

**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**

Nicholas Kyriazi, Biomedical Engineer

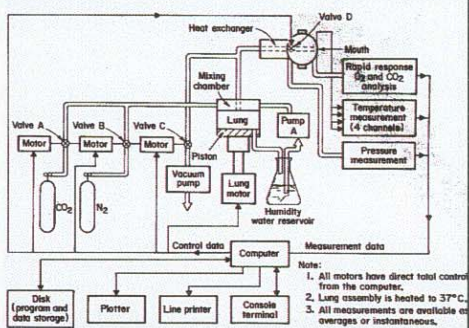
19 July 2005



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



Automated Breathing and Metabolic Simulator



CDC Workplace Safety and Health

NIOSH

NPPTL Research to Practice through Partnerships

Changes to Work Rate and Stressor Level Limits

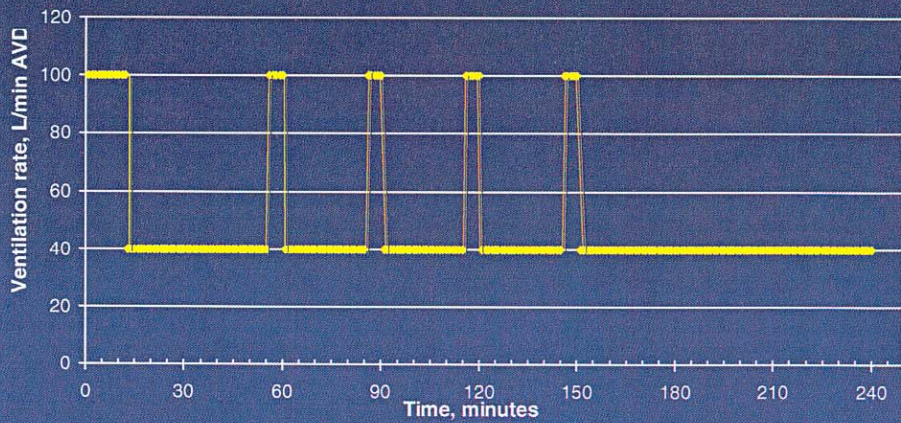
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Moderate work rate adjusted to be more human-like

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 CO_2
- Average Inhaled O_2
- Inhaled WB Temperature
- From 89 to 200 mm H_2O
- 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

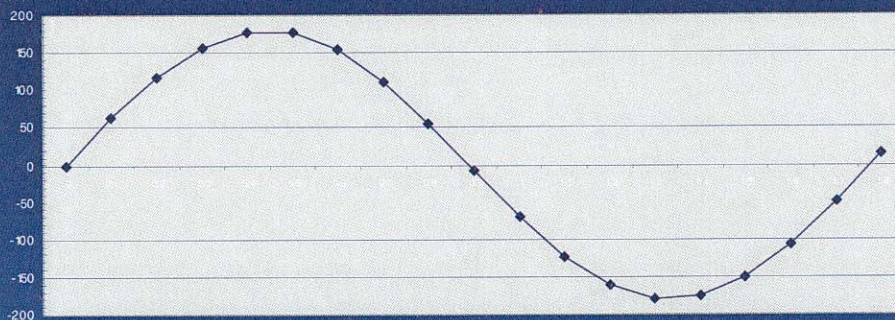
- Pressure measured on breathing machine test with no humidity or CO₂.
- CO₂, O₂, and temperature measured only during **rest** periods of human-subject testing.

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.

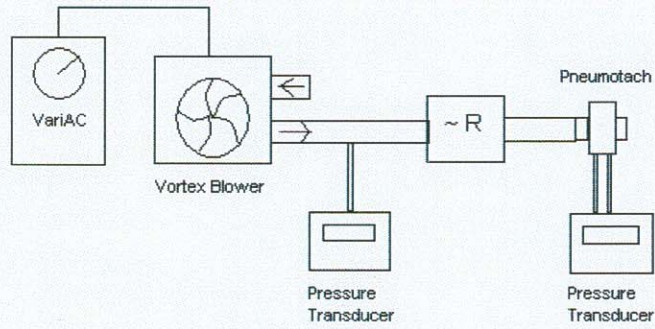
A **resistance** is defined as a **pressure at a flow rate**.

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

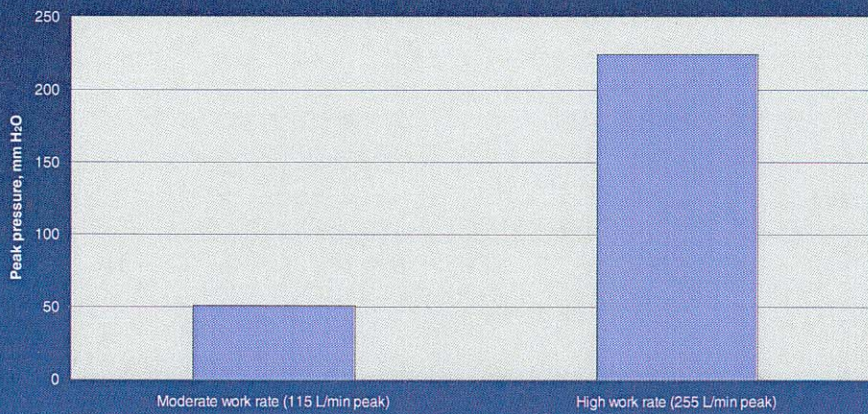
Variable-Resistance Test

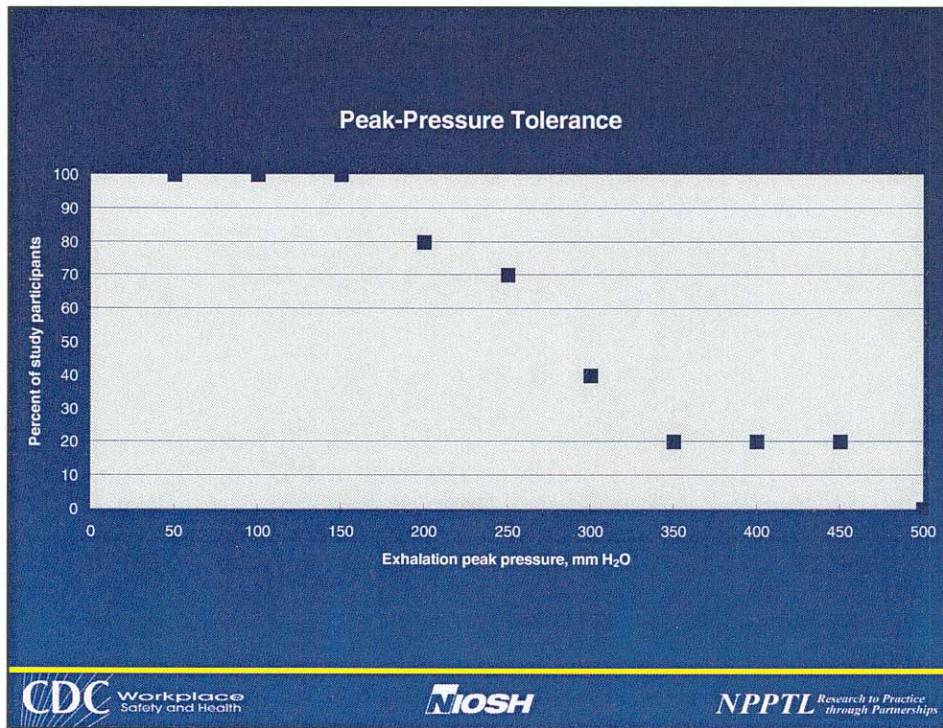
If a particular apparatus exhibits a pressure of 51 mm H₂O at the NIOSH ventilation rate of 40 L/min (peak flow rate of **115 L/min**), what pressure will it exhibit at the NFPA ventilation rate of 103 L/min (peak flow rate of **255 L/min**)?

Variable Resistance Test Set-up



Same resistance showing two pressures at two flow rates





Questions

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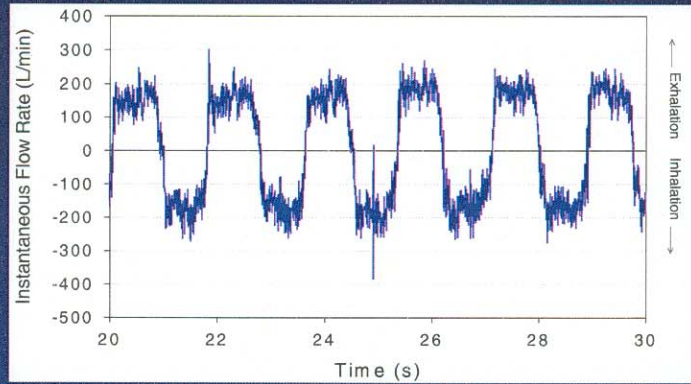
<http://www.cdc.gov/niosh/npptl/default.html>

1-800-35-NIOSH

npptl@cdc.gov

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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

