

THE POWERED AIR PURIFYING HELMET, A PRODUCT OF RESEARCH

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True artists and true scientists share a legitimate privilege. The musician, the obscure poet, and abstract painter, together with the research scientists in any field are all entitled to explore and to express the esoteric aspects of existence. They all study, perform, and work to achieve results which at first may have no purpose but to make the aware even more aware, or the knowledgeable even more knowledgeable.

Artisans and technologists share a very different but equally legitimate privilege. Technologists seek to achieve results which have immediately practical application in the real world. They do not exist in a refined intellectual universe of speculation but they operate in an earthy world of use and relevance.

Any feelings of inferiority that might spring from this apparently lesser role are soon dispelled by realizing that most occupations and professions are conducted on the same plane. Including, for example, those among us who are airline pilots or farmers or trash collectors or bureaucrats!

There is gentle irony as truth in the realization that technologists probably have more natural affinity with legislators than they do with scientists! Being here, essentially as a technologist addressing scientists and legislators makes me feel a little like the statistician with one leg in a furnace and the other in a deep freeze: I am, on average, quite comfortable.

I have had the good fortune to live and work in this country for the past six years, and this experience, together with my equally good fortune in acquiring a New Jersey wife, have impelled a substantial change in my vocabulary. I have learned to say aluminum and schedule; I'm working on tomato and twenty. My conversion is, I suppose, fifty-fifty. You could say half and half. My life, professional and domestic, would be even more confused were it not the absolute authority of Webster's Collegiate Dictionary. To ensure we are talking the same language, let me quote, direct, how Webster defines technology: a technical method of achieving a practical purpose, the totality of the means employed to provide objects necessary for human sustenance and comfort.

Yes, I am a technologist, and proud to be one. And Racal's Airstream Helmet is certainly a product of technology, brought about by using technical methods to achieve a practical purpose, and contributing to human comfort.

Our particular concern with Airstream is for those people in our society exposed to occupational hazards. As advanced as our technology may be, the telechiric worker is still a thing of the future. Robots are the work force of the twenty-first century – maybe. The manufactured goods, mining products, equipment, vehicles, building, and so on that we here will use will be produced by people. People exposed to occupational hazards.

Let me discuss a basic design philosophy, relating to the product characteristic called "protection factor". The PF of a product. This characteristic is a fundamental measure of performance being the ratio of the challenge to the penetration. Suppose a force of 300 lbs. is exerted, for example, on a safety shoe, and 30 lbs. is transmitted to the foot of the man who wears it. Then 300 lbs. can be considered as the challenge, and 30 lbs. as the penetration, the PF in this instance would be 300 divided by 30, or 10. This concept of protection factor is built into many of our judgements in the real world and often determines our solutions, because it is related to technological value. It is somewhat built into the certification procedures of government departments, but as a student of some regulations, it is my opinion that many rules need to be restructured to give the concept more significance.

The PF can be the single most important characteristic under a given set of circumstances. But, and here is drama, there is another even more basic and simple characteristic that can make the protection factor of any system become completely unimportant, and be of no consequence whatsoever.

What is this technological characteristic that has the power to negate our protection factor?

The answer is gloriously simple, but overwhelming in its importance.

The answer is wearability.

Consider our hypothetical safety shoe with its PF of 10. If a force of 30 lbs. strikes this, the wearer will feel 3 lbs. But if our man is not wearing it for some reason, he will feel the full 30 lbs. I can envisage a shoe with a PF of millions. It could weight half a ton, be made of cast iron, and have a diameter measured in real feet! And nobody would wear it. And so its wearability or absence of wearability would negate completely its high protection factor.

There are three main factors that affect wearability:

1. is the immediacy of the hazard. No one will knowingly breathe a highly toxic atmosphere that causes death in a few seconds and no one will enter a chamber devoid of oxygen.
2. is the level of control and supervision. OSHA and MSHA regulations have the force of law, and employers must ensure that employees are protected. Safety procedures and rules must be supervised and enforced.

But the vast majority of occupational hazards are long-term cumulative or have a low incident probability. Black lung takes time before it becomes serious, it doesn't kill within seconds. People are not good at responding to risk and dangers that are not immediate to us.

Factor three in considering wearability is comfort, because comfort determines acceptance. Hardhats are generally widely worn because they are accepted, because they are comfortable.

Comfort may be difficult to measure, but its consequences can be readily quantified. Take the case of a worker in a uranium mine who is wearing a high efficiency respirator with a PF of 500. This means that the filtered air he breathes through this respirator contains only 1/500th or 0.002 of the hazard in the outside air. Consider this worker's eight-hour day in the mine. He has to work and communicate with his supervisor, monitor his machines, speak to a friend, wipe his face because his respirator is tight, and so on. Even a diligent man could easily need to spend ten minutes communicating with a supervisor, ten minutes examining his machine closely, five minutes talking to a friend, and five minutes mopping his face. What has happened to the PF of this respirator? Remember, it is nominally 500. But in the relatively short removal spans, our worker has been unprotected and exposed to the full contamination in the air. His experience protection is much less than 500. It is even less than 100. It is, in fact, less than 20.

Consider briefly another instance of a respirator with a PF of 3000. If that respirator is removed for just five minutes in an eight-hour day, the effective PF is reduced from 3000 to 100. If it is not worn for 10% of the day, the PF is effectively 10. Not 3000, but 10.

This is the secret dilemma of respirator design. High protection factors can be achieved by engineering techniques leading to better face fits, tighter clamping actions, and so on. But the very features that improve the PF are the same features that reduce wearability. And low wearability will destroy PFactors. Human face variations need complex facepiece profiles, increasing the possibility of hyperventilation. Restrictions on comfort, workability, speech, vision, communication, movement and, yes, even socializing are just not acceptable to users. And the associated loss of productivity should be unacceptable to owners.

The solution for respiratory protection is to accept that conventional designs have the inherent clash between protection and wearability, and then to force technology to meet the demands of new concepts.

The key to the design of a device that avoids the problems associated with conventional respirators, is the successful engineering of a powered air-purifying system and the subsequent packaging of this system into a wearable, comfortable product. The basic concept of Airstream came out of the Safety in Mines Research Establishment in Sheffield; a concept which was patented, licensed exclusively to us at Racal for further development and engineering, production, and marketing.

In its most usual configuration, this powered air-purifying device consists of a safety helmet with an integral faceshield and a built-in double filtration system, the second and main filter being located inside the

hardhat above the wearer's head. Contaminated air is drawn from the back of the helmet, through the filters, delivered to the breathing zone, and, after passing across the wearer's face, flows through a space at the bottom of the faceshield.

This has maximized the inherent advantages of powered air-purifying respirators. It is easy fitting. Since the positive pressure behind the faceshield tends to prevent contamination entering the breathing zone, the face seals were made very light and still are effective. The powered airflow itself is used to eliminate the need for tight fitting, nose and mouth clamping seal arrangements. Other user advantages have resulted from the technological emphasis on comfort and wearability.

I don't intend to dwell on the characteristics of our particular products, because such information is readily available to you.

But I will emphasize that a disciplined application of technical methods to achieve a practical purpose did indeed contribute to human comfort I

I have relected a little on the nature of technology and on the design approach that created this range of approved PAPRs. I would now like a little more time to consider the future of such products.

Technology never ceases to be responsive to need. The user advantages of PAPR's are adding to the demand for such products, and it is becoming clear that the already widespread use is only a beginning. Racal, as other innovative companies must be, are still forcing the technology and we have new versions in various stages of product development.

There are some inhibiting factors that must be resolved if users are to receive the full benefits of this revolution. And the growth of PAPR applications is indeed revolutionary! The major inhibiting factors relate to regulations, and I urge those regulators here to remember that they, like technologists, need to use technical methods for practical purposes. I am a firm advocate of the need for government certification of protective devices, and of the need for enforcement of occupational health standards in the workplace.

But our regulations are out-of-step with our technology. We must have programs that certify combination protection devices. These are no longer products of the future, they are already in use, thousands and thousands of them, in the workplace. And the numbers will increase and increase! The absence of such programs is inhibiting to technological advance. Worse, it is causing workers to remain exposed to risks.

Also, the acceptability and performance of certain PAPRs should be cause to review the now outdated distinction between engineering controls and respirators. There is a need for the acceptance of certain PAPR configuration as permanent elements of conformance programs in the workplace. The absence of such acceptance is inhibiting technological advance. Worse, it is causing workers to remain exposed to risks.

We technologists will improve the vital attributes of PAPRs. We will reduce costs, reduce weight, improve comforts and improve performance. I believe the short-term future will see only two types of respiratory devices in use in all except specialized applications, and that these two types will be improvements of the current disposable respirators and powered air-purifying devices.

The technology for these developments will soon be available. However, considerable technology is available now as we at Racal have demonstrated PAPR technology is developing and improving. Let us all remember its purpose. To provide human comfort.

APPENDIXEQUATIONS RELATION PROTECTION FACTORS TO TIME WORN

Let Total Time Duration be D
 Let Duration of time the device is not worn be $\bar{D}$
 Let ambient contaminant concentration be C_o
 Let breathing zone contaminant concentration when device worn be C_i
 Let Nominal Protection Factor = $PF = \frac{C_o}{C_i}$

$$\begin{aligned} \text{Then the average breathing zone contamination } C_a &= \frac{(D - \bar{D})}{D} C_i + \frac{\bar{D}}{D} \times C_o \\ &= \frac{1}{D} \left\{ (D - \bar{D}) C_i + \bar{D} \times C_o \right\} \end{aligned}$$

Since the outside contamination is C_o

$$\begin{aligned} \text{The in-use Protection Factor will be } = \frac{C_o}{C_a} &= \frac{C_o \times D}{(D - \bar{D}) C_i + \bar{D} \times C_o} \\ &= \frac{D}{\frac{(D - \bar{D})}{PF} + \bar{D}} \\ &= \frac{D \times PF}{D - \bar{D} + PF \times \bar{D}} \quad (1) \end{aligned}$$

If p' is proportion of time device not worn, then $p' = \frac{\bar{D}}{D}$

$$\text{and (1) becomes } = \frac{PF}{.1 - p' + p' \times PF}$$



AH15 Intrinsically Safe System



AH5 Standard Air Purifying System