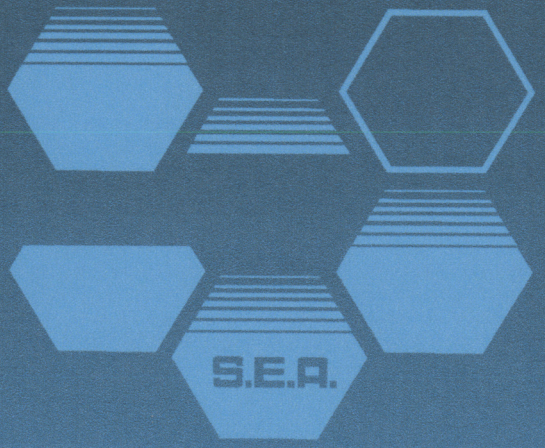

Why is PIAF so important that we need to change the way we test APR's.

Brief Overview

Pittsburgh June 19 2002

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Company structure

Leif Anderzon

Leif Palmaer

Safety Equipment Sweden AB

Flisa Berndtsson

Göran Berndtsson

Safety Equipment America Inc.

Bengt Kjellberg

Safety Equipment Europe AB

Lennart Backman

Safety Equipment Australia Pty Ltd

Graham Powe

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FUNDAMENTAL FACTORS IN THE DESIGN OF PROTECTIVE RESPIRATORY EQUIPMENT

INSPIRATORY AIR FLOW MEASUREMENTS ON HUMAN SUBJECTS WITH AND WITHOUT RESISTANCE.

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The successful design of protective respiratory device, such as canister masks for chemical warfare, depends upon a number of physical and physiological factors. Two of the most important of these are the maximum rate at which air flows, during each inspiration, through a particular canister or filter and the length of time during which this maximum flow

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The opening statement of their CONCLUSION reads:

The result shows that the present flow rate for evaluating the efficiency of protective canisters is inadequate. Etc.

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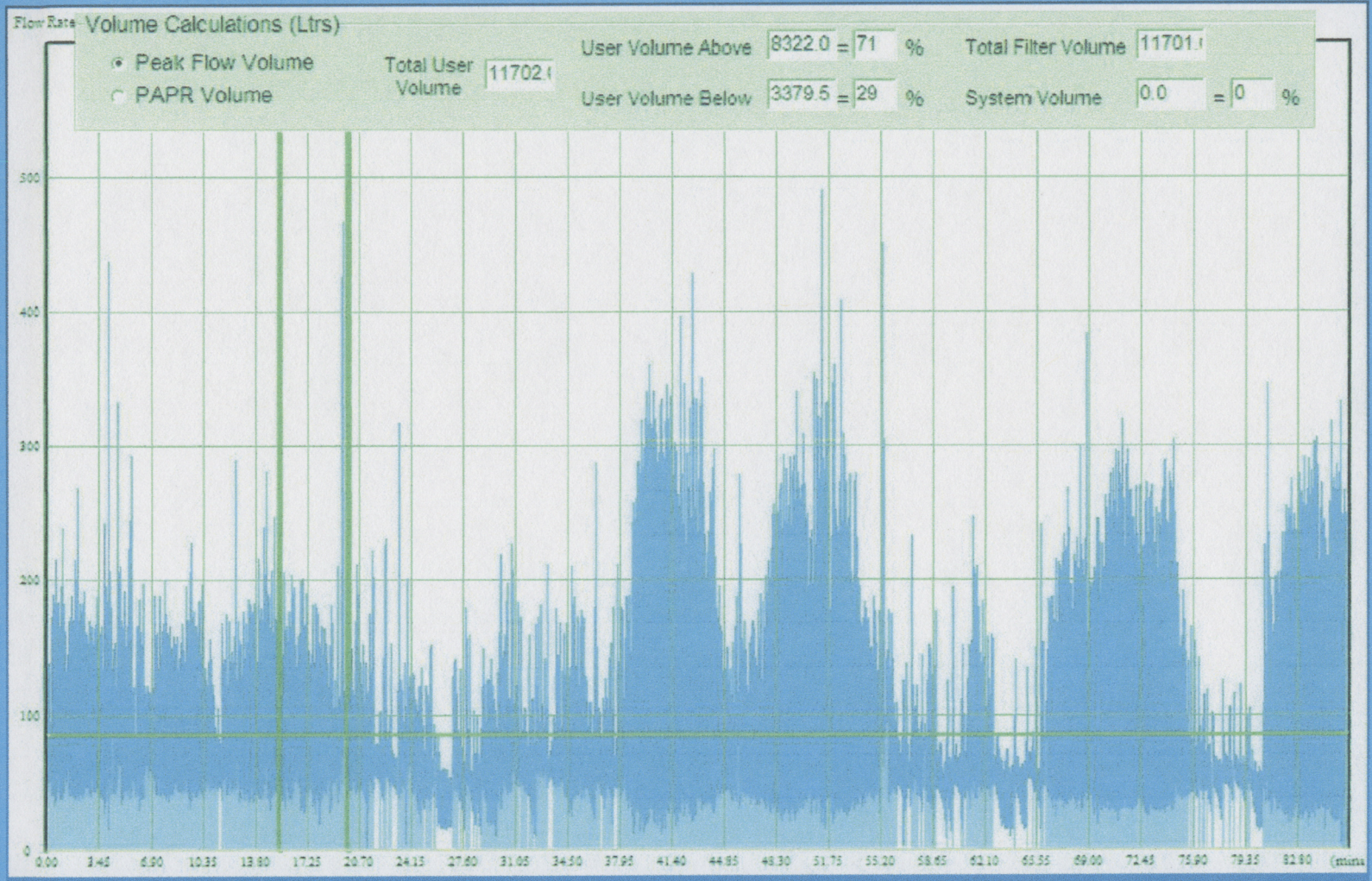

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Textbook of Work Physiology by Per-Olof Åstrand and Kaare Rodahl.

- *Pulmonary ventilation during exercise (VE) from resting values of 6.0 liter per minute to 100-150 liter per minute and in extreme cases 200 liter per minute* (page 229). *Maximum Volunteer Ventilation (MVV) has been measured up to 211 liters Minute Volume. Well-trained and fit athletes can utilize some 95% of MVV during exercise, but less fit subjects normally, only attain 60 to 70% of their MVV*

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"Moderately well trained individuals may walk or run for about one hour with an oxygen uptake up to about 50% of there Vo2 max, maintaining the oxygen uptake, heart rate, and cardiac output at approximately the same level as attained after about 5 minutes of exercise. Well-trained athletes, including marathon runners, can exercise for hours with an oxygen uptake around 70-80% of their maximum."

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NUNN'S APPLIED RESPIRATORY PHYSIOLOGY 4th Edition,

- *"The average fit young male adult should have an MBC (maximum breathing capacity) of about 170 l/min but normal values depend upon body size, age and sex, the range being 47-253 l/min for men and 55-139 l/min for women"*

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Nunn also claims on Page 83 in regards to PIAF the following

- *In the more usual types of breathing the peak flow/minute volume ratios tend to be in the range 3.5:1 — 5:1.*

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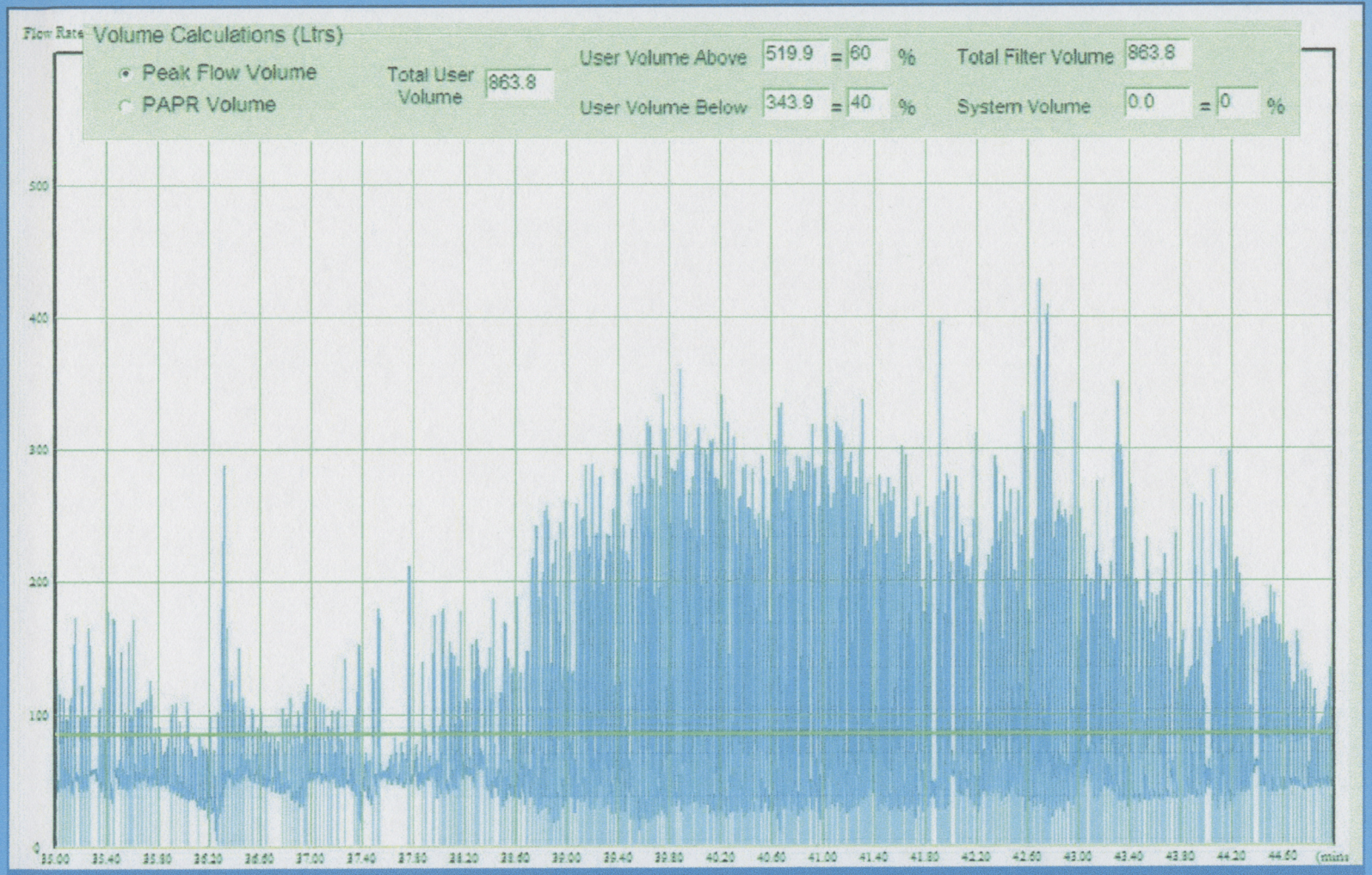

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How much faster?

- Some of the air goes just a bit faster but surprisingly, a whole 332.2 liter per minute or 38% flows faster than 170 liter per minute or *twice* the testing flow rate and 101.8 liter per minute or 12% flows faster than 255 liter per minute or *tree* times the testing flow rate.

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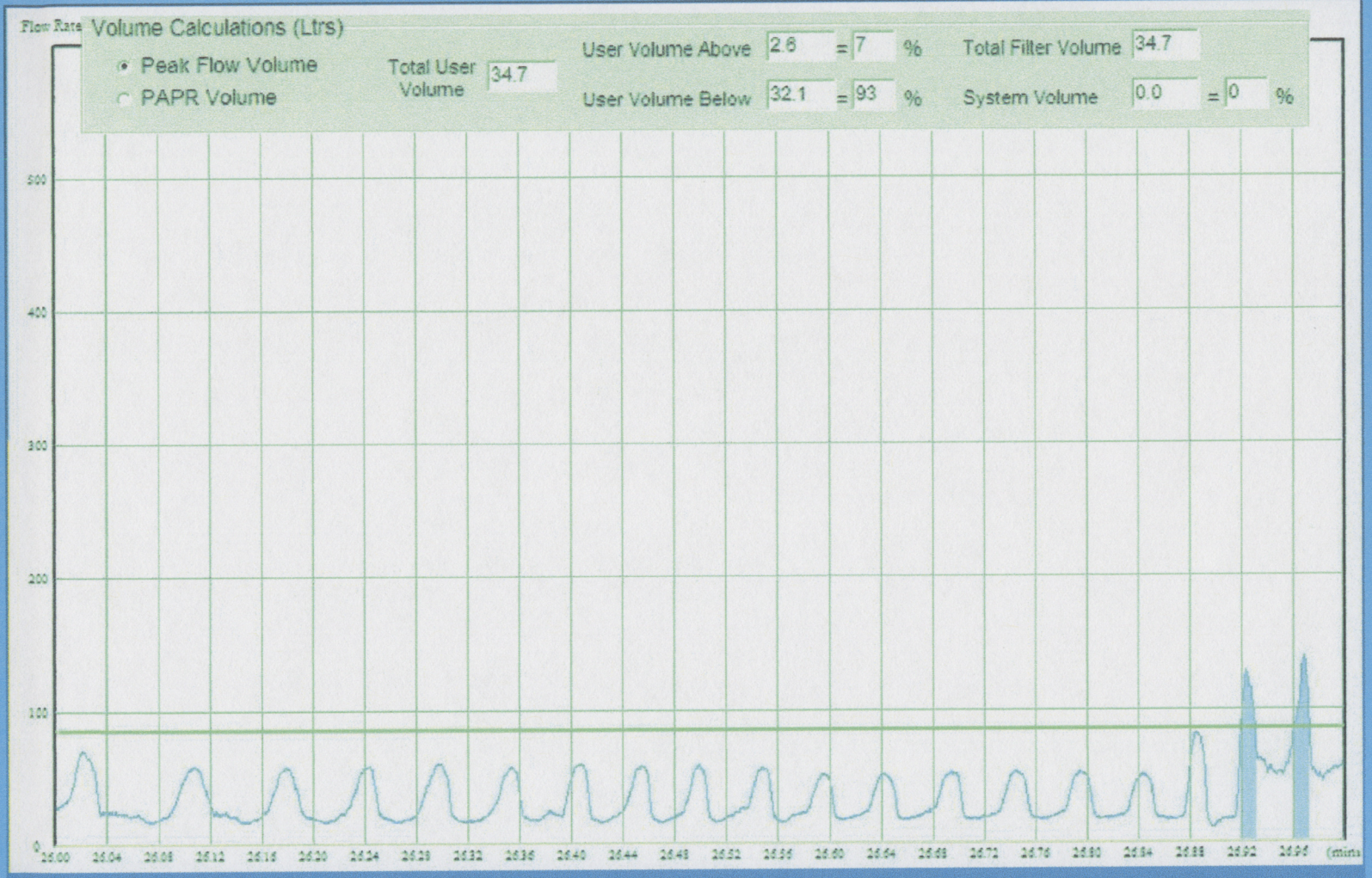

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- The reason I think this sample is important is the difference in peak flows within one minute, the smallest one being just over 100 liters per minute and the highest just under 500 liters. It is very difficult to argue that there is some kind of average PIAF rate. This is very representative of the data we have collected over the years.
- In this sample, 63.7 liters per minute or 67% of the air is flowing faster than 85 liter per minute.

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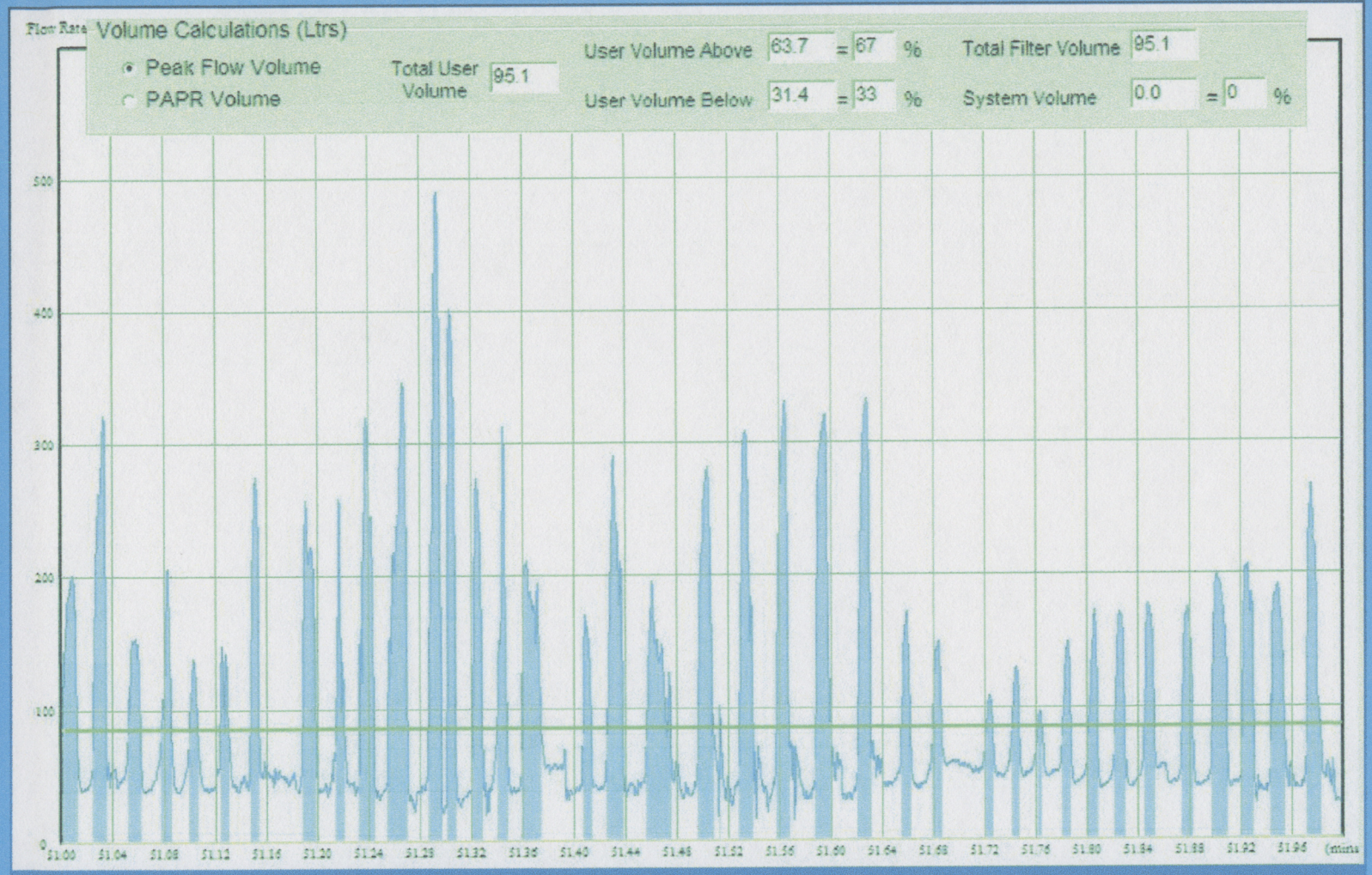

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What does this mean to the user of APR?

- If we don't test APRs at higher, more representative flow rates, it is likely that the filtering capacity is not what the user would expect. Equally important, he or she may not even be able to breathe through the respirator, as the pressure drop would prevent him or her from getting the air trough the filter.

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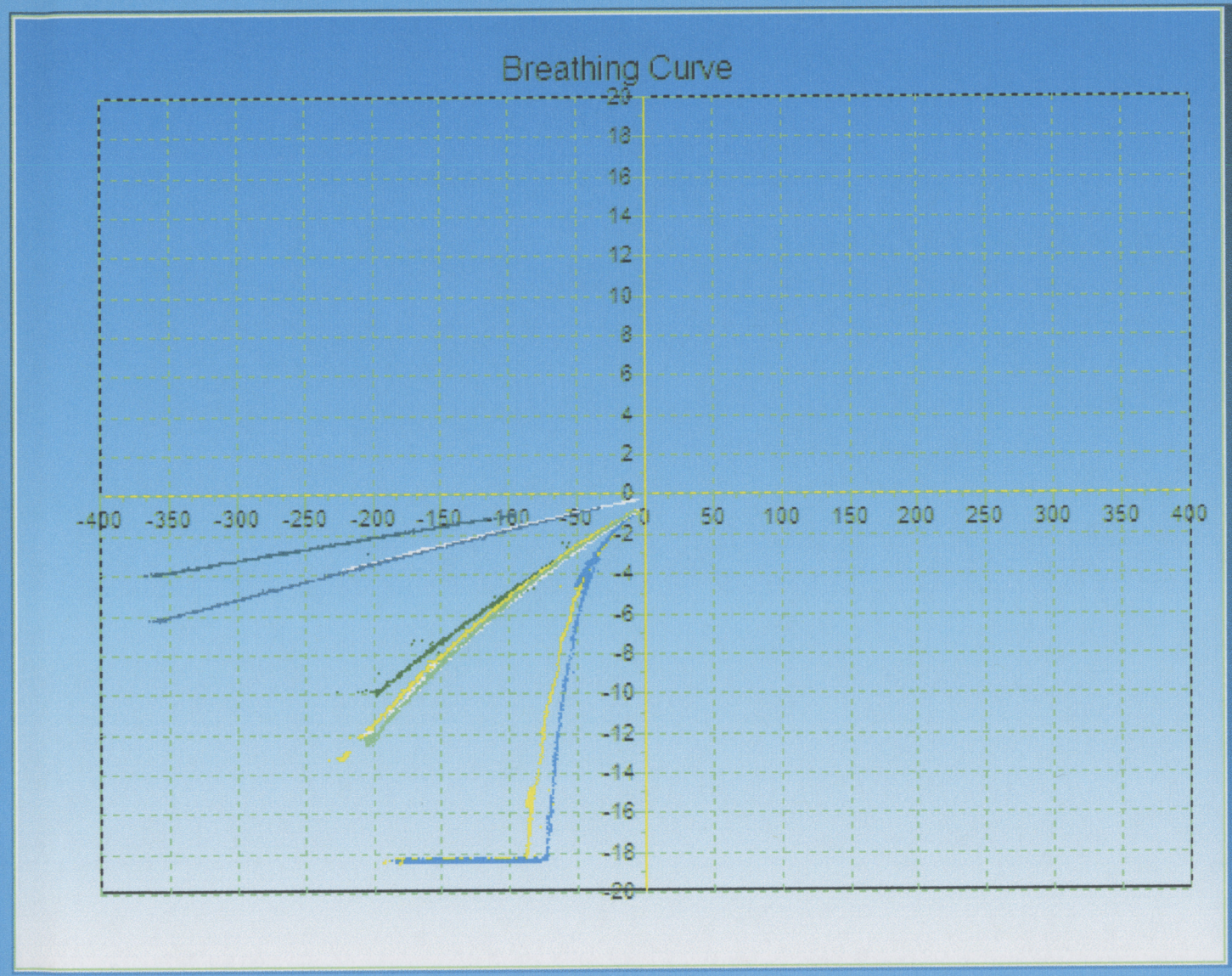

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If we don't believe this is relevant to First Responders, lets have a look at some exercises we performed together with New South Wales Fire Services on May 8, 2002.

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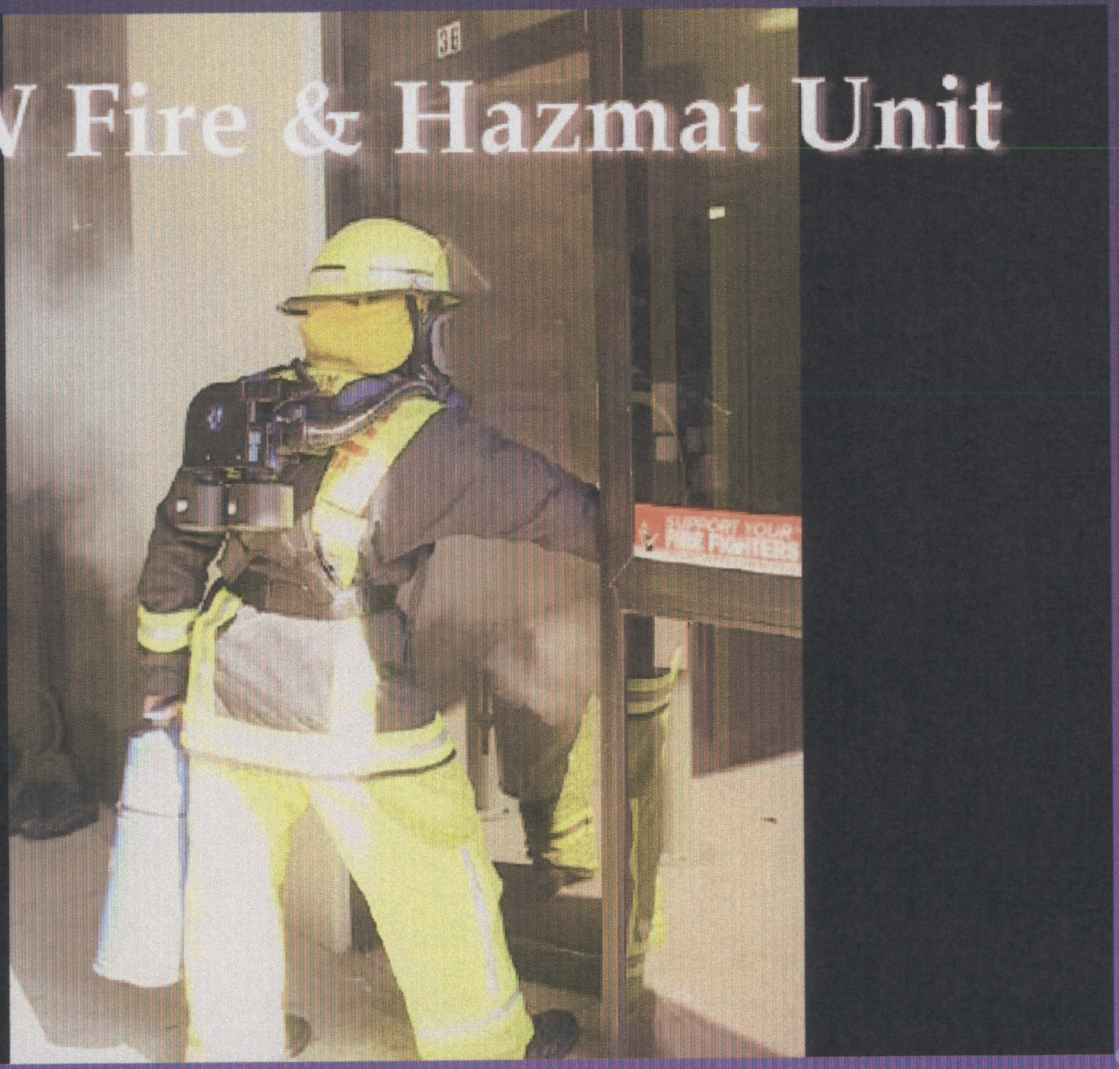
NSW Fire & Hazmat Unit



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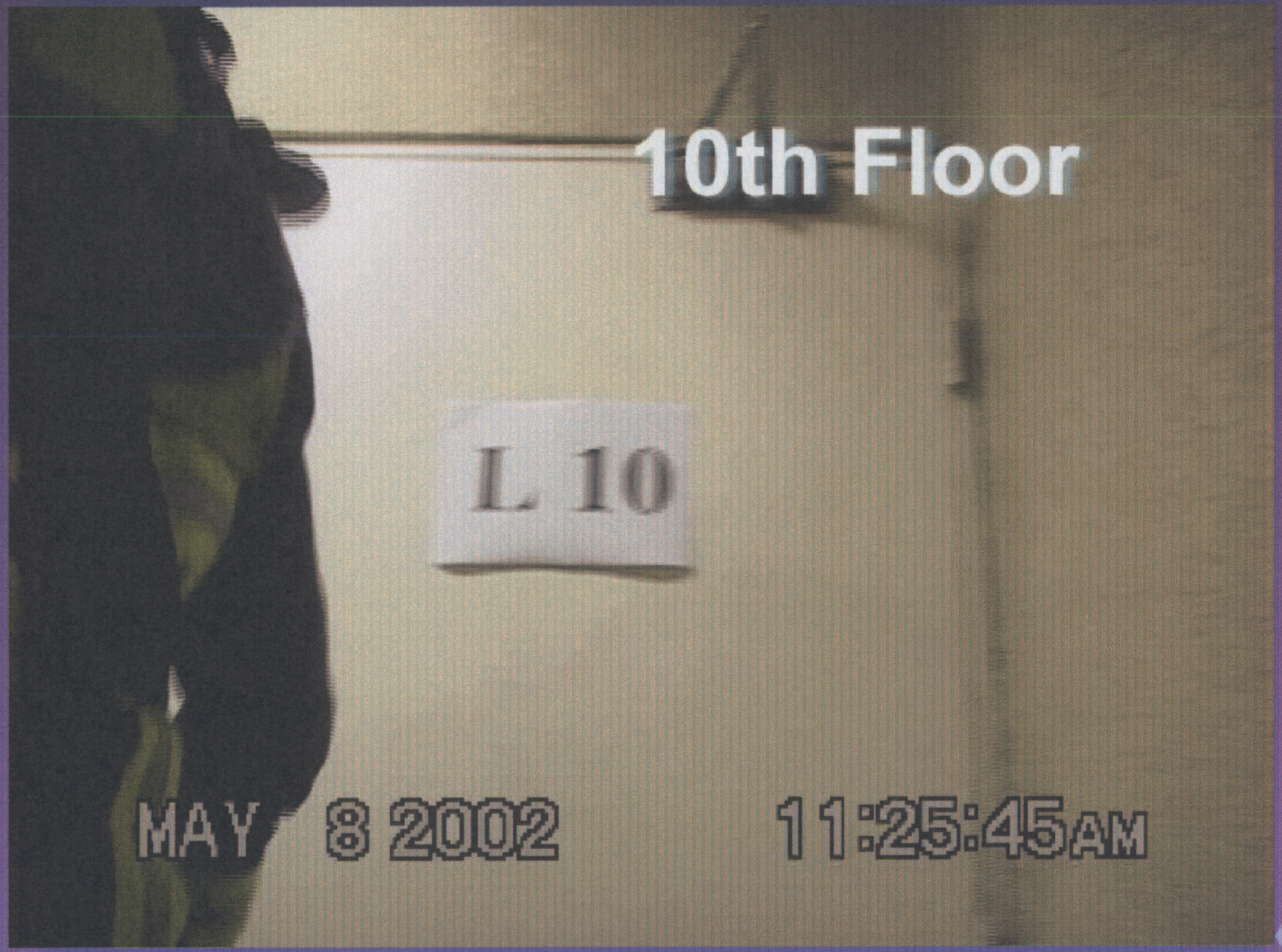

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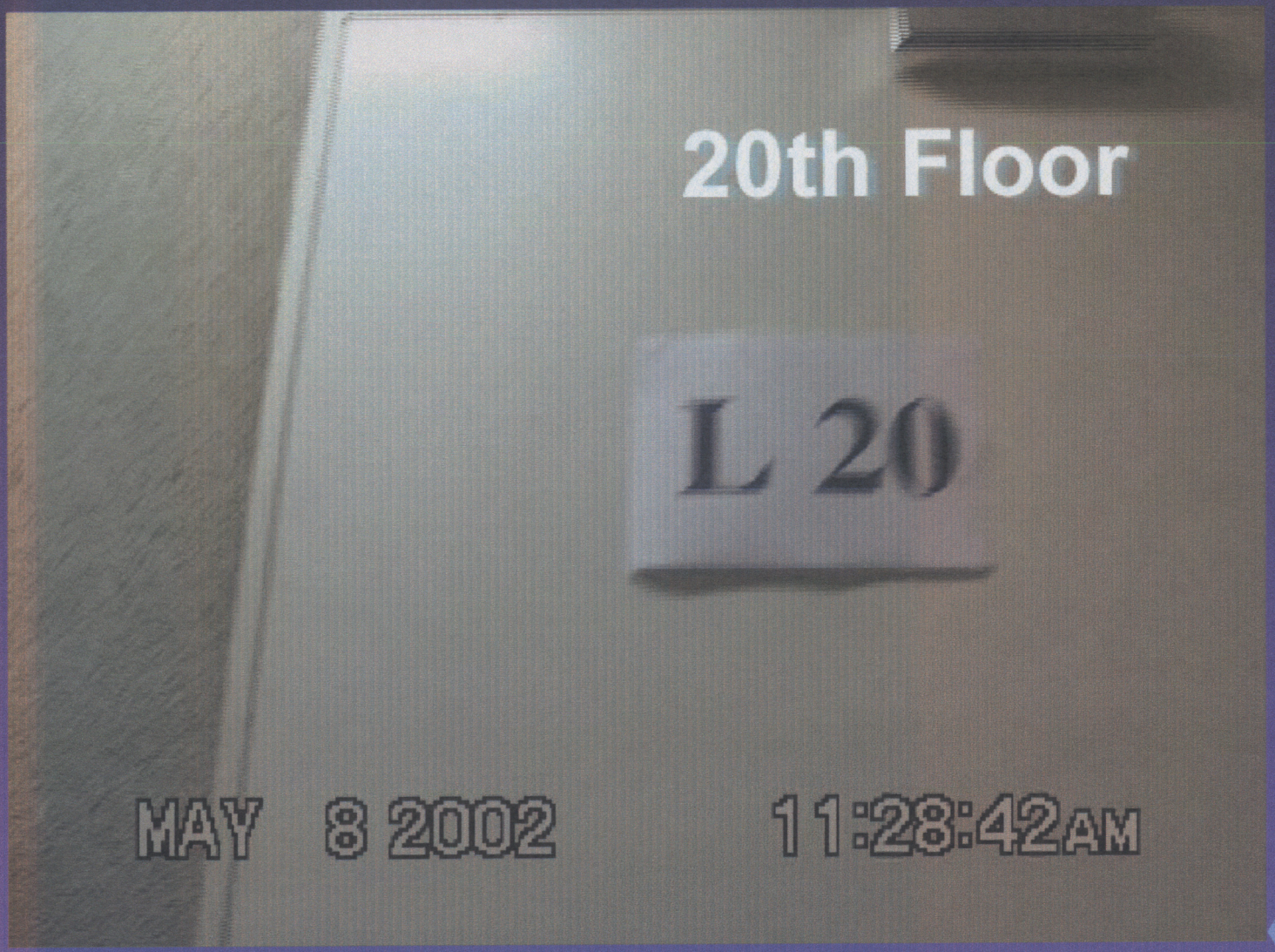

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Subject	Age	Gender
Fire Fighter 1	35	M
Fire Fighter 2	43	M
Fire Fighter 3	28	M
Fire Fighter 4	29	F
Fire Fighter 5		M
Fire Fighter 6		M
SEA GB	51	M
SEA KB	22	M
SEA GP	49	M
SEA JB	25	M
SEA SK	32	F
SEA TS	25	M
SEA SJ	22	F

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Subject	Max PIAF	Total Air used	Average Min/Liter	Time
Fire Fighter 1	400	967	173	5.60
Fire Fighter 2	420	1152	136	8.45
Fire Fighter 3	390	923	148	6.25
Fire Fighter 4	315	1217	148	8.25
Fire Fighter 5	410	1049	150	7.00
Fire Fighter 6	490	1176	168	7.00
SEA GB	430	840	163	5.15
SEA KB	380	1116	178	6.25
SEA GP	400	1254	191	6.55
SEA JB	390	813	161	5.05
SEA SK	395	1069	156	6.85
SEA TS	430	1048	172	6.10
SEA SJ	305	1141	163	7.00

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Subject	Age	Gender	Max PIAF	Total Air used	Average Min/Liter	Time
Average Fire Fighter	34		404	1081	154	7.09
S/D	7		56	120	14	1.11
Average Civilian	32		390	1040	169	6.14
S/D	13		42	160	12	0.77

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Subject	Percentage over liter flow		
	115	200	300
Fire Fighter 1	37	15	3
Fire Fighter 2	36	17	4
Fire Fighter 3	40	19	3
Fire Fighter 4	30	9	0
Fire Fighter 5	42	22	6
Fire Fighter 6	50	33	16
SEA GB	42	23	7
SEA KB	39	18	3
SEA GP	40	15	3
SEA JB	41	20	3
SEA SK	37	18	2
SEA TS	44	23	6
SEA SJ	32	8	0
Average	39.23	18.46	4.31
S/D	5.13	6.41	4.09

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Conclusion:

- In regards to Full Face Mask requirements for First Responders, we need to test filters or complete assemblies for not only filter performance but also pressure drop at more that one flow rate. Compulsory minimum performance should include pressure drop at 100 liters, 200 liters, and a voluntary test to meet a 300 liter requirement for high work rate approval. It is equally important to establish an acceptable exhalation resistance for those flow rates.

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- If those levels are too high, the user will risk getting into oxygen debt, resulting in an increase in the lactate level in the muscles, which in turn leads to fatigue. As we experienced from the WTC event, the rescue workers were more concerned about helping their work mates that keeping the respirator snugly on the face, mainly because it was too hard to breathe and talk through.

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- In regards to PAPR's for First Responders, we need to ensure that we require air flows high enough to maintain Positive Pressure inside the face cover when performing typical tasks, including working in the open, overcoming not only the contaminant in calm weather but also when the wind is blowing. Those requirements have sometimes been overlooked when arguing that performance for RPE that does not require a snug fitting mask.

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Questions?

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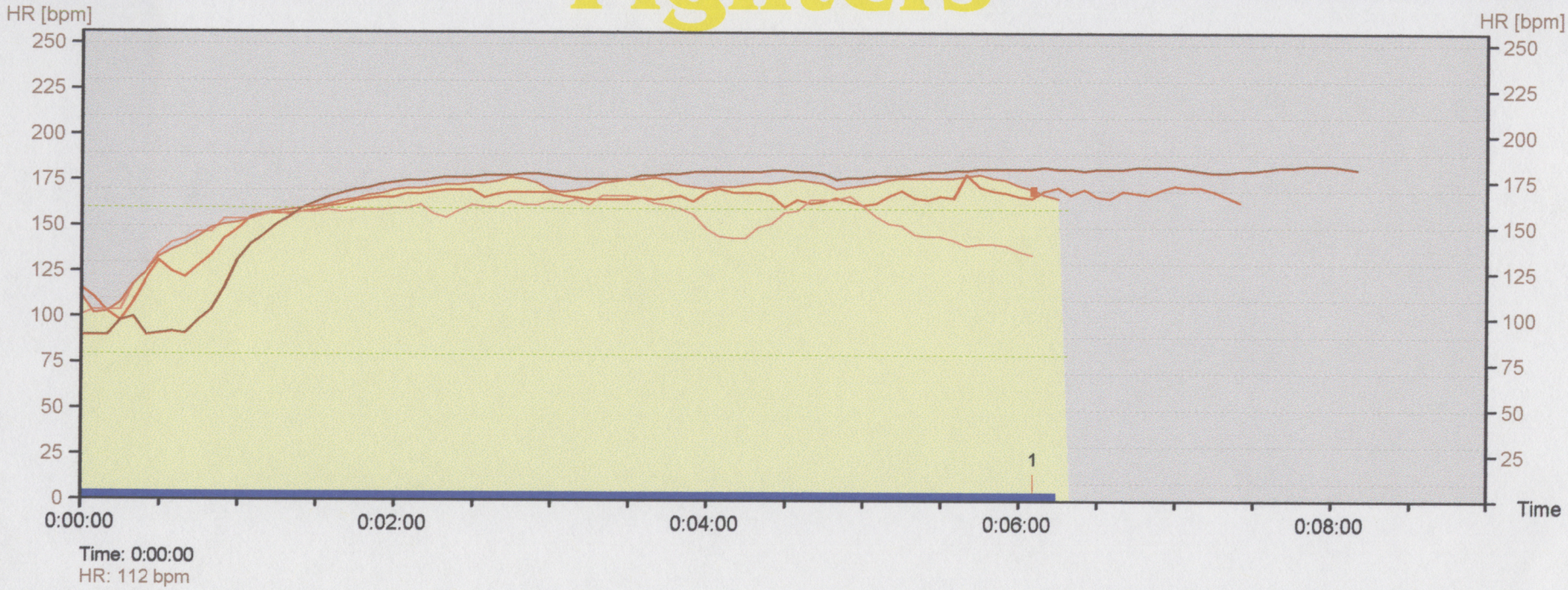
Hart rate of 5 Fire Fighters



No	Exercise	Date	Cursor HR	Heart rate	Duration	Note
1.		08/05/02	116	160 / 179	0:07:30.0	SE-400 Red, watch # 1
2.		08/05/02	101	151 / 167	0:06:10.0	SE400 Yellow W 2
3.		08/05/02	90	166 / 184	0:08:15.0	SE400 W2 Green
4.		08/05/02	112	164 / 179	0:06:20.0	SE400 Blue W 1
5.		08/05/02	112	164 / 179	0:06:20.0	SE400 Blue W 1

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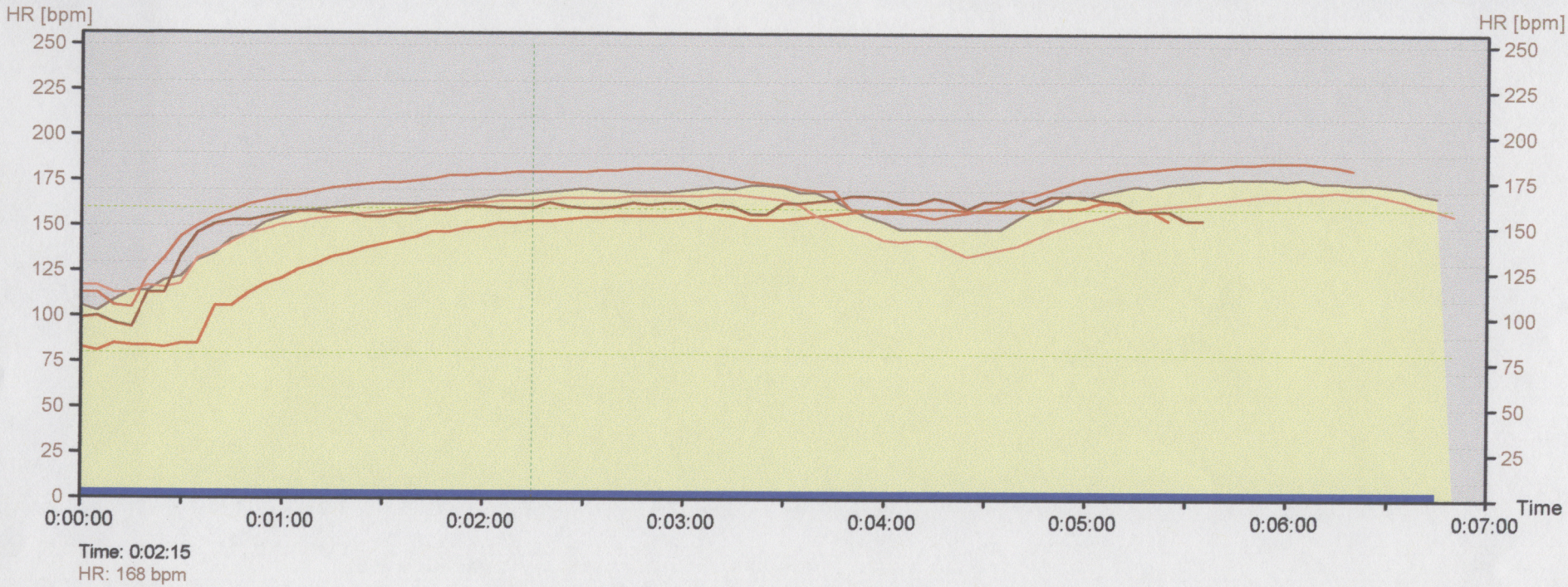
Hart Rate of 5 Civilians



No	Exercise	Date	Cursor HR	Heart rate	Duration	Note
1.		08/05/02	153	141 / 164	0:05:30.0	SE400 W2 Blue
2.		08/05/02	164	154 / 170	0:06:55.0	
3.		08/05/02	160	154 / 167	0:05:40.0	SE400 W1 Green
4.		08/05/02	180	168 / 186	0:06:25.0	SE400 Green W 1
5.		08/05/02	168	160 / 177	0:06:50.0	

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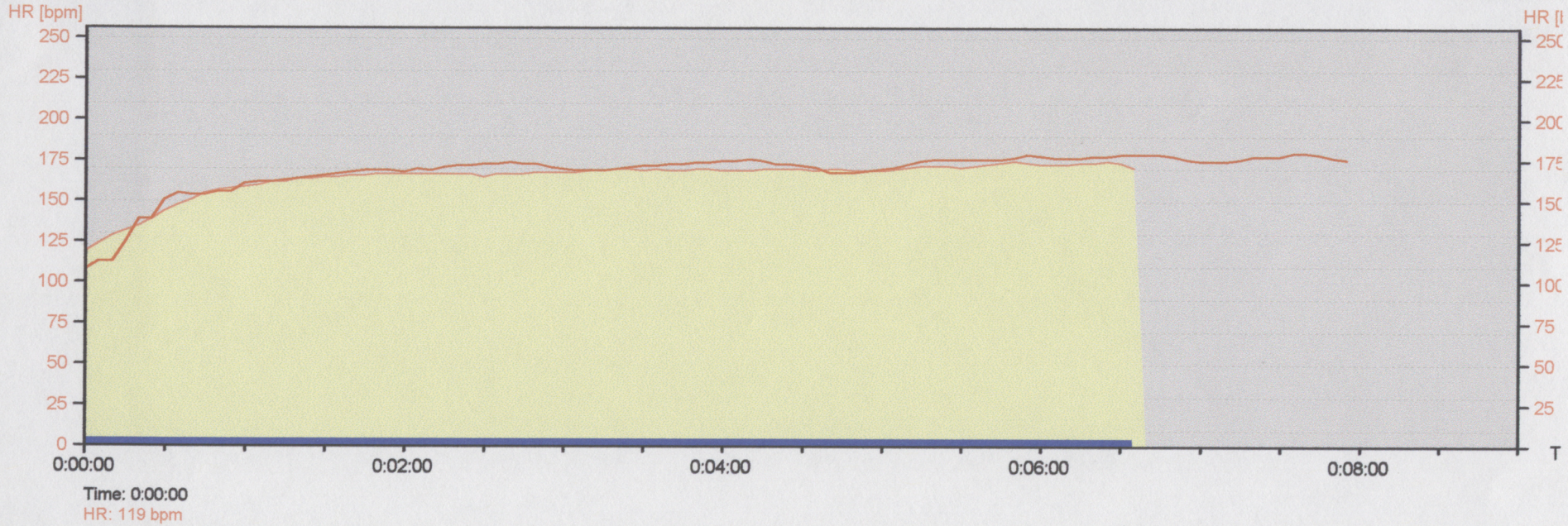
Hart Rate of 2 Females One Fire Fighter and One Civilian



No	Exercise	Date	Cursor HR	Heart rate	Duration	Note
1.		08/05/02	108	168 / 180	0:08:00.0	SE400 W1 Yellow
2.		08/05/02	119	164 / 175	0:06:40.0	SE400 Green W 2
3.						
4.						
5.						

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