

**National Personal Protective
Technology Laboratory**

**Powered Air-Purifying Respirator
(PAPR)**

Work Rate Evolution

Policy and Standards Development Branch

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**December 2, 2008
Docket 008A**

Stages of PAPR Work Rate Evolution

- **Current Approval Method**
 - Constant flow requirement
- **Work Rates Proposed in December 21, 2007 Draft of PAPR Standard**
 - Positive pressure at maximum manufacturer specified work rate
- **Additional Work Rates Now Under Consideration**
 - Breath Assisted and Positive Pressure PAPR classifications
 - Approval requirement to be determined for Breath Assisted class



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Current PAPR Airflow Requirements

- **Minimum constant airflow required for approval**
 - Respiratory inlet covering mounted on headform in sealed chamber with blower outside
 - Vacuum blower removes air from chamber to maintain zero pressure differential between chamber and atmosphere
 - Vacuum blower flow monitored with dry test meter



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Current PAPR Airflow Requirements

Currently Approved Minimum Flow Rates

Tight-fitting PAPR	115 Lpm
Loose-fitting PAPR	170 Lpm

- In most cases, these flows are capable of maintaining positive pressure in the breathing zone of the PAPR respiratory inlet covering at a work rate corresponding to 40 Lpm breathing rate



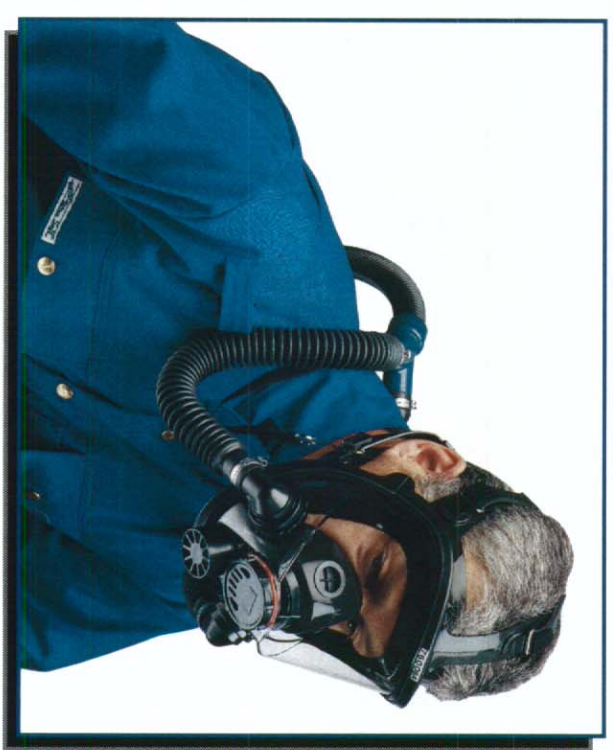
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Work Rates Proposed in PAPR Standard Concept Paper (December 21, 2007)

- Original objectives of multiple work rate approvals
 - Improved protection
 - Sufficient airflow
 - Positive pressure
 - Flexibility
 - Comfort
 - Cost savings



Work Rates Proposed in PAPR Standard Concept Paper (December 21, 2007)

Proposed NIOSH Work Rates (Sinusoidal Waveform)
Expressed as Respiration Rates

Work Rate	Minute Volume	Tidal Volume and Respirations	Peak Flow
Low	25 liters	1.30 liters @ 19.2 per minute	78.54 Lpm
Moderate	40 liters	1.67 liters @ 24 per minute	125.66 Lpm
High	57 liters	1.95 liters @ 29.1 per minute	179.07 Lpm

Work Rates Proposed in PAPR Standard Concept Paper (December 21, 2007)

- **Projected test protocol**
 - Manufacturer specifies highest work rate from table for intended use of PAPR
 - PAPR must maintain positive pressure in breathing zone of respiratory inlet covering while properly mounted on a breathing machine operating at the specified work rate



Work Rates Proposed in PAPR Standard Concept Paper (December 21, 2007)

- **Additional criteria for fully evaluating PAPR performance at specified work rate**
 - Appropriate airflow for particulate and gas/vapor challenge testing
 - Minimum constant airflow required to maintain positive pressure in the breathing zone of the respiratory inlet covering
 - Required flows experimentally determined for moderate and high work rates for tight-fitting PAPR and for all three work rates for loose-fitting PAPR



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Work Rates Proposed in PAPR Standard Concept Paper (December 21, 2007)

PAPR Bench Test Constant Airflow Requirements Based on Positive Pressure Tests With Single Speed Units

Respirator Type	Flow Associated with Each Work Rate		
	Low Work Rate	Moderate Work Rate	High Work Rate
Tight-fitting	Not Applicable	115 Lpm	170 Lpm
Loose-fitting	115 Lpm	170 Lpm	235 Lpm

Work Rates Proposed in PAPR Standard Concept Paper (December 21, 2007)

- Experimental determination of constant airflows required to maintain positive pressure in breathing zones of PAPR respiratory inlet coverings
 - PAPRs designed to operate at desired constant flow rates not commercially available
- Flow rates of several samples of two blower models equipped with both tight and loose-fitting respiratory inlet coverings controlled by varying input voltage through external power supply in lieu of manufacturer battery packs

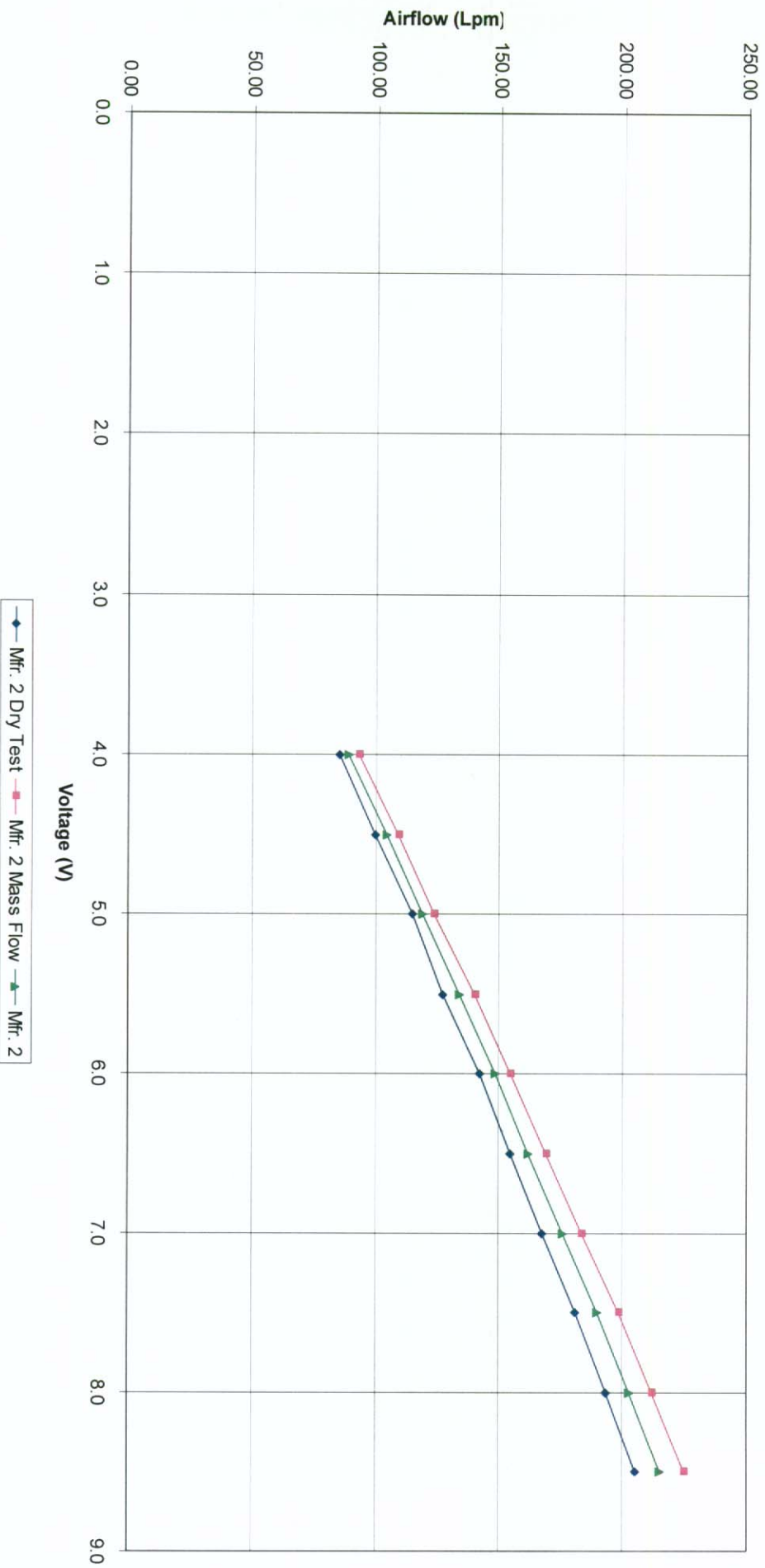


Work Rates Proposed in PAPR Standard Concept Paper (December 21, 2007)

- **Calibration of airflow versus voltage**
 - Vary voltage and record airflow for each PAPR sample
 - Measure airflow for each sample using both a dry test meter and a mass flow meter
 - Plot data and correlate using second order polynomial fit
 - Voltages required to obtain desired test flows can now be predicted
 - Flow at voltage required to maintain positive pressure can be calculated

Work Rates Proposed in PAPR Standard Concept Paper (December 21, 2007)

Mfr. 2 Composite Tight Fitting PAPR Flow vs Voltage Data



Work Rates Proposed in PAPR Standard Concept Paper (December 21, 2007)

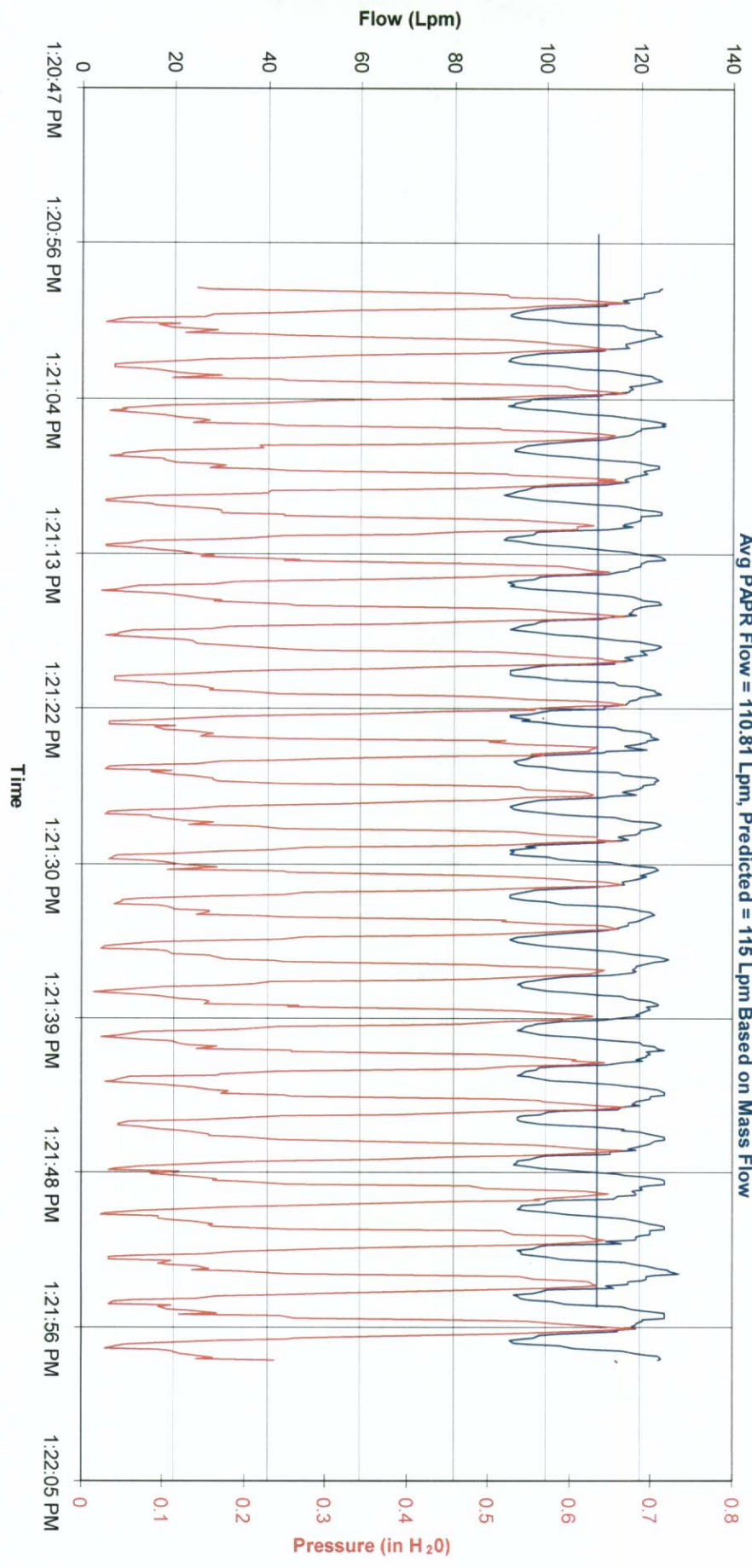
- **Positive pressure breathing machine test**
 - Mount PAPR respiratory inlet covering on torso coupled to a variable frequency and tidal volume breathing machine
 - Monitor and record breathing zone pressure and canister pressure drop
 - Plot pressure profile, flow profile calculated from canister ΔP and average PAPR flow



Work Rates Proposed in PAPR Standard Concept Paper (December 21, 2007)

Mfr. 1 Unit A Tight Fitting PAPR Canisters A B & C 40 Lpm Test 2

Avg PAPR Flow = 110.81 Lpm, Predicted = 115 Lpm Based on Mass Flow



— PAPR Flow — Average Flow — Mask Pressure

Work Rates Proposed in PAPR Standard Concept Paper (December 21, 2007)

- **Conclusions from positive pressure PAPR breathing machine tests**
 - Flow versus voltage correlations were similar regardless of whether dry test meter or mass flow meter used to determine flow
 - Excellent repeatability between different samples of same model
 - Excellent agreement of predicted flow with average of flow calculated from canister pressure drop

Work Rates Proposed in PAPR Standard Concept Paper (December 21, 2007)

- **Conclusions from positive pressure PAPR breathing machine tests (cont.)**
 - Flow required to maintain positive pressure at both work rates for tight-fitting PAPR similar for both models tested
 - Flow required to maintain positive pressure at all three work rates for loose-fitting PAPR similar for both models tested

Work Rates Under Consideration for Inclusion in PAPR Standard

- **Two PAPR classes**
 - Breath assisted
 - Positive pressure
- **Additional work rates (expressed as respiratory rates)**
 - Sedentary (11Lpm)
 - Extremely high (78 Lpm, 99 Lpm or both)
 - Based on International Technical Specification ISO/TS 16976-1:2007, Classes 1, 7 and 8 for the ISO standard man (body surface of 1.8m²)



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Work Rates Under Consideration for Inclusion in PAPR Standard

- **Characterization of proposed work rates**
 - Sedentary rate
 - Sinusoidal ventilation profile
 - Undefined tidal volume and frequency
 - Extremely high work rate(s)
 - Undefined ventilation profile
 - Undefined tidal volume and frequency

Work Rates Under Consideration for Inclusion in PAPR Standard

(PAPR Subpart P)

