Will your respirator let you breathe?

New research, derived from practical experiments in actual work situations, shows that up to 70% of a working person's breathing requirements are well above the levels at which filter respirators are tested according to US Standards.

The study serves to confirm a situation that has been known for some sixty years, but is rarely discussed or referred to.

The research also found that many respirators — although they comply with the Standards — are simply incapable of satisfying users' actual demands for air. Such devices do not allow a wearer to breathe normally at work.

The tests, conducted by The S.E.A. Group (Safety Equipment America), were prompted by the events following the September 11 tragedy at the World Trade Center in New York. Rescue and recovery personnel, issued with industrial respirators, could not perform their required tasks, chiefly because they could not draw enough air through the filters.

"We constantly find serious deficiencies in all types of breathing gear," says Mr Goran Berndtsson, CEO of The S.E.A. Group. "And we have established that it's not only fire-fighters working under extreme pressure and great workloads that experience inadequate air supply: just about any worker can easily out-breathe the equipment while performing normal routines."

Historical reasons

Mr Berndtsson points out that the great divergence between test methods and actual breathing has been known for a long time. The air flow used in US Standards testing dates back as far as the First World War, when it was believed — wrongly — that humans breathe on average a volume of 42.5 liters/minute. Since we spend as much time inhaling as exhaling, the experts said, the air must travel at a speed of 85 liters/minute. This has since proved to be far from true.

Only twenty years later, during WWII, the noted Dr Leslie Silverman found that people breathe at much higher flow rates, and that the speed of the air flow is not double the volume inhaled, but more like 3.5 times greater. He stated officially that the test flows were unrealistically low, and should be raised.

"What troubles me is that although we now have the technology and know-how to make filters and cartridges that can satisfy human breathing without cutting corners on efficiency, the Standards have not changed," Mr Berndtsson says. "We are still testing according to sixty-year-old methods. The result is that air purifying respirators are still made and used today, that will never be able to live up to the requirements of real life. This was sorely and sadly demonstrated in the WTC incident."

Fire drills

The S.E.A. Group became interested in establishing the actual breathing requirements of a person hard at work. In January 2002, the company hired the fire stairs of a city high-rise building and conducted an experiment in which a dozen people were required to dress in fireman's outfits and climb the stairs of 25 floors, carrying customary weights such as fully charged fire extinguishers.

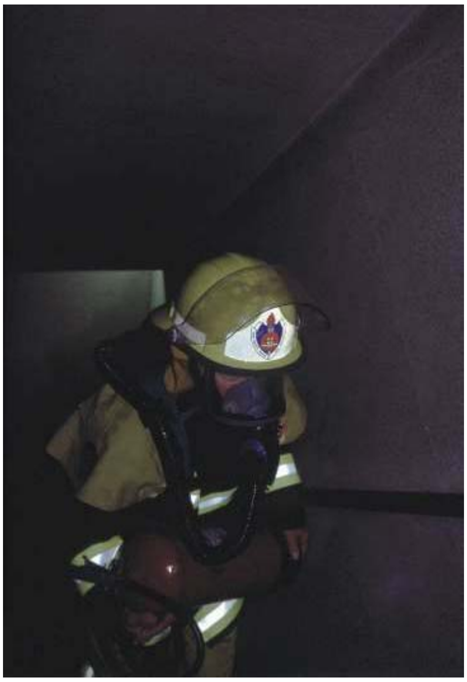
Each climber's breathing was measured during the entire exercise, and later processed to give a detailed picture of the breathing pattern and air requirements. The volume, speed and timing of every single breath was recorded and plotted on a graph.

Briefing the NSW fire fighters

The results were surprising. All of the test subjects reached peak breathing rates of four times the flow rate of NIOSH-stipulated Standards testing. The experiment comprised both male and female test subjects of widely differing age, fitness level, and body weight.

When this information was presented to NIOSH, the organization became very interested in the testing. However, it was generally believed that the results might not be truly representative, as "real" fire-fighters would presumably be fitter, more trained, and more used to the work load, and the climb would be performed in a calmer, slower, more deliberate way.

In compliance with the comments, the entire exercise was repeated in May 2002, this time in cooperation with the city fire department, and using professional fire-fighters.



Surprisingly, the results concurred with the preliminary test five months earlier. There was little difference in the breathing patterns of the participants: the fire-fighters breathed as much air, and as rapidly, as the 'civilians'.

How we breathe

Climbing 25 floors with around 55 lbs of clothing and equipment is hard, hot, heavy work. It is extremely taxing on the body.

One feature common in all participants was that the lungs reached their peak cycle very early in the climb. In less than a minute, all the climbers' breathing became deep and rapid, reaching peak inhalation air flows (that is, the speed at which the air travels near the mouth) of around 400 liters/minute. After reaching the peak breathing rate, the lungs kept up this work for the rest of the climb, that is, for an additional five to seven minutes.

The entire exercise was recorded on video. The footage, along with explanations and breathing charts, is available from The S.E.A. Group web site, www.sea.com.au/docs/videos/videomenu.htm *(look for "Fire drill")*

Industrial tests

To complement the picture of breathing in humans at work, The S.E.A. Group proceeded to test industrial respirator users in their normal workplace. The company collected a large database of breathing cycles, each covering a different worker performing his or her ordinary tasks over a full 90-minute period.

The results showed a surprising similarity to the fire-drill exercise. In essence, S.E.A. now had ample evidence that almost *any* normal human being is capable of reaching and sustaining peak air flows of 400-500 liters/minute during work, regardless of age, level of fitness, gender, size, weight, or type of work.

On average, about 40% of a worker's breathing reached speeds twice as fast as the test flow used in the United States. Between 10% and 15% of the human breathing was more than three times faster.

Concerns

"What does this mean?" asks Goran Berndtsson. "To start with, look at the air flows used in respirator testing: the pressure-drop in a particle filter is tested at 85 liters/minute. We found that as much as two thirds of a person's breathing is faster than that."

This raises the question: how do we know that a Standards-approved mask will function during real work?

The S.E.A. Group decided to find out. A great many respirators were tested at air flows ranging from 0 to 300 liters/minute.

"Many of them failed miserably. They were all relatively fine up to the Standards rate, but above it the breathing resistance became so high that no hard-working person would be able to breathe through the mask. With some devices, it was as though they had been manufactured only to pass the Standards test — not to be used in real life."

Reaction from NIOSH

Armed with the information, Mr Berndtsson again approached NIOSH. There was still a lot of interest, and Berndtsson was invited to make a comprehensive presentation in June 2002. Attending the meeting was also a group of experts from the US Marine Corps, who had become concerned that their respiratory equipment might not live up to their servicemen's demands during hard work.

The main point of the presentation was to push for increased testing air flows, and for respirators to be tested at more than one flow rate,. "Only then will we have any idea at all whether the equipment is likely to work in real life," Goran Berndtsson said.

"The reason for testing at several rates is that the pressure-drop in a filter is not linear, so it cannot be extrapolated from a single value."

The reception was "extraordinarily positive," according to Berndtsson. This and other convincing research has prompted NIOSH to write new Standards in addition to the existing ones, and stipulating testing at higher, more realistic air flows. A new such standard for full face masks is due in October 2002. Standards for protective hoods and powered respirators are scheduled for April and July 2003 respectively. As yet, these Standards concern specifically equipment for first response and homeland preparedness use. Goran Berndtsson remains convinced that sooner or later, all Standards will be re-written to better reflect respirator use in real life.

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