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National Personal Protective Technology Laboratory

Concept Standard for CBRN, Full-Facepiece, Closed-Circuit, Self-Contained Breathing Apparatus (SCBA)

Holiday Inn Select, Pittsburgh South
Pittsburgh, PA

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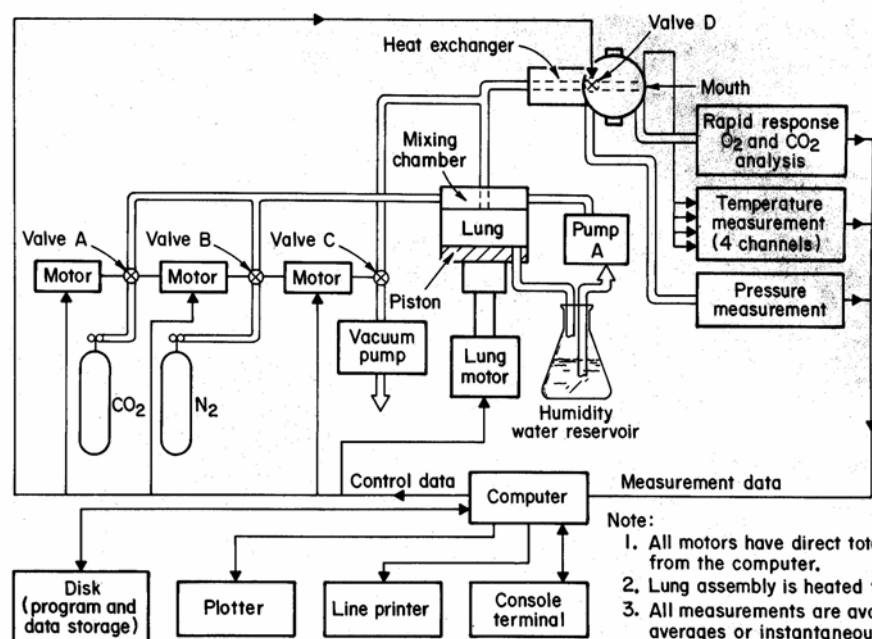
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CBRN Respirator Standards

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.

Automated Breathing and Metabolic Simulator (ABMS) Testing of Closed-Circuit Breathing Apparatus to NFPA/CBRN Standards

Automated Breathing and Metabolic Simulator

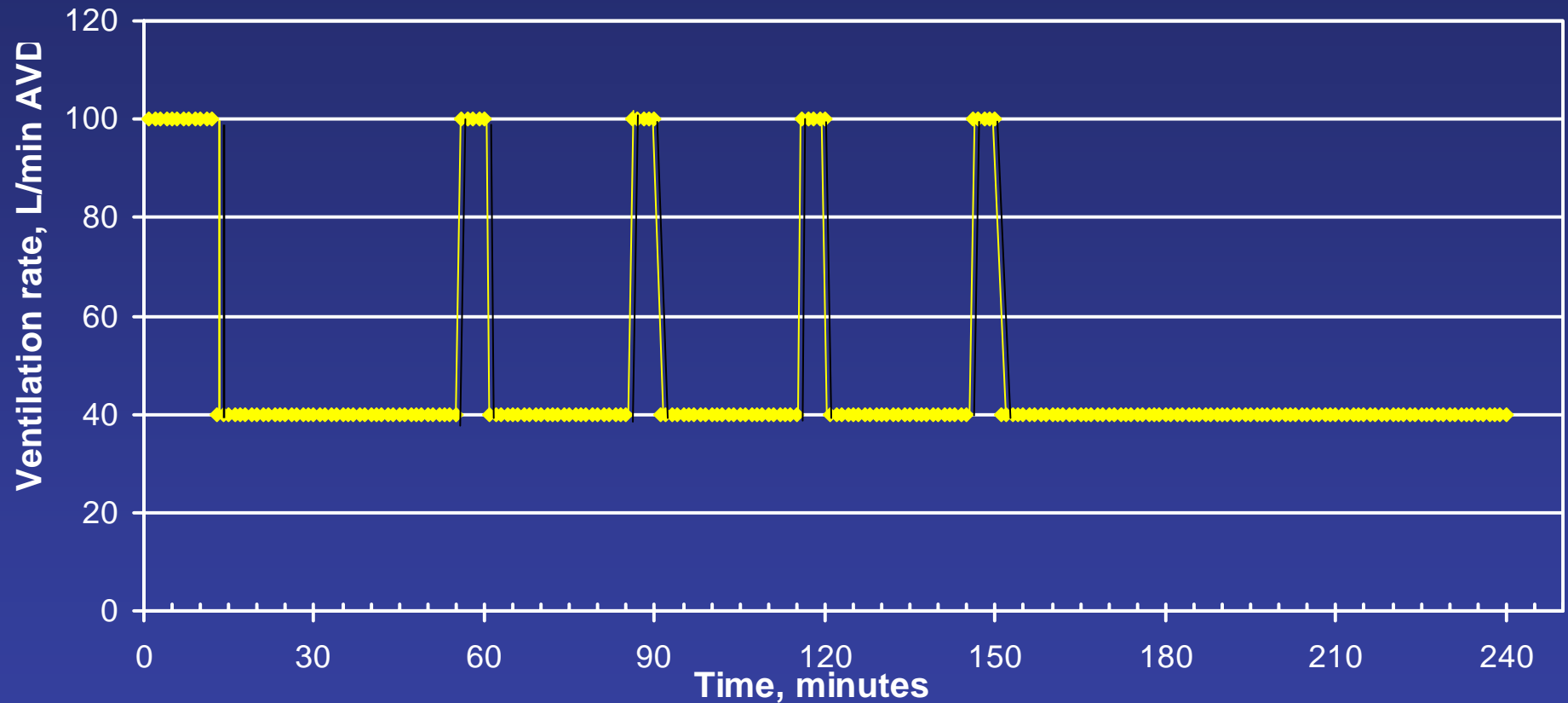


Changes to Work Rate and Stressor Level Limits

Moderate work rate

adjusted to be more human-like

V_e for Proposed NFPA/CBRN Protocol



Moderate Work Rate Changes

- Ventilation rate
- VO_2
- VCO_2
- Respiratory Frequency
- Unchanged from **40 L/min**
- From 1.60 to **1.35 L/min**
- From 1.60 to **1.15 L/min**
- From 24 to **18 bpm**

Stressor Level Limits Changes

- Exhalation Peak Pressure
- Average Inhaled CO₂
- Average Inhaled O₂
- Inhaled WB Temperature
- From 89 to **200 mm H₂O**
- From 2 to **4%**
- From 19.5 to **15%**
- From 45 to **50 °C**

Justification

- New stressor level limits are based on human physiological tolerance, not tradition or apparatus capability.
- If a stressor level exceeds its limit for >1 minute, the apparatus fails.
- High stressor levels will occur during high work rates.
- At low work rates, stressor levels will be low.
- If stressor levels are high at low work rates, they will exceed the limits at high work rates.
- High work rates are not sustainable for long periods of time; therefore, high stressor levels will not be experienced for long periods of time.

NOTE

*If an apparatus is engineered to be comfortable at the **highest** work rate at which it is ever likely to be used, it will be bigger and heavier than it need be for **normal** work rates.*

NIOSH 42 CFR 84 testing versus Proposed CBRN testing

42 CFR 84

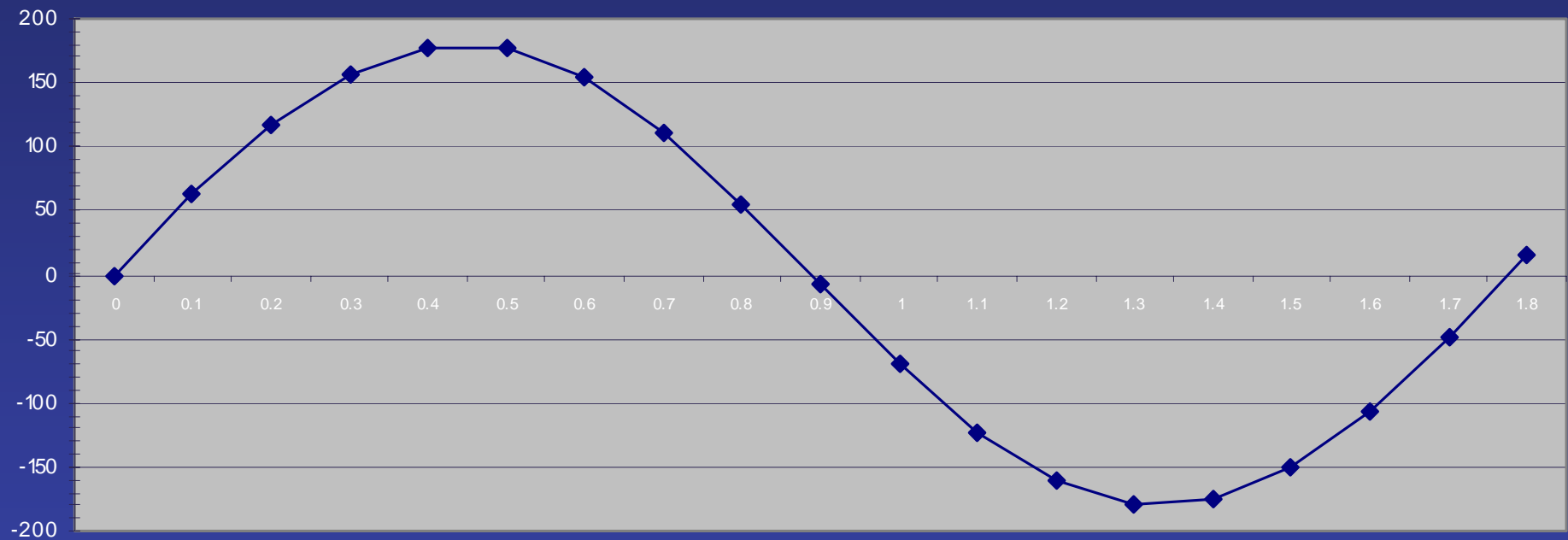
- Pressure measured on breathing machine test with no humidity or CO₂.
- CO₂, O₂, and temperature measured only during **rest** periods of human-subject testing.

Proposed CBRN testing

- Pressure measured on an ABMS with humidity and CO₂, eliciting more human-like performance.
- CO₂, O₂, and temperature measured **continuously** including during high-work periods. We see everything a user will see.

Ventilation rate
(minute volume of exhalations)
versus
peak flow rate
(instantaneous flow rate)

Sinewave Breath Waveform



Minute-volume versus peak flow rate

NIOSH (moderate)

- 40 L/min ventilation rate
- 115 L/min peak flow rate

NFPA (high)

- 103 L/min ventilation rate
- 255 L/min peak flow rate

NOTES

The peak **pressure** will occur at the peak **flow** rate.

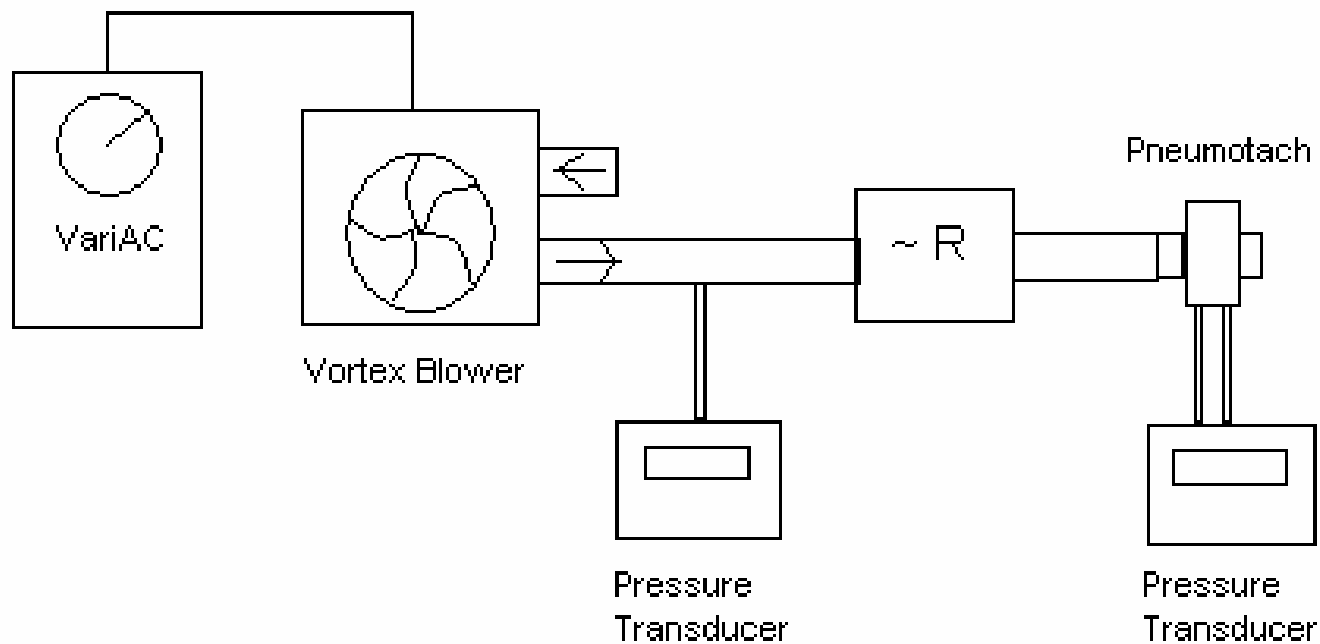
A **resistance** is defined as a ***pressure at a flow rate.***

A **resistance** will exhibit different **pressures** at different flow rates.

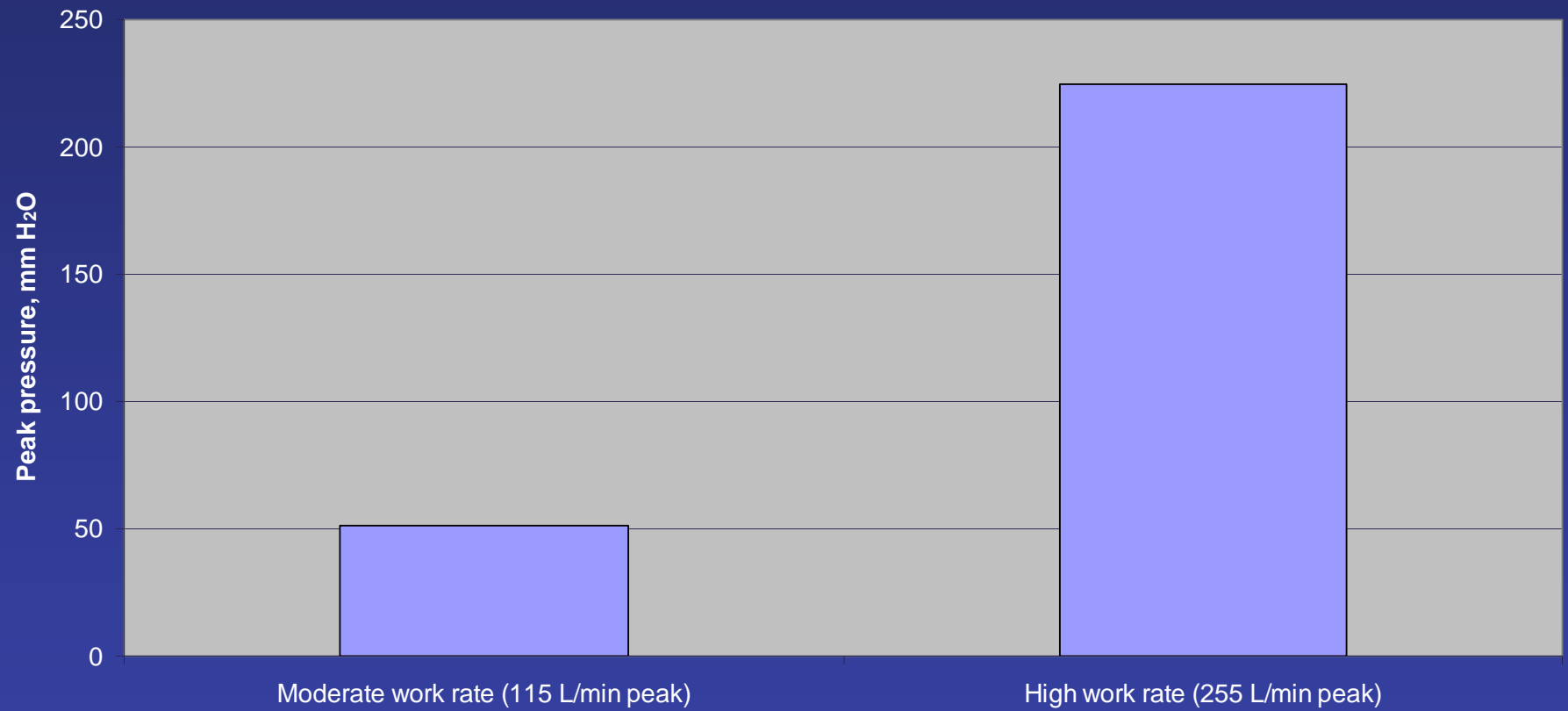
Variable-Resistance Test

If a particular apparatus exhibits a pressure of 51 mm H₂O at the NIOSH ventilation rate of 40 L/min (peak flow rate of 115 L/min), what pressure will it exhibit at the NFPA ventilation rate of 103 L/min (peak flow rate of 255 L/min)?

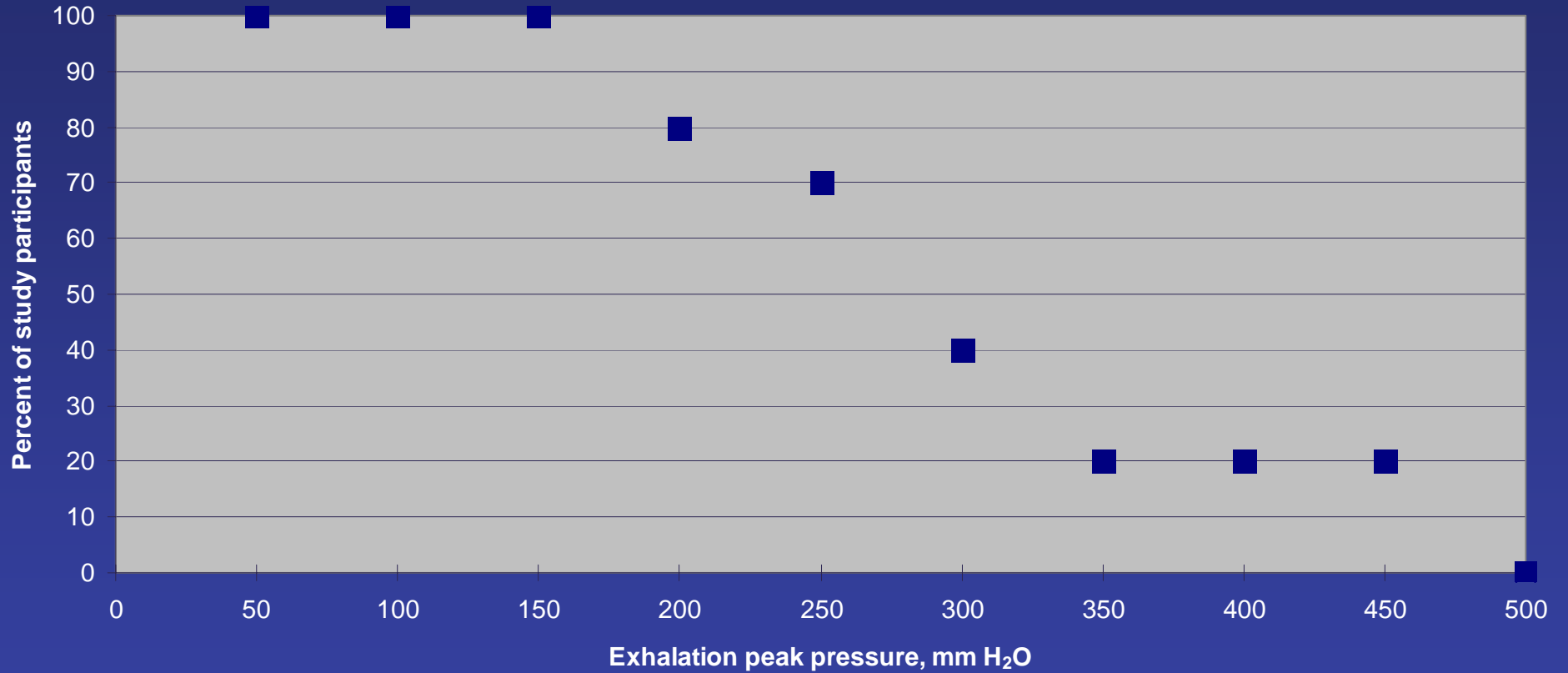
Variable Resistance Test Set-up



Same resistance showing two pressures at two flow rates



Peak-Pressure Tolerance



Questions

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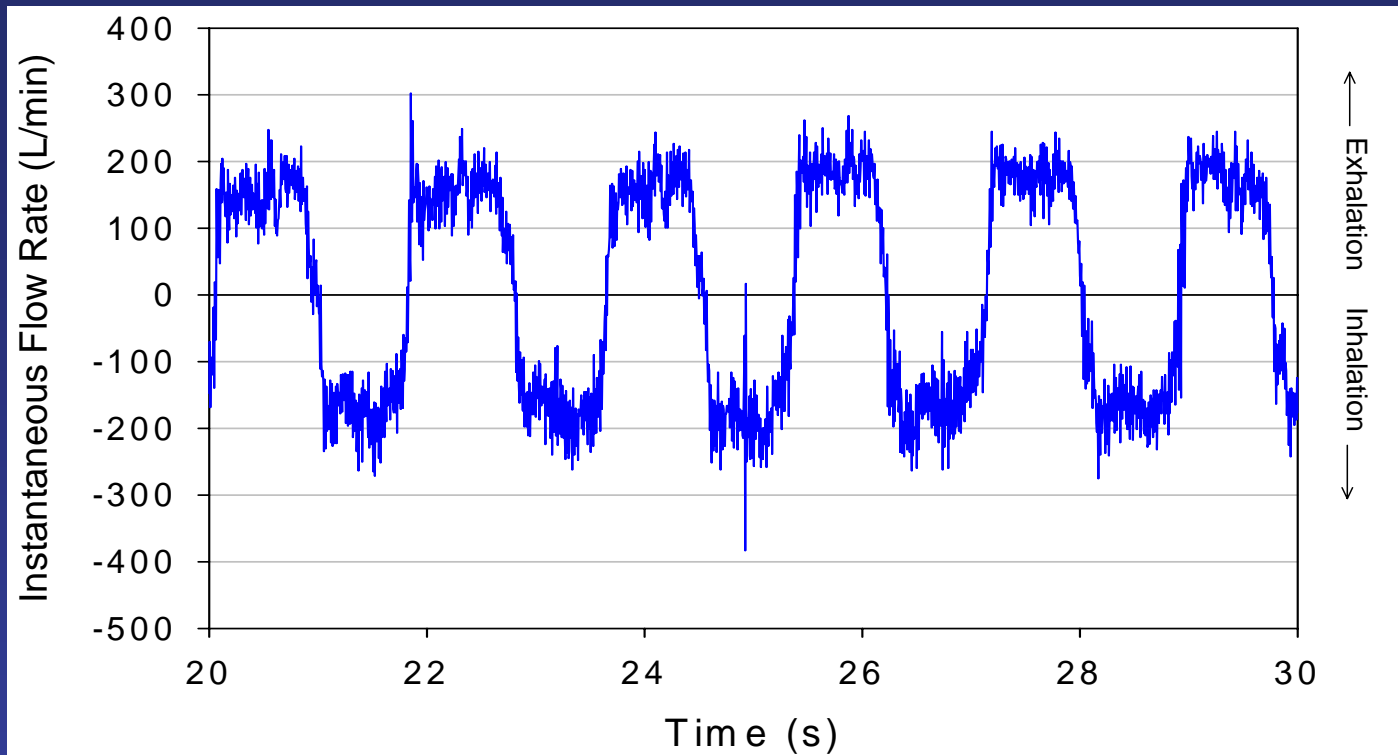
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1-800-35-NIOSH

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Data Compilation



TI (s)	TE (s)	f (1/min)	VT (L)	VI (L/min)	VT/VI (L/s)	TI/TTOT	PIFR (L/min)	PEFR (L/min)	PIFR/VE	PEFR/VE
0.94	0.82	34.01	2.16	73.52	2.30	0.53	271.49	302.67	3.69	4.12
1.00	0.84	32.72	2.35	76.94	2.36	0.54	262.26	243.96	3.41	3.17
0.89	0.82	34.93	2.16	75.45	2.42	0.52	383.51	268.75	5.08	3.56
0.86	0.92	33.79	2.42	81.92	2.82	0.48	263.58	245.27	3.22	2.99
0.89	0.89	33.57	2.43	81.58	2.72	0.50	275.44	245.27	3.38	3.01