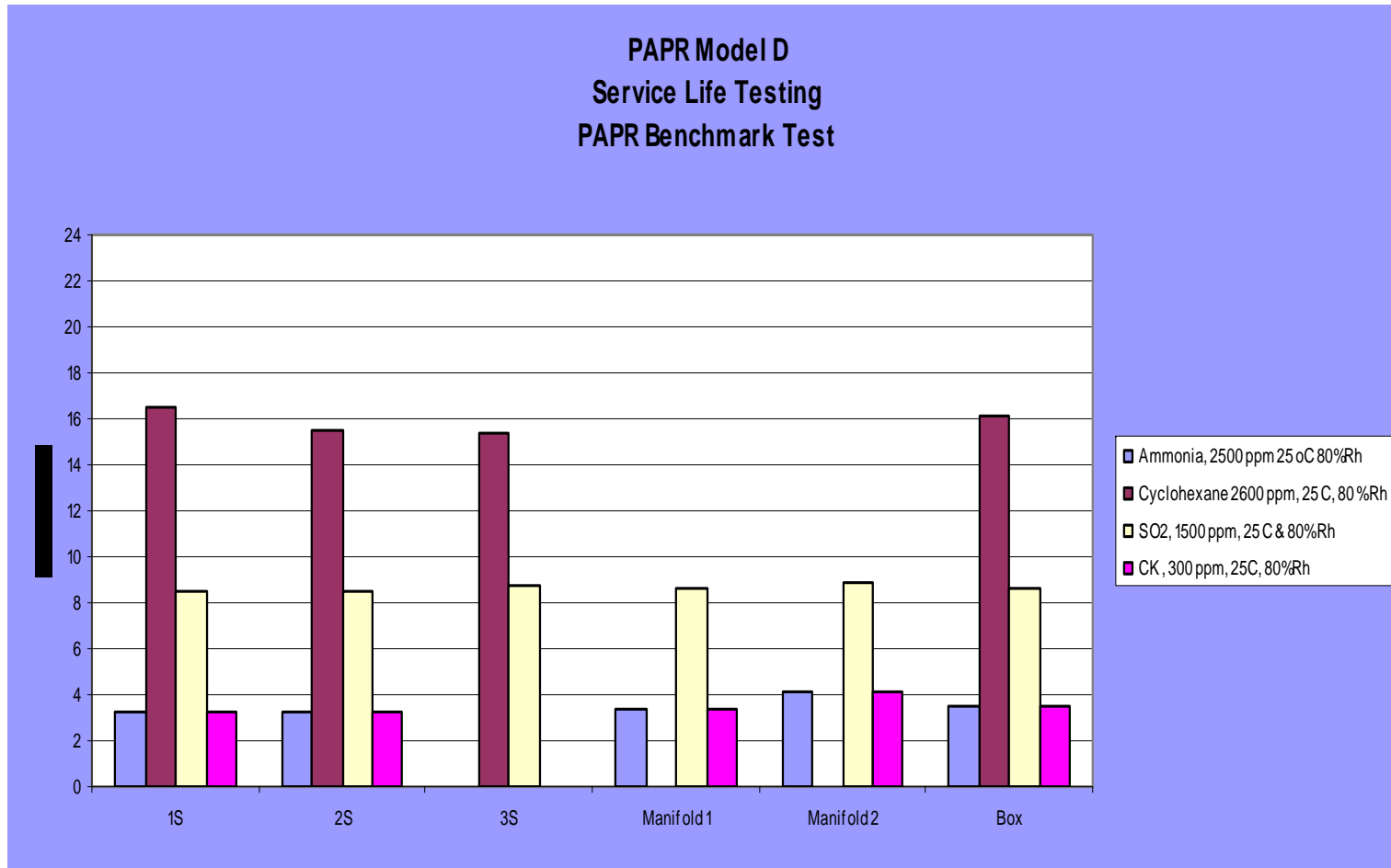
Service Life Benchmark Testing



Service Life Benchmark Testing



Service Life Benchmark Testing



Service Life Benchmark Tests

Experiences at High Flow Service Life Testing

Phosphine: Bed depth is a concern. At 300 ppm phosphine, canister testing at 300 Lpm (2 canisters) shows instantaneous breakthrough.

Flow adjusted to 120 Lpm with 300 ppm phosphine, breakthrough falls to less than 0.3 ppm



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

Service Life Benchmark Tests

Experiences at High Flow Service Life Testing

Phosgene: Canister testing shows service life greater than 30 minutes for testing at 300, 150, 71, 56 Lpm. This was performed with both single and multiple canisters.

Service Life Benchmark Tests

Questions?



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

National Personal Protective Technology Laboratory

PAPR Benchmark Tests

Air flow Measurements



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

Air Flow Measurements

Aspects of Air Flow Measurements

- **PAPR Air Flow Measurement Procedure**
- **Breathing Machine Comparison**
- **Reproducibility of PAPR Models**



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

Review of PAPR Air Flow Measurement Technique Discussed at the July '05 Public Meeting

Objective

- Derive a new flow measurement method that will allow both constant flow and demand response flow PAPRs to be evaluated utilizing the same test method and equipment

Review of PAPR Air Flow Measurement Technique Discussed at the July '05 Public Meeting

Method

- A flow curve was developed for each PAPR tested using the following method
 - Mount the facepiece on a head form and leak test
 - Install a pressure tap at the PAPR manifold outlet
 - Plug the pressure tap in the head form
 - Connect the head form breathing tube to a flowmeter and vacuum blower
 - PAPR switched “Off”

Review of PAPR Air Flow Measurement Technique Discussed at the July '05 Public Meeting

Method

- Incrementally increase the vacuum flow through the PAPR and record the corresponding manifold pressures
- Collect points from zero flow to 500 Lpm in increments of 50 Lpm
- Create a pressure vs. flow graph (polynomial fit)

Review of PAPR Air Flow Measurement Technique Discussed at the July '05 Public Meeting



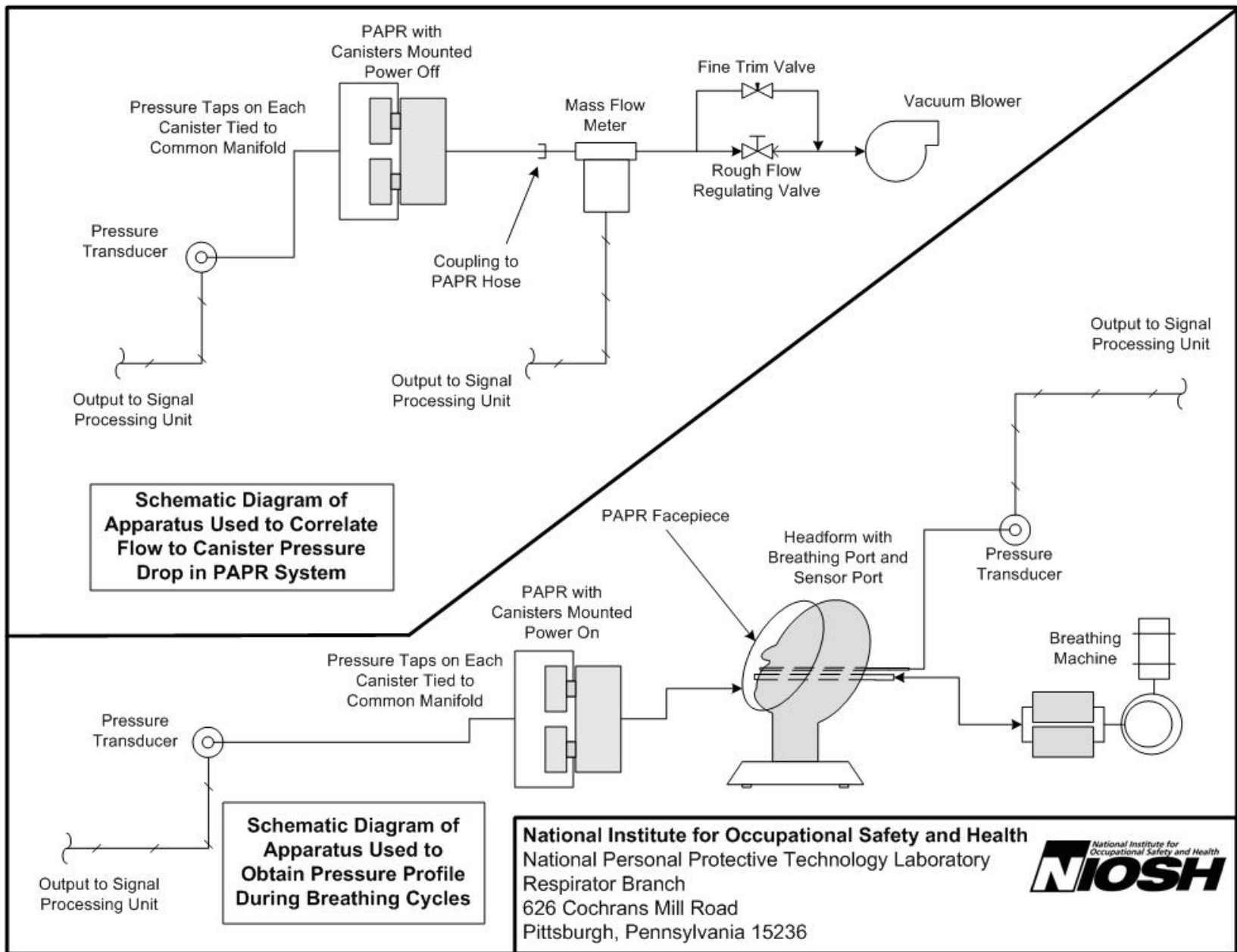
PAPR Air Flow Measurement

- **Correlate PAPR Flow to Pressure Drop Across Canisters**
 - Tap canister(s) and manifold to pressure transducer
 - Connect PAPR hose directly to flow measurement, flow control, and vacuum blower assembly
 - Record pressure drop vs. air flow data over typical range of PAPR operation (PAPR blower off)
 - Correlate using second order polynomial fit

PAPR Air Flow Measurement

- **Generate PAPR Flow Profile Using Breathing Machine**
 - Mount mask on headform coupled with breathing machine
 - At specified breathing rate start PAPR operation and record pressure drop profile across canister(s)
 - Use pressure drop vs. flow correlation to convert to flow profile

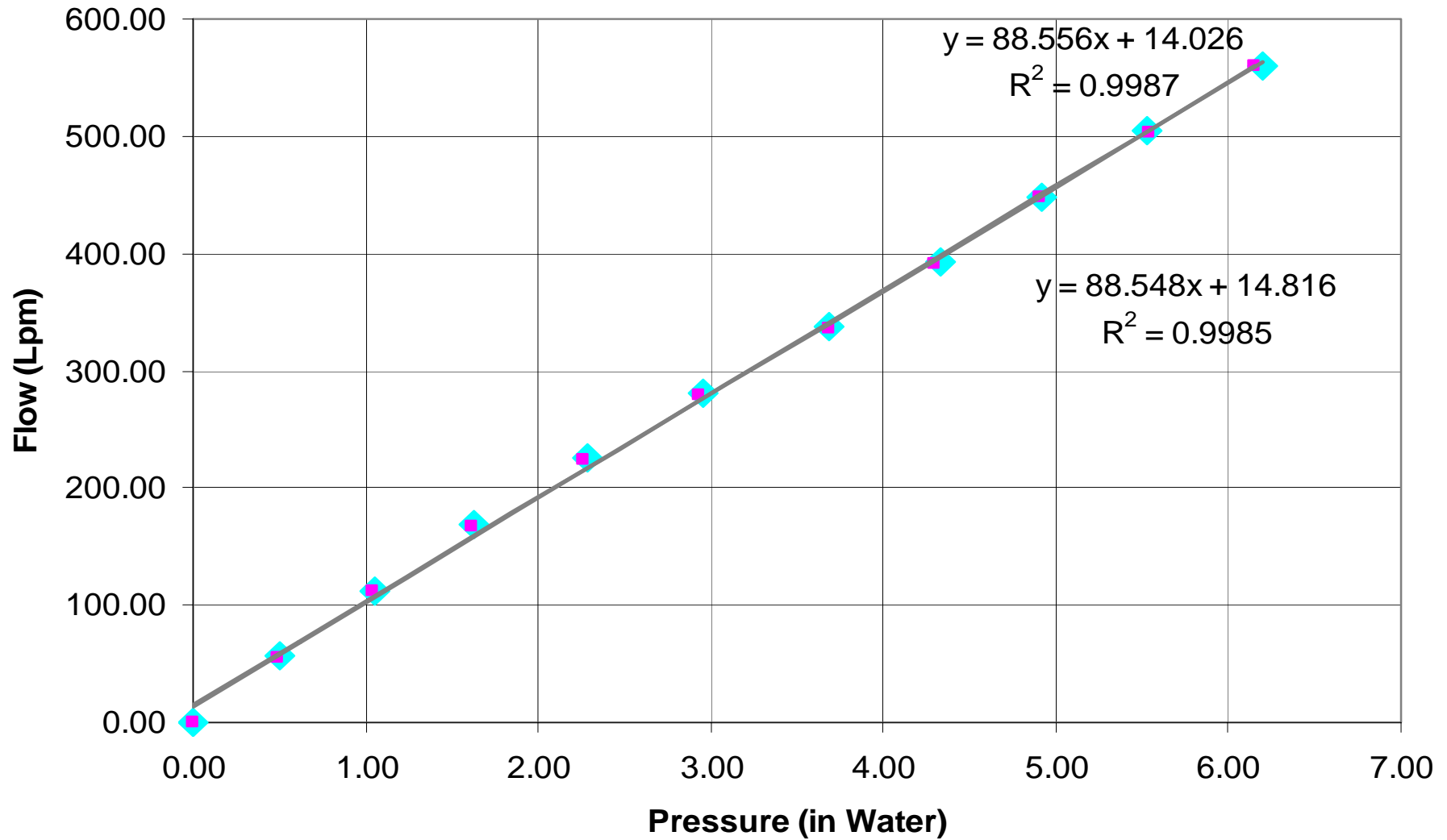




National Institute for Occupational Safety and Health
 National Personal Protective Technology Laboratory
 Respirator Branch
 626 Cochran's Mill Road
 Pittsburgh, Pennsylvania 15236



Filter Calibration Chart - Tests 1 & 2 (Linear Curve Fit)

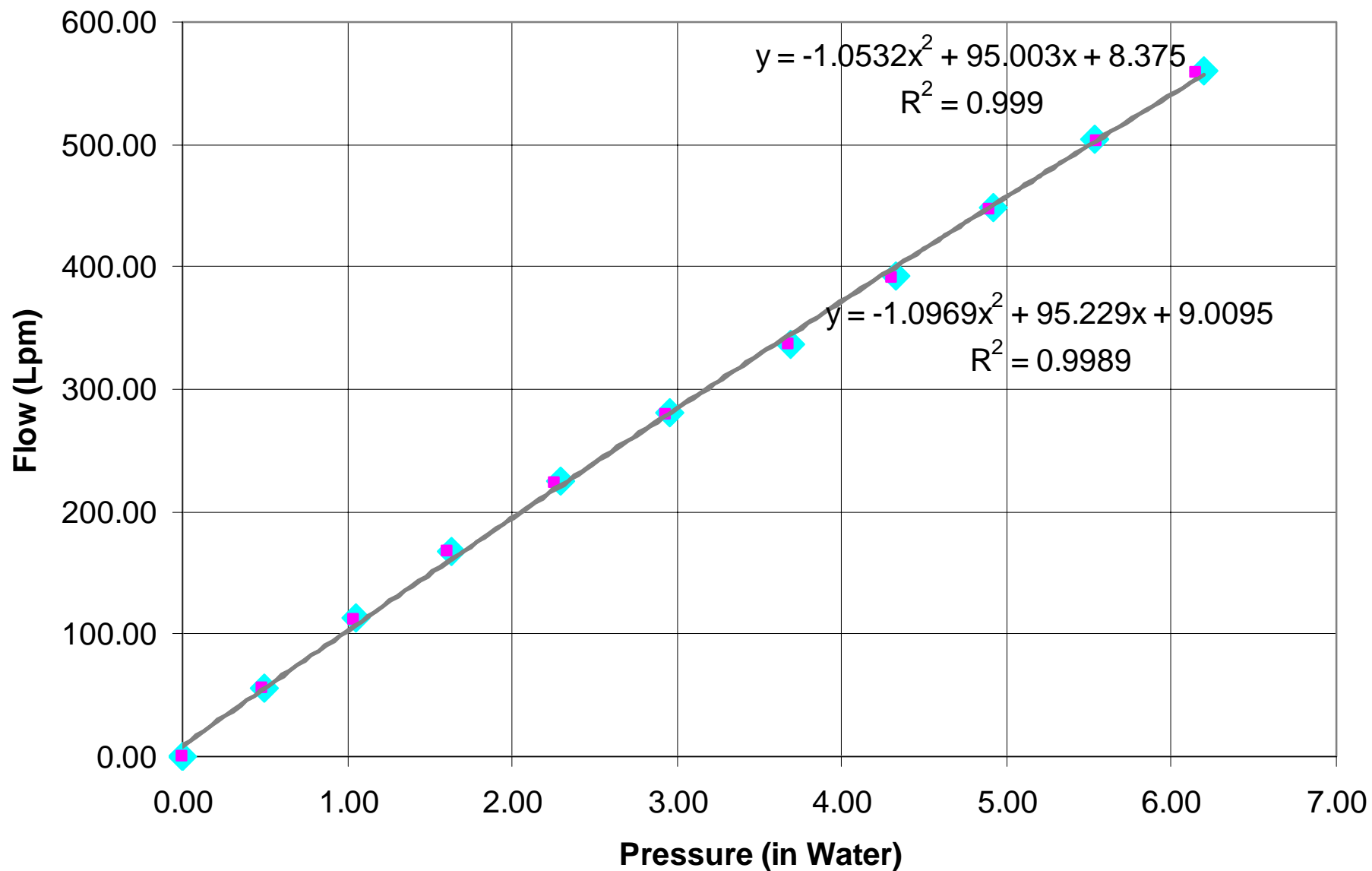


Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

Filter Calibration Chart - Tests 1 & 2 (Polynomial Curve Fit)



Breathing Machines

- **Performance Comparison Between Fixed and Variable Tidal Volume Breathing Machines**
 - Traditionally fixed volume machines have been used for testing
 - Potential benefits of variable volume breathing machines
 - Single machine for multiple tidal volume applications
 - Accurate and repeatable stroke frequency control
 - Ability to simulate human breathing patterns

Breathing Machines

- Performance Comparison Between Fixed and Variable Tidal Volume Breathing Machines

Fixed

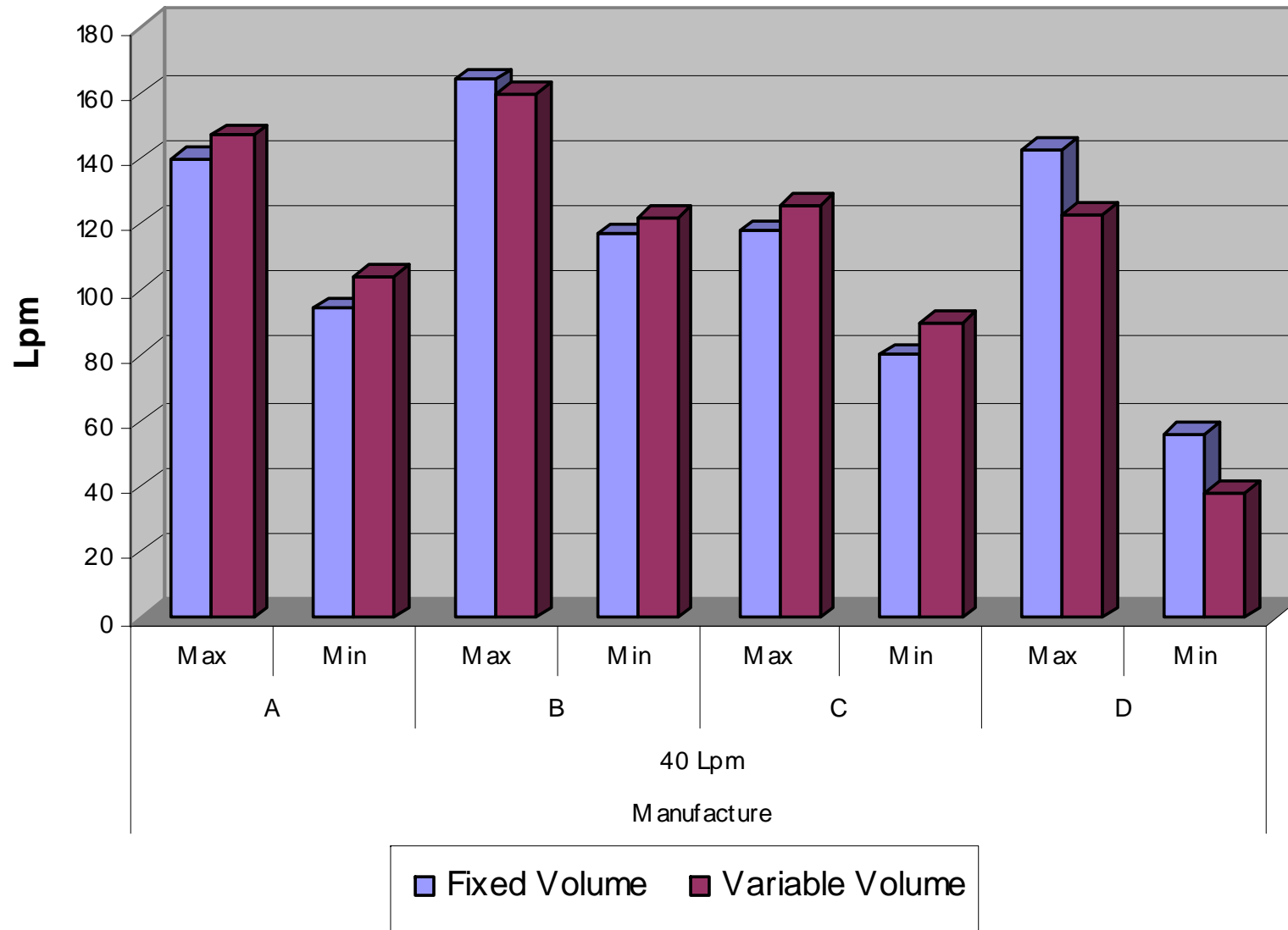
- 40 Lpm: 26 rpm X 1.57 Liters
- 86 Lpm: 21 rpm X 4.1 Liters
- 103 Lpm: 25 rpm X 4.1 Liters

Variable

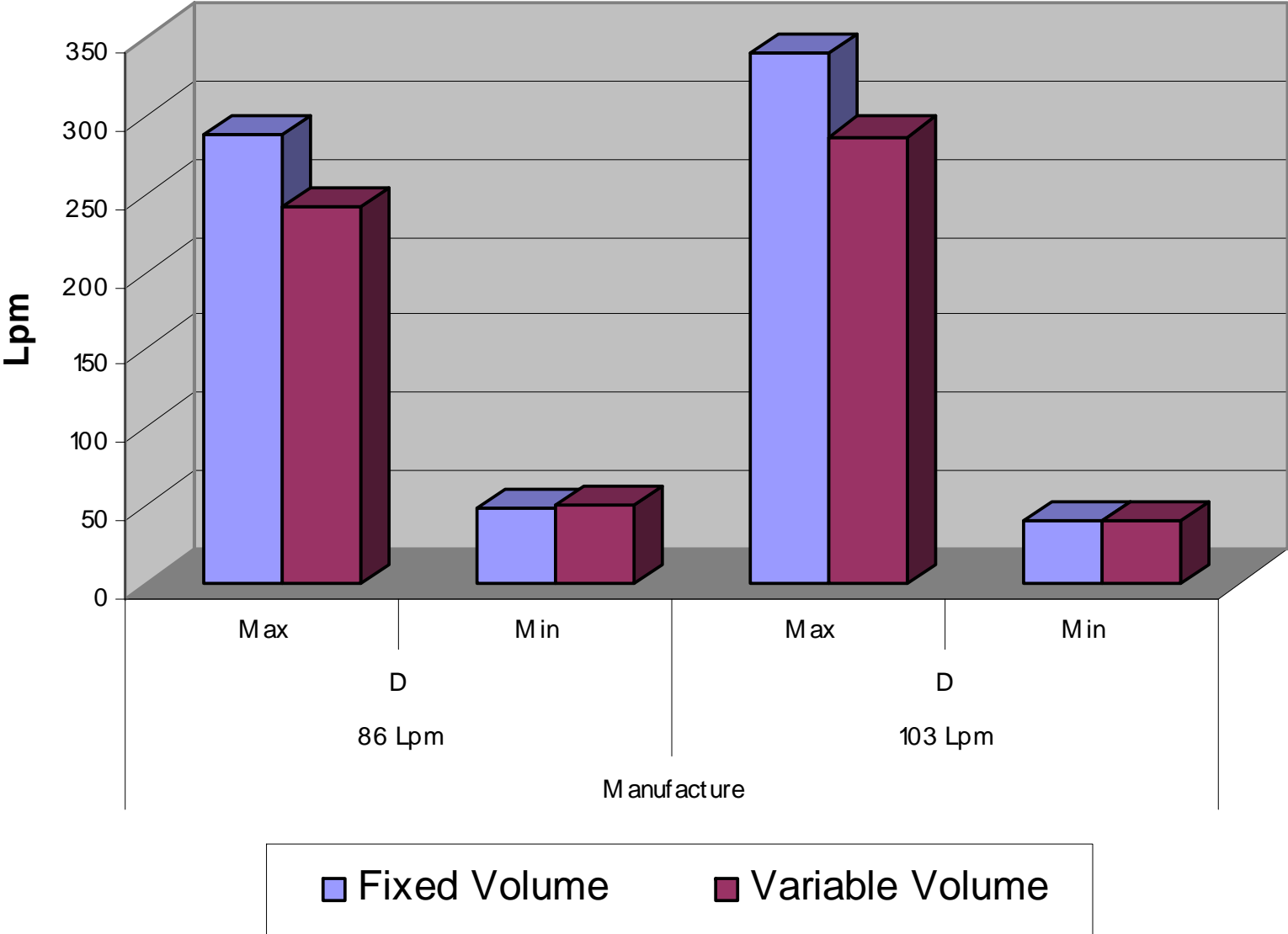
- 40 Lpm: 24 rpm X 1.67 Liters
- 86 Lpm: 25 rpm X 3.43 Liters
- 103 Lpm: 30 rpm X 3.43 Liters



Fixed vs. Variable Tidal Volume Breathing Machines



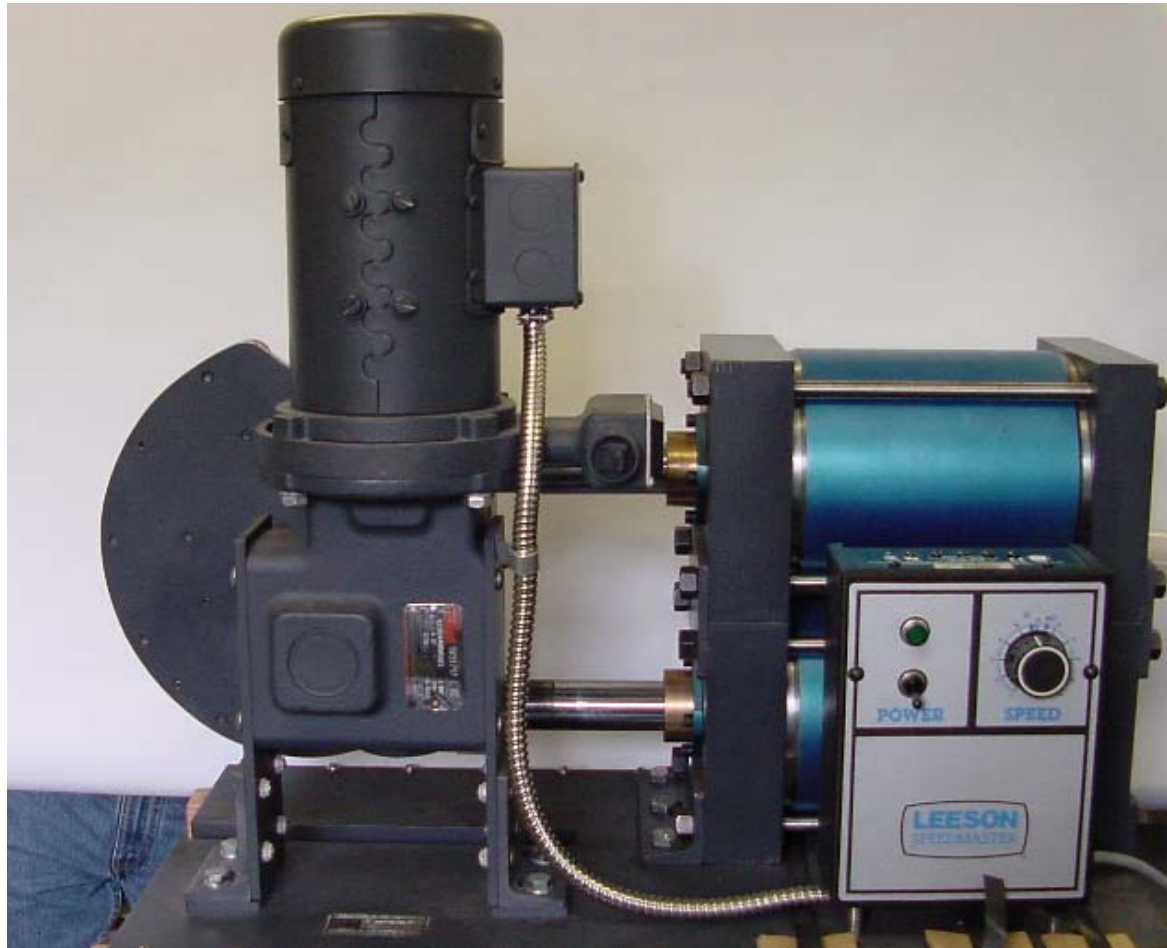
Fixed vs. Variable Tidal Volume Breathing Machine



Variable Tidal Volume Breathing Machine



Fixed Tidal Volume Breathing Machine



Reproducibility of PAPR Models

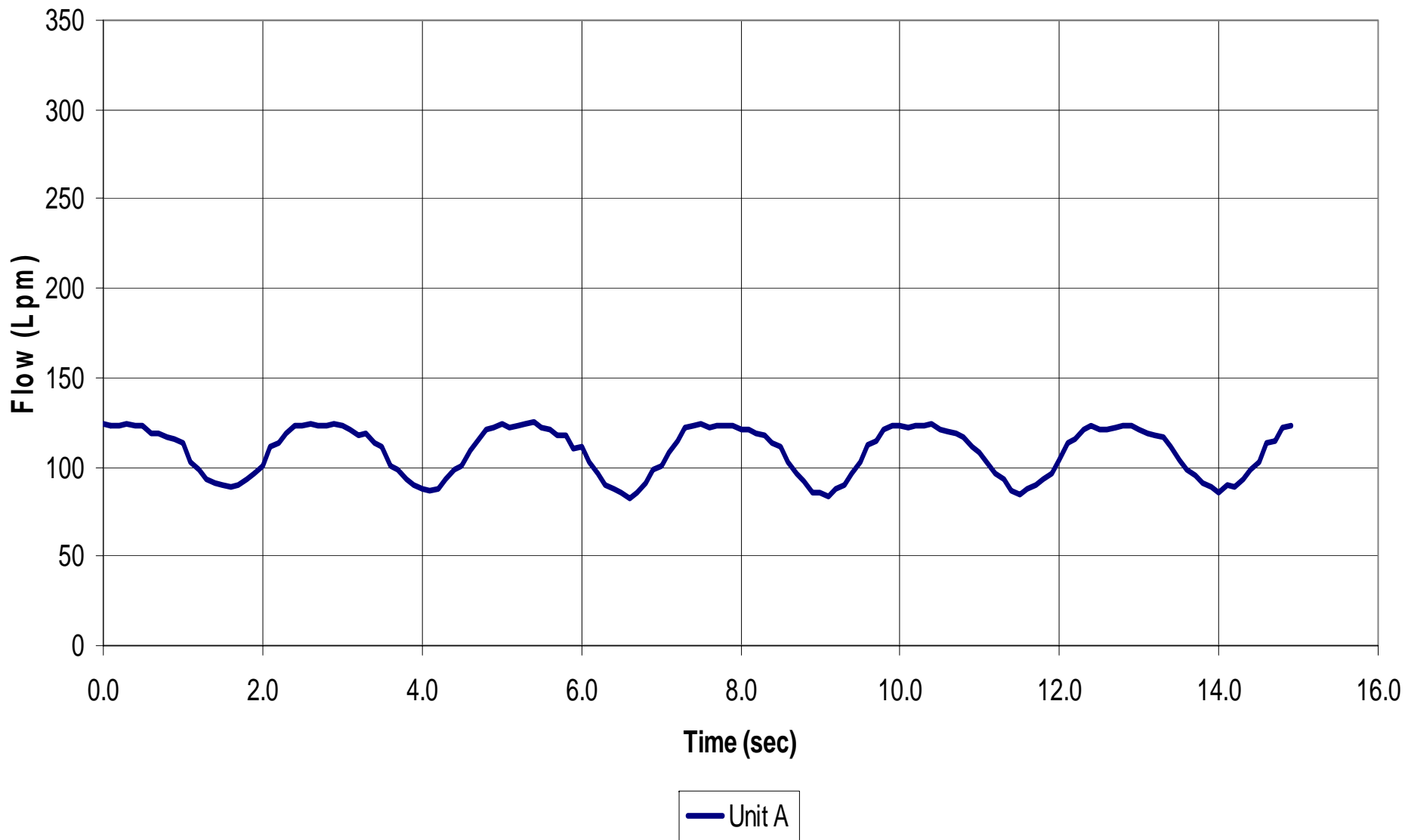
- **Determine unit to unit consistency within product lines**
- **Products from four manufacturers evaluated**
 - Three examples of each unit tested
 - Pressure profiles from all four manufacturers generated at 40 Lpm breathing rate
 - Data also generated at 86 and 103 Lpm for single higher capacity model

Reproducibility of PAPR Models

- **Comparison Procedure**

- Equivalent data snapshots for each test
- Converted pressure profile to flow profile using previously determined correlation
- Superimposed flow profiles from each manufacturer

PAPR A Unit to Unit Repeatability

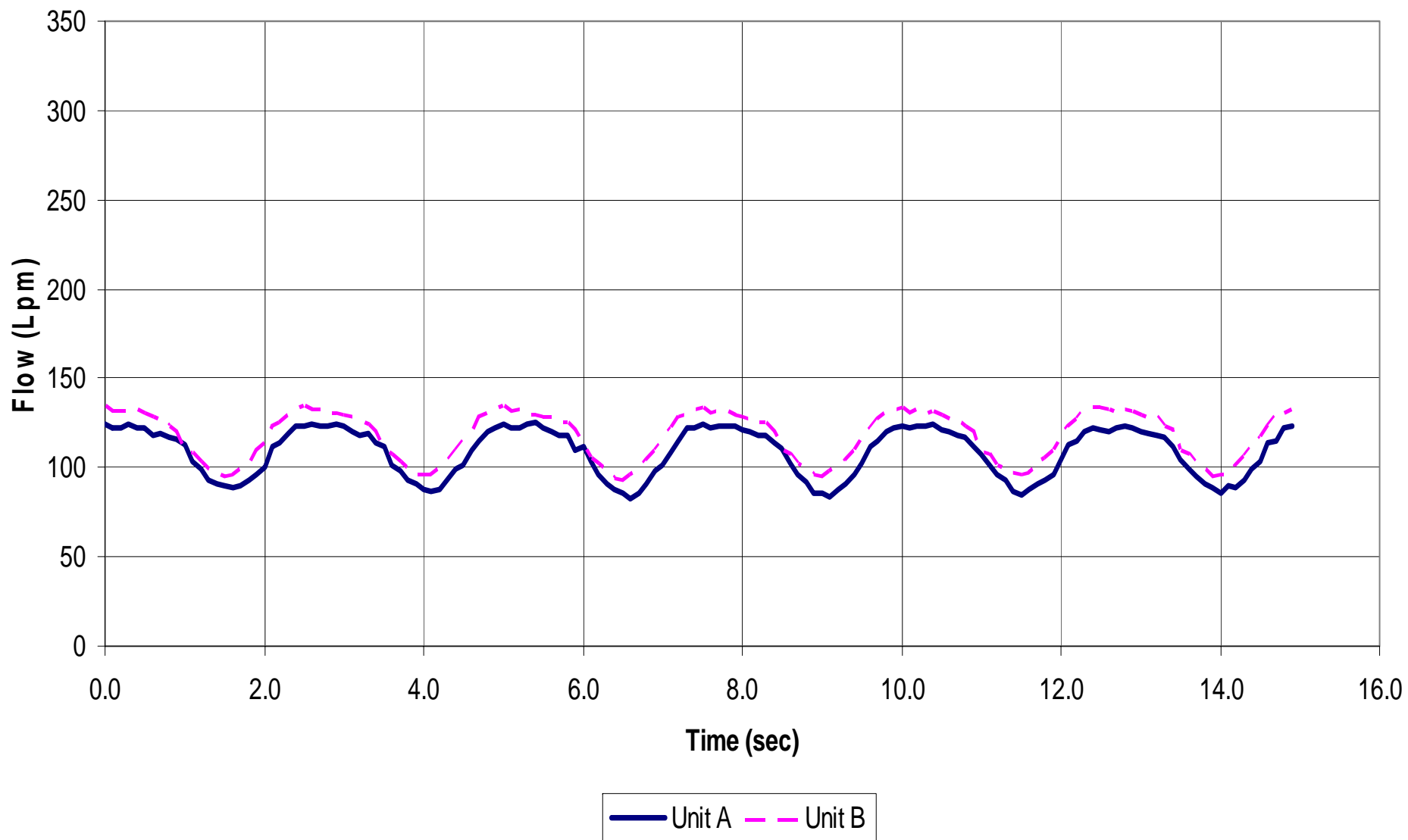


Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

PAPR A Unit to Unit Repeatability

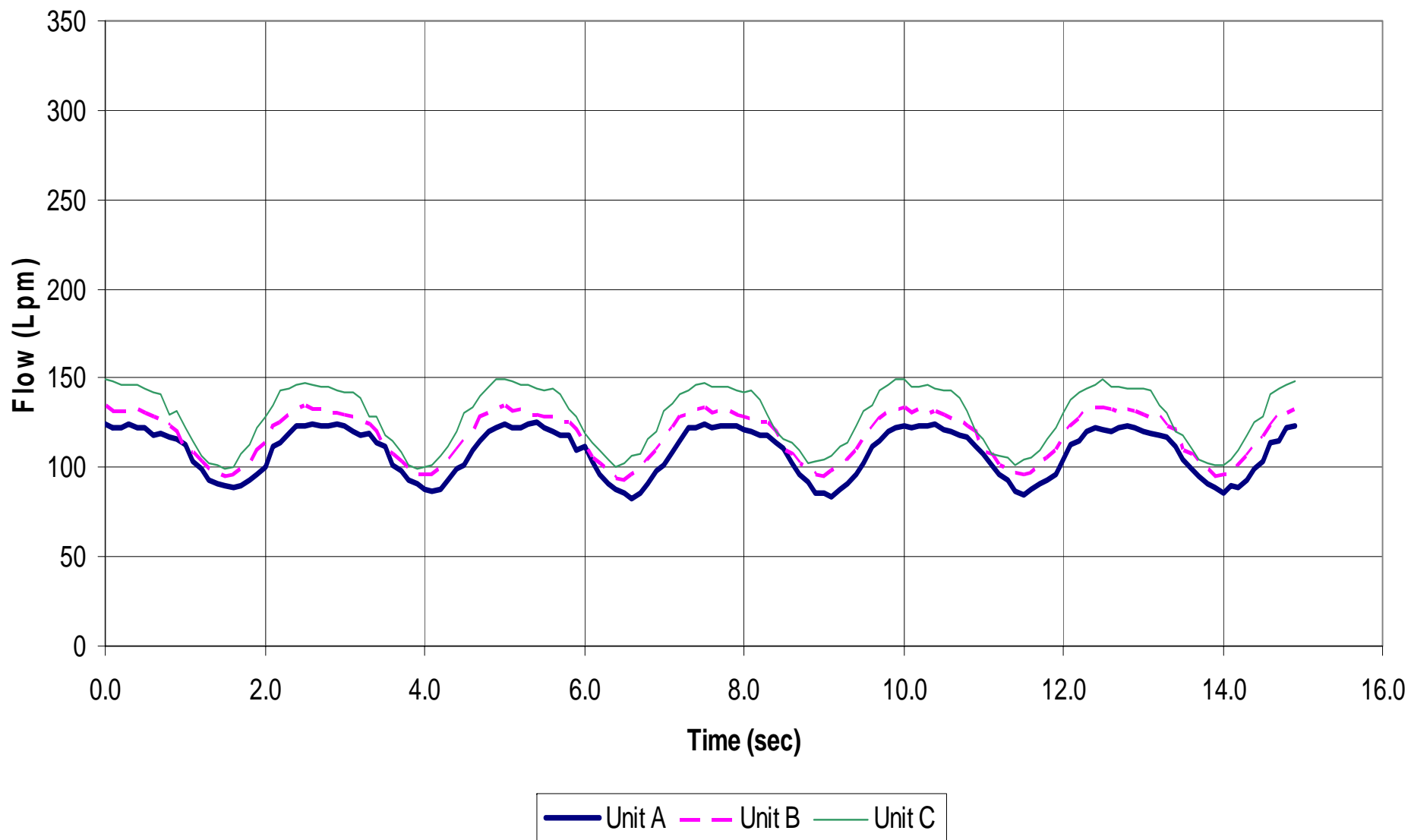


Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

PAPR A Unit to Unit Repeatability

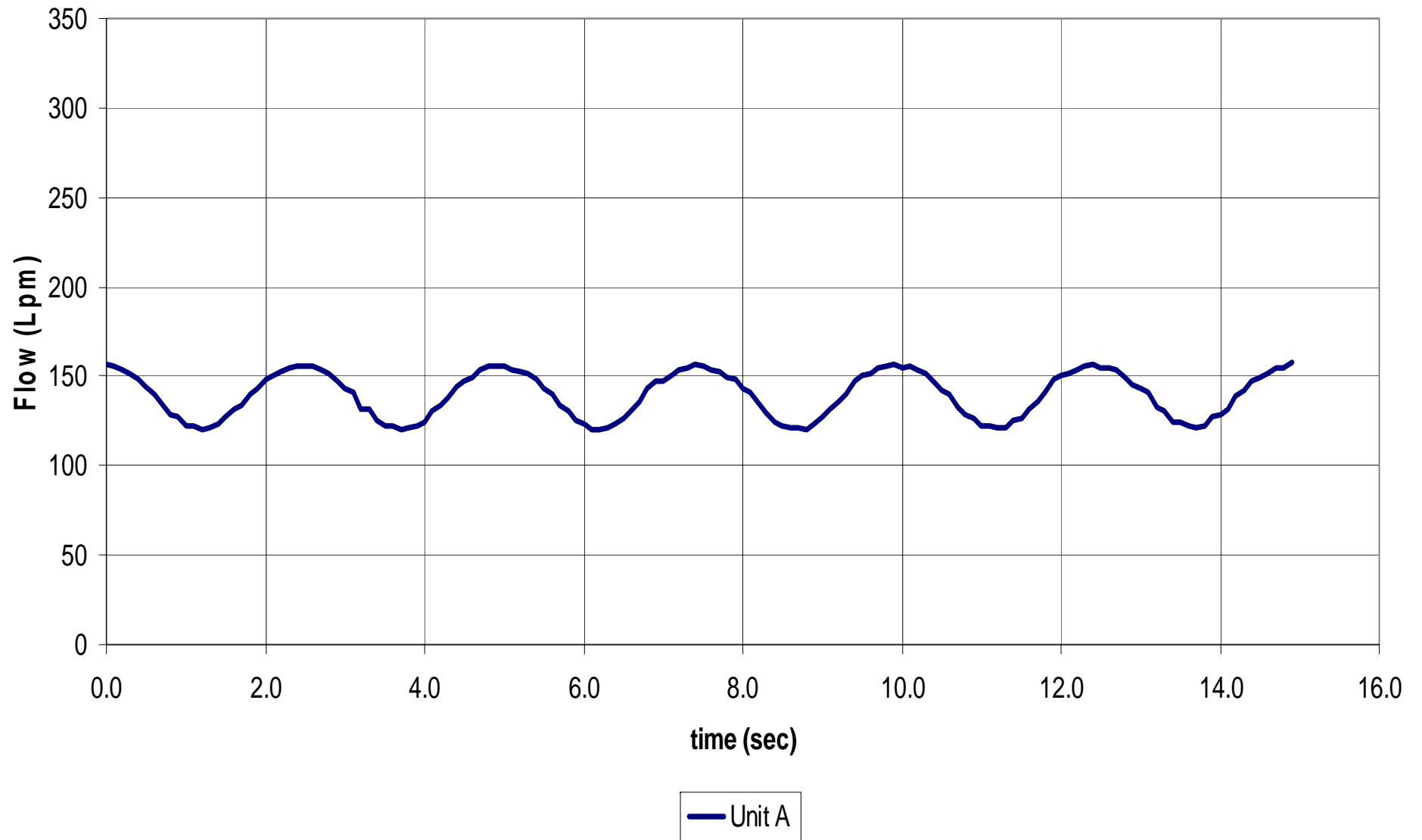


Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

PAPR B Unit to Unit repeatability

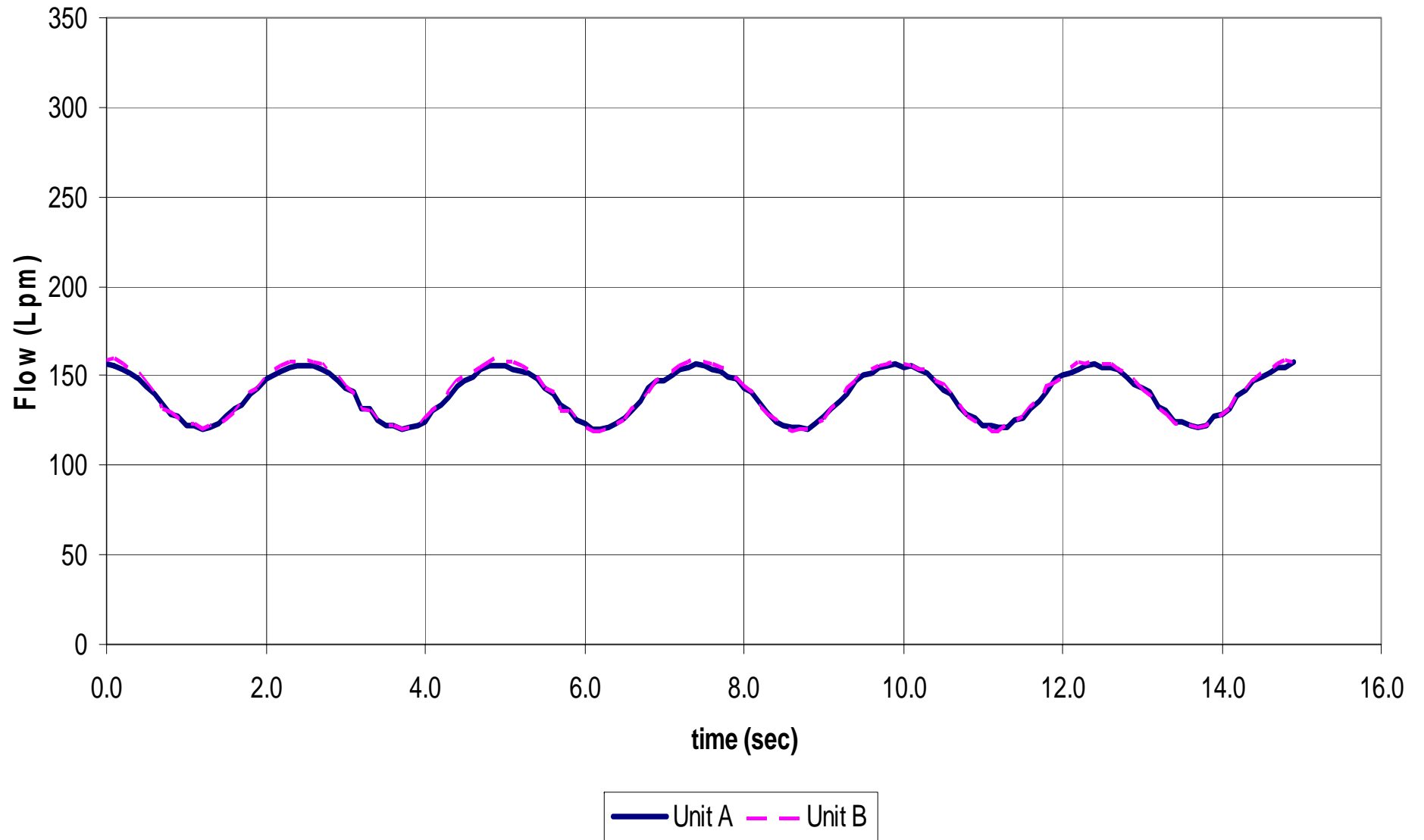


Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

PAPR B Unit to Unit repeatability

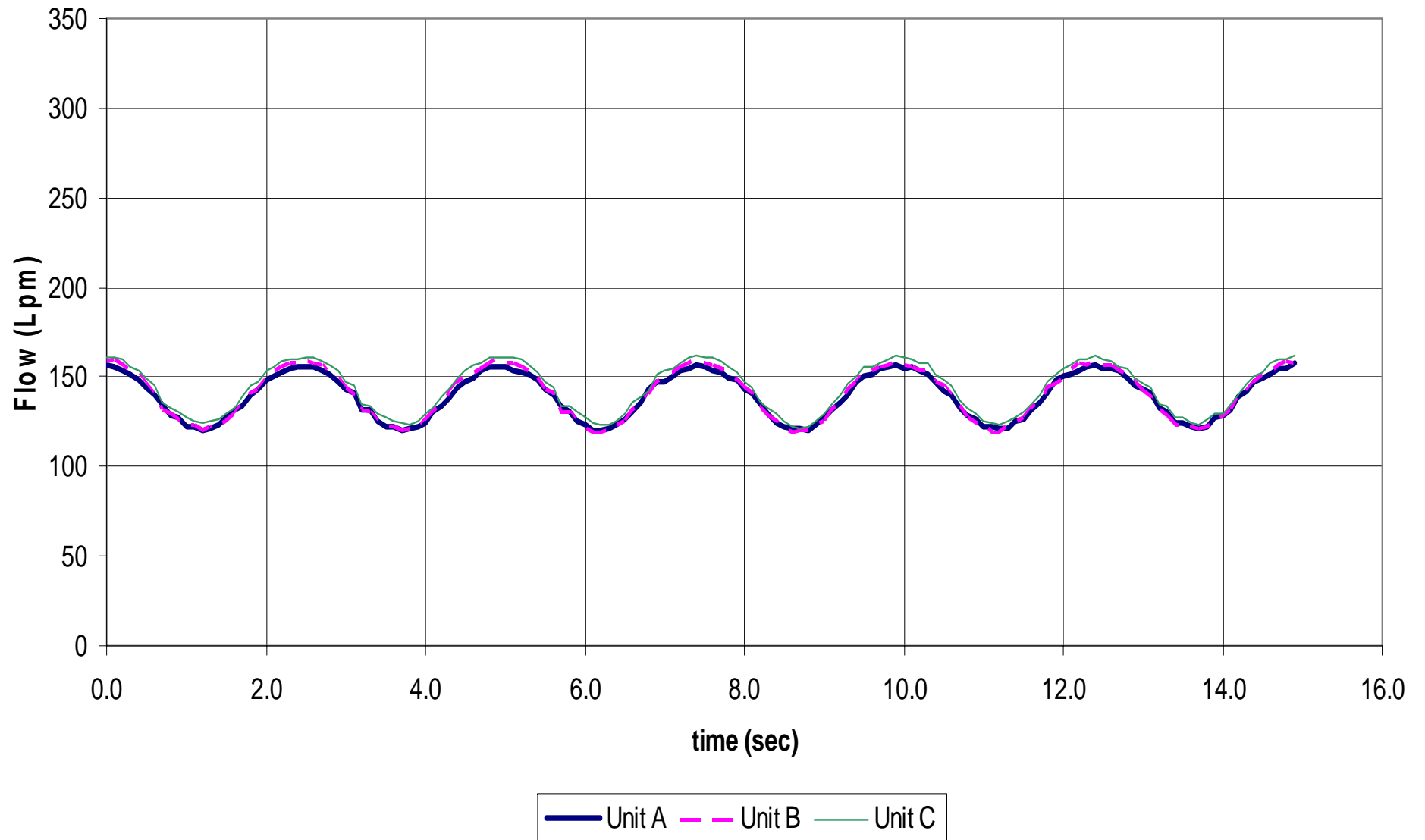


Workplace
Safety and Health

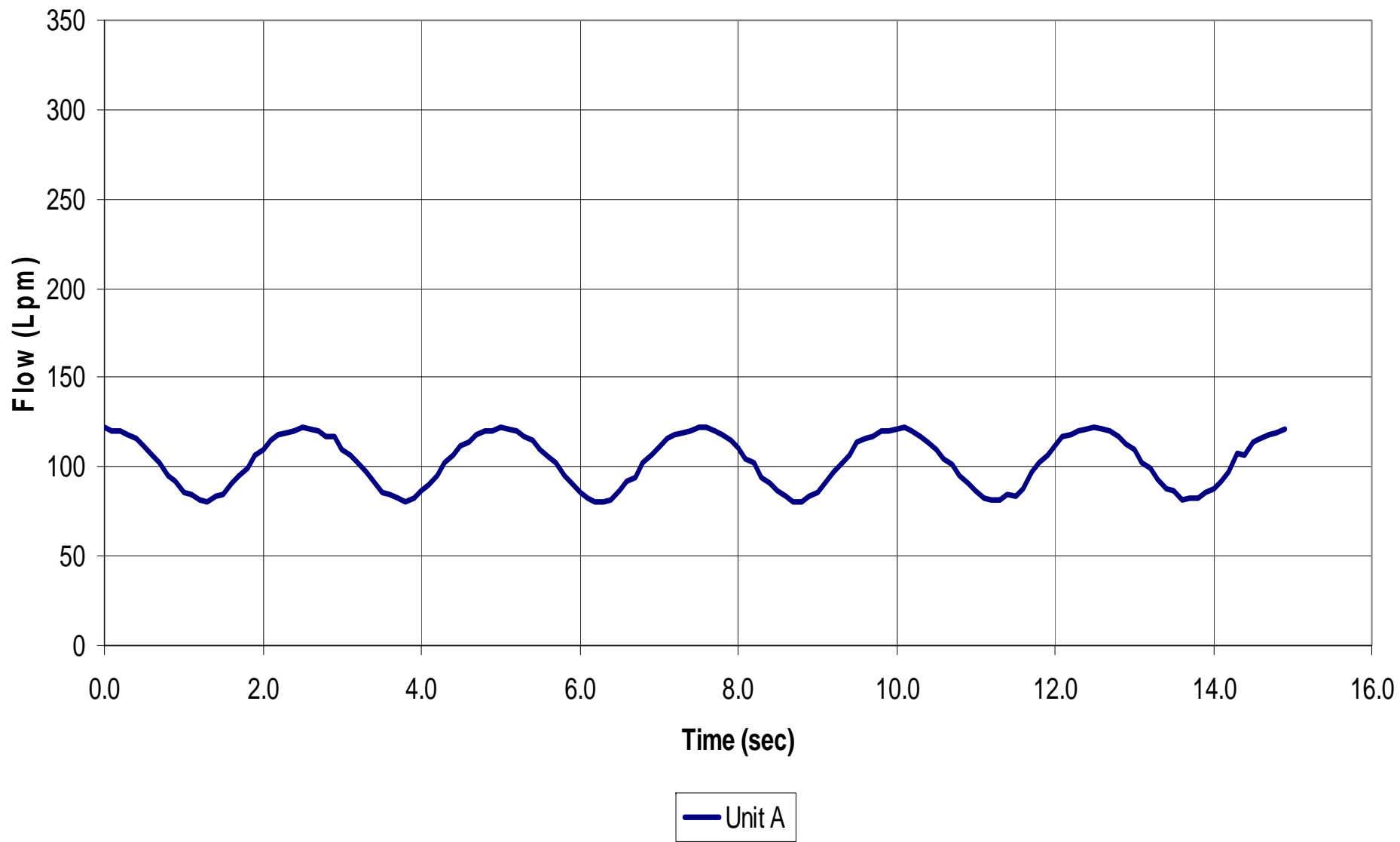


NPPTL *Research to Practice
through Partnerships*

PAPR B Unit to Unit repeatability



PAPR C Unit to Unit Repeatability

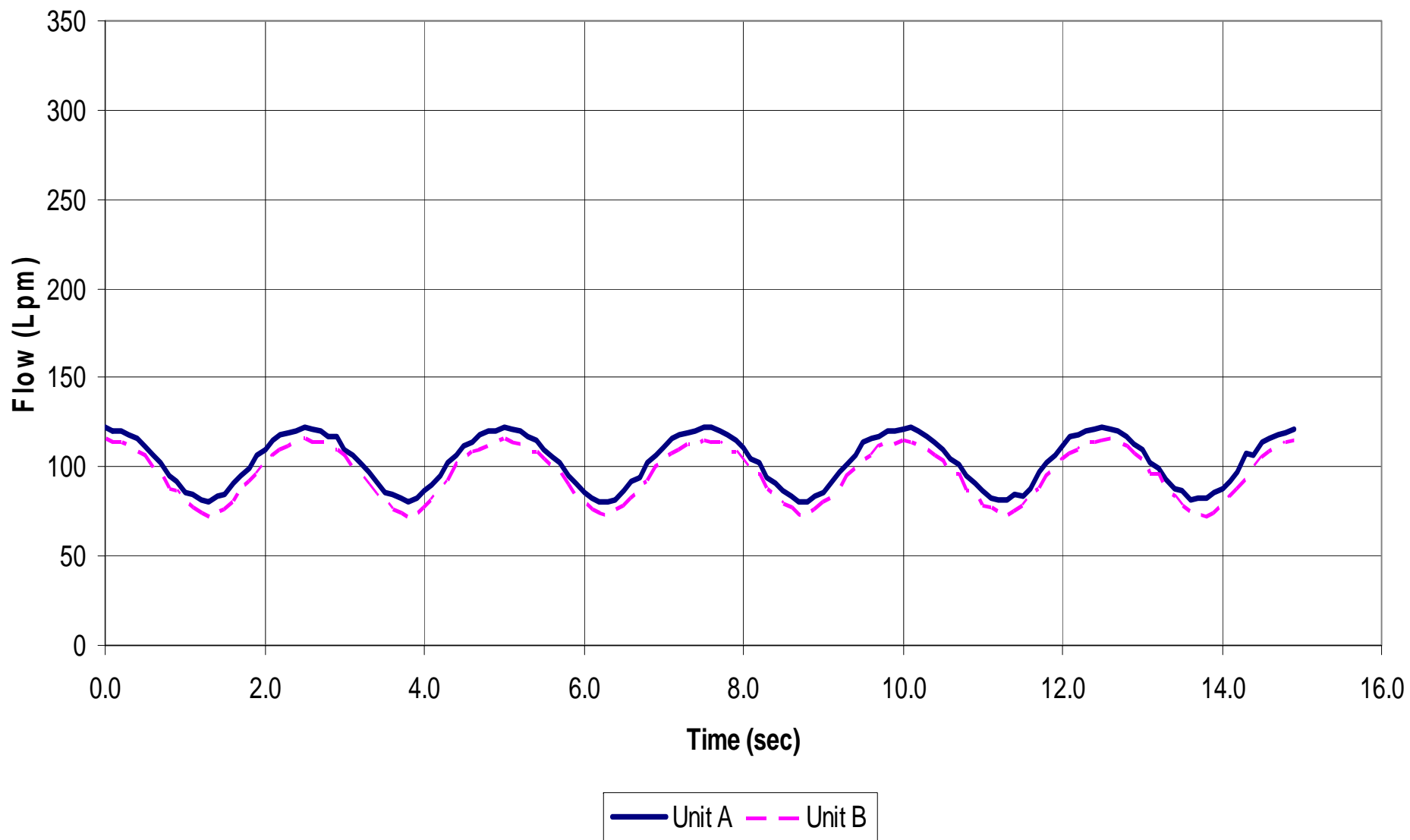


Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

PAPR C Unit to Unit Repeatability

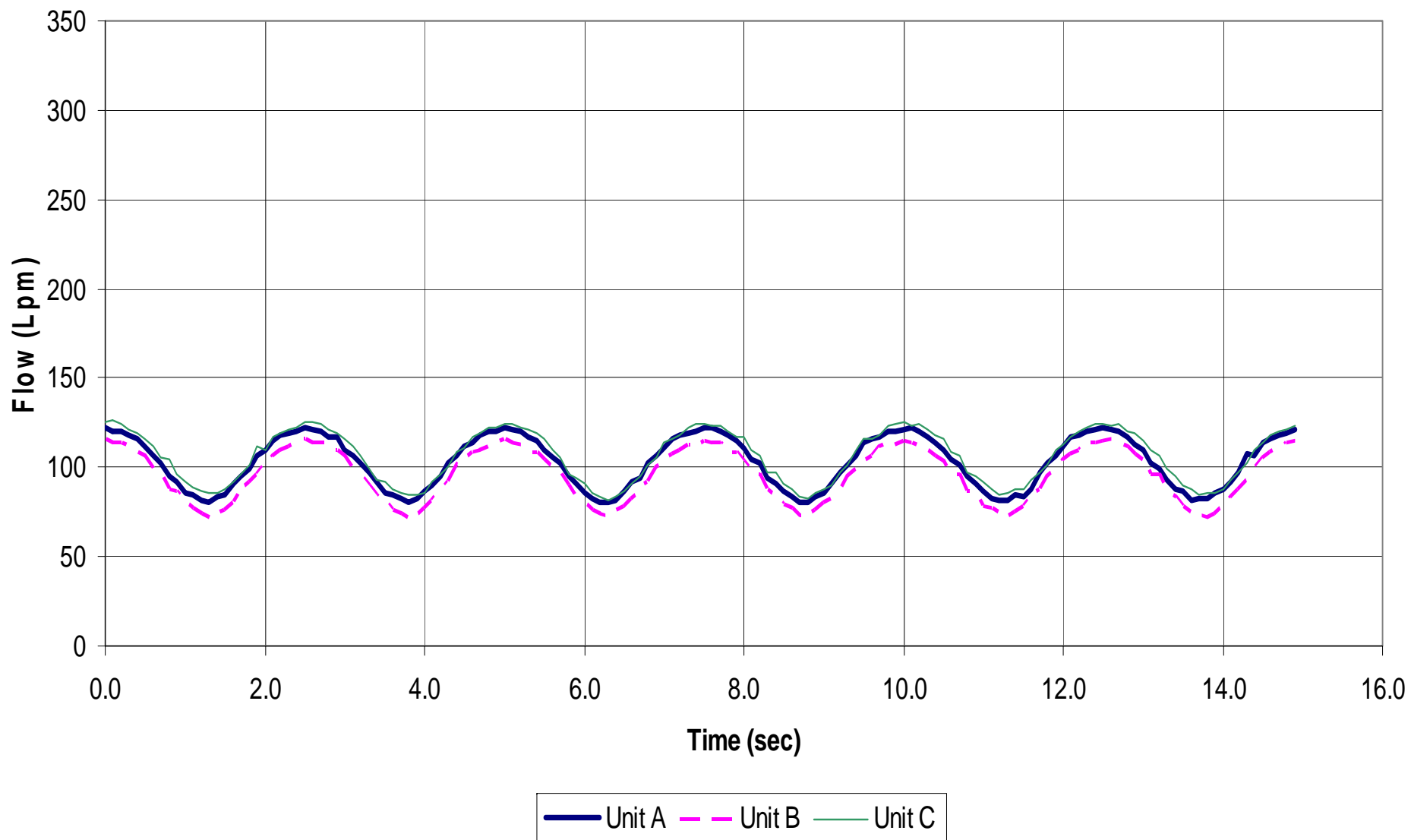


Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

PAPR C Unit to Unit Repeatability

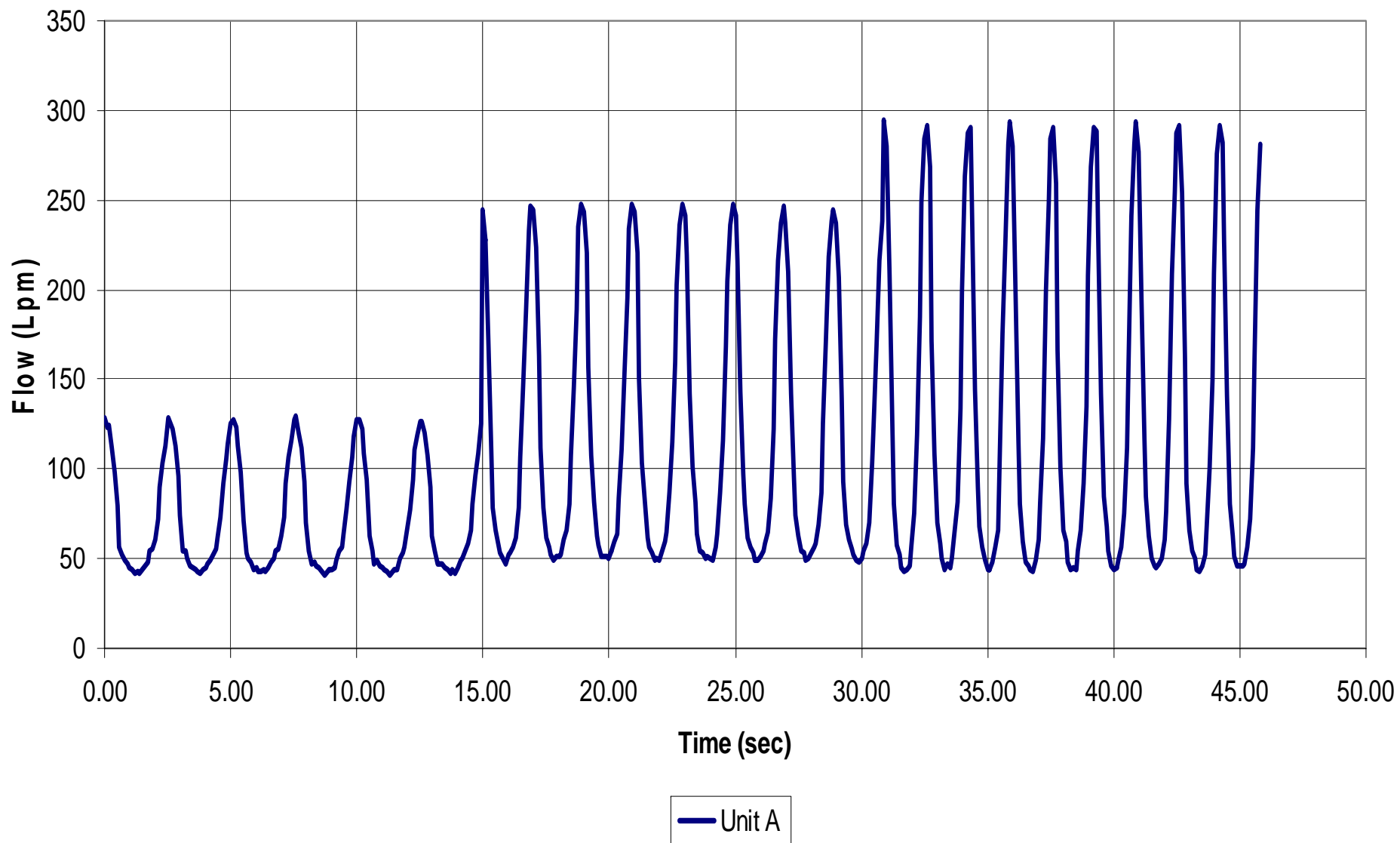


Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

PAPR D Unit to Unit Repeatability

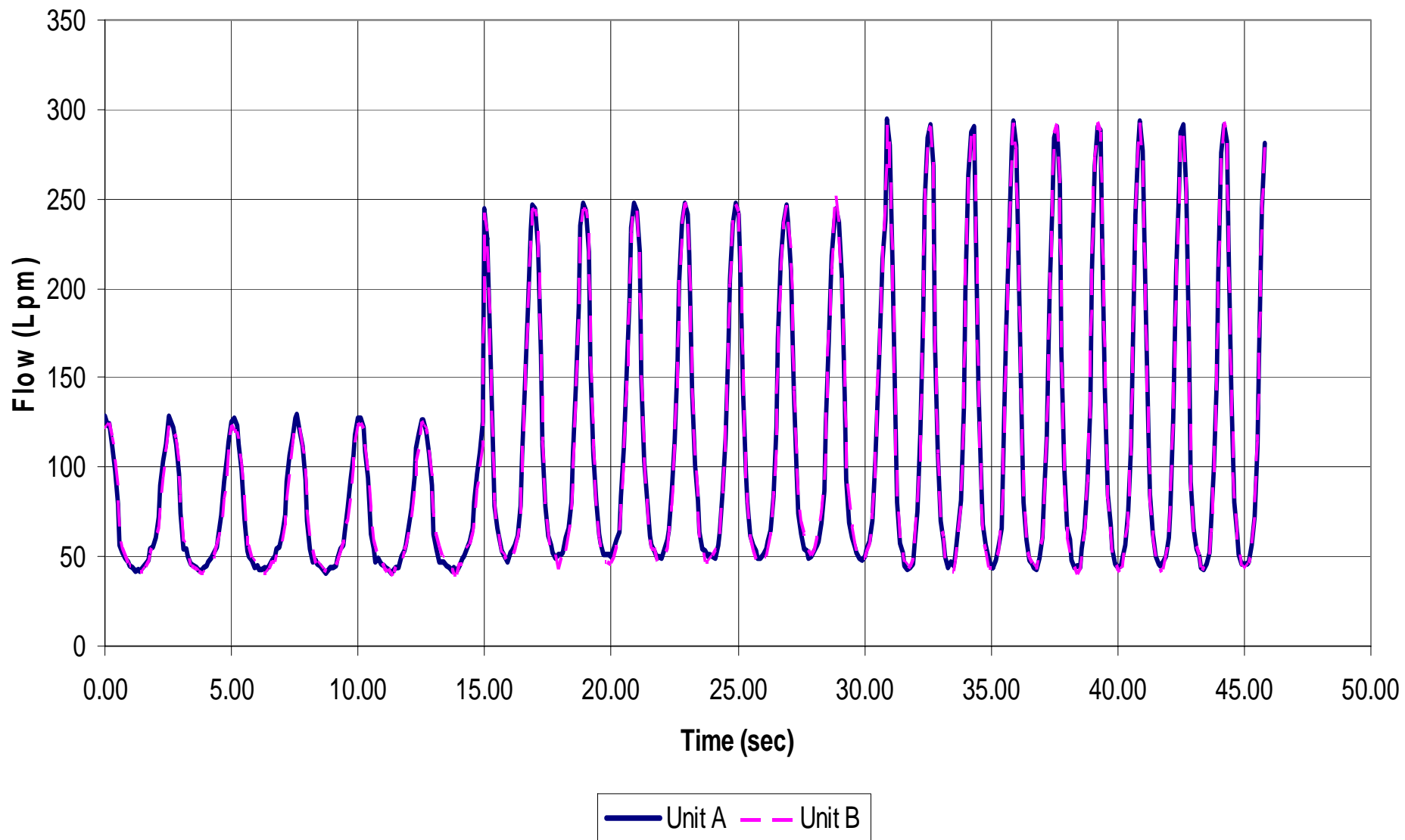


Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

PAPR D Unit to Unit Repeatability

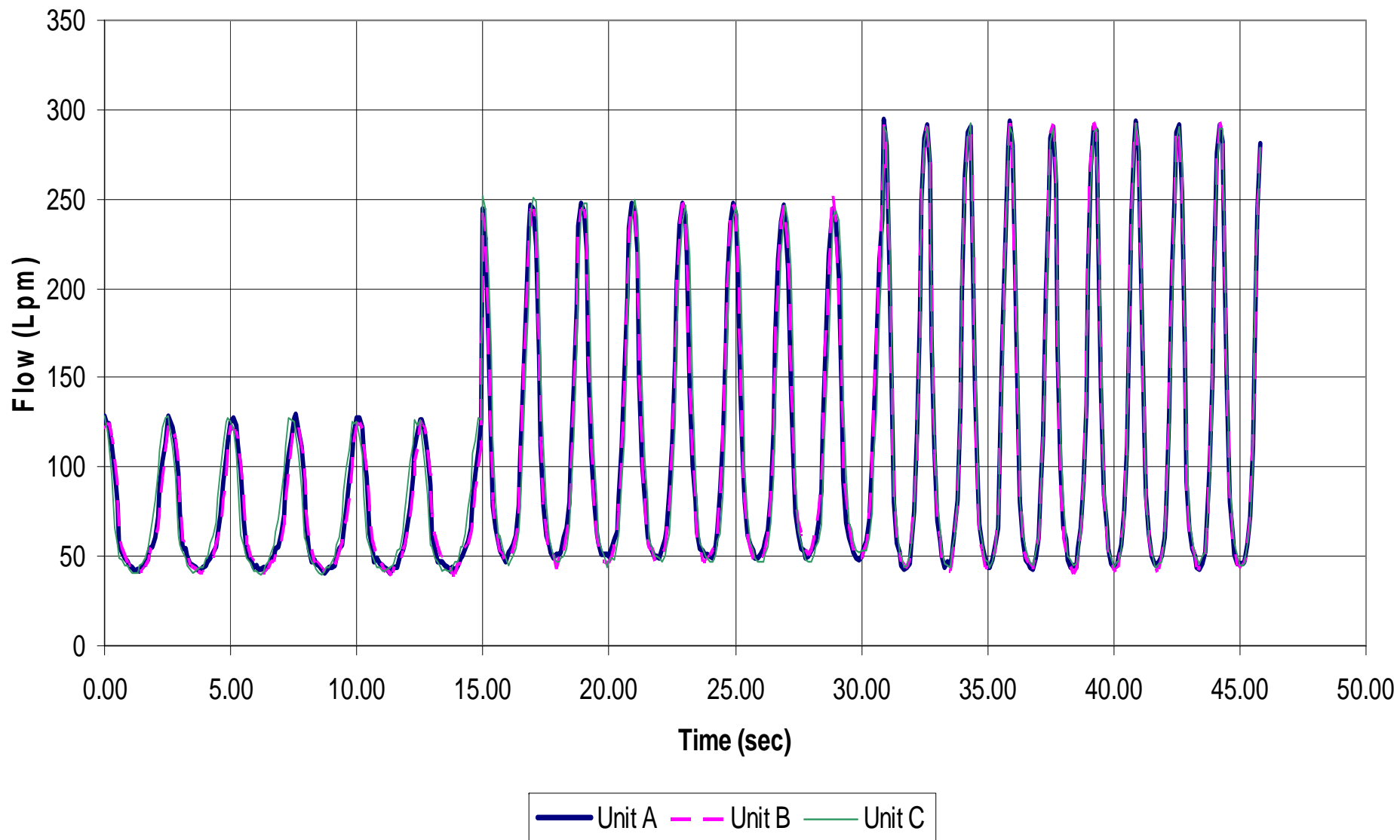


Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

PAPR D Unit to Unit Repeatability



Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

Air Flow Measurements

Questions?



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

National Personal Protective Technology Laboratory

*PAPR Benchmark Tests
Alarms*

*Sheraton Station Square
Pittsburgh, PA*

Terry Thornton, Chemist

December 13, 2005



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*

Low Pressure Alarms

- **Studies of a procedure to test Low pressure alarms**
- **An alarm is desired to alert the user that there is no longer sufficient pressure / flow in the facepiece to maintain positive pressure or maintain the protection**
- **Pressure is easier to measure in the facepiece than flow**
- **Technology will be for both the tight-fitting and loose-fitting**

Low Pressure Alarms

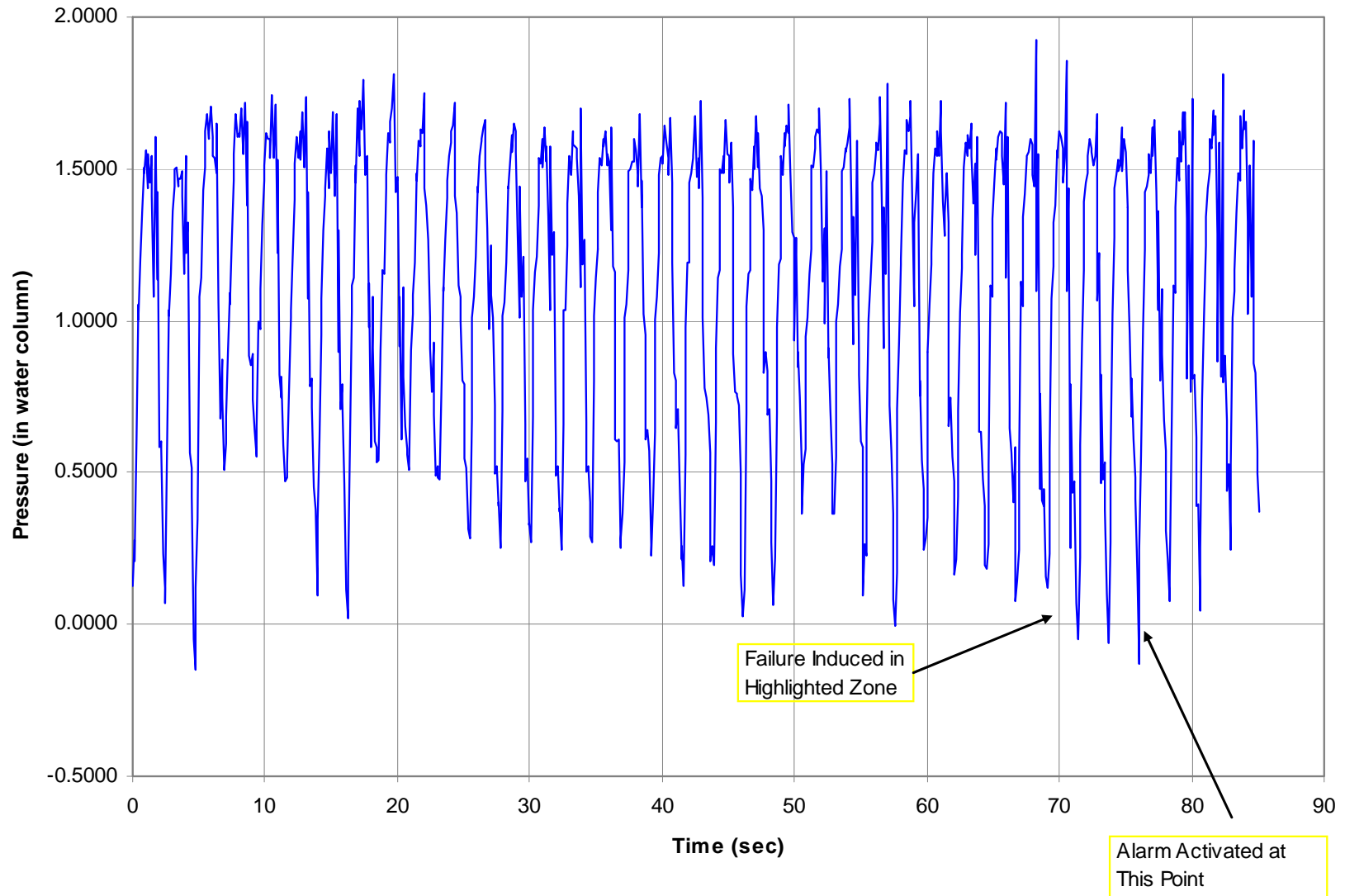
- Simple tests are to restrict the flow into the facepiece
- Room Temperature
- Cold Temperature



Low Pressure Alarm Facepiece Simulator



Low Pressure in Facepiece Failure



Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

Low Battery Alarms

- **Studies of a procedure to test Low Battery Alarms**
- **An alarm is desired to alert the user that there is sufficient battery life for a given amount of time**
- **What amount of time is sufficient?**
- **Under what conditions?**
 - Room temperature and low temperature?
 - Breathing rates?

Low Battery Alarms

- **Evaluate alarm response to PAPR performance**
 - Audible, visual & vibratory
 - Facepiece pressure
 - No voltage measurement

Low Battery Alarms

- **Monitored alarm performance of PAPR's B & D**
 - Evaluated at manufacturer's minimum recommended operating temperature
 - Batteries not cold soaked
 - Blower units cold soaked unless battery integrated
 - Insufficient data to draw conclusions on current technology vs. concept paper
 - Inconsistent battery life at cold temperatures

Environmental Testing



Workplace
Safety and Health



NPPTL *Research to Practice
through Partnerships*

Alarms

Questions?



Workplace
Safety and Health

NIOSH

NPPTL *Research to Practice
through Partnerships*