

Protection Factors—Who Do They Protect?

A summary of recent discussions within ISRP on the term "Protection Factor"

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European Forum

In the fall of 1994 the European Section of ISRP held an open forum with the purpose of searching for a consensus on the meaning, definition and use of the term "protection factor". The need for such a forum was prompted by concern that little real understanding of the term existed with those who need to understand it (manufacturers), those who must understand it (users), and those who should understand it because they may be asked to enforce its use (legislative bodies).

Although this concern appeared to have existed for many years, it seemed that little clarification had been forthcoming, at least not within Europe. The subject was apparently raised at the ISRP Toronto

conference in 1987 with a reply that the topic had been dealt with in the *Journal of the American Industrial Hygiene Association* (AIHA) in May 1985.

After a lively debate, the European forum endorsed the existing AIHA definitions. However there was a strong feeling that there were too many definitions which were sometimes too complicated for most people. The European section concluded that a good understanding of the terms "Nominal Protection Factor", "Assigned Protection Factor" and "Workplace Protection Factor" would be the one action that would make the most significant improvement in worker protection.

Vancouver Meeting

Following the European Section meeting in 1994, the Seventh Biennial Conference of ISRP in Vancouver, September 1995 held a protection factor workshop session to debate the views of the European Section and to provide ISRP with a consensus view on the way forward to promulgate a common understanding.

The still urgent need for such an understanding of the terms was demonstrated by the returns from an impromptu questionnaire completed just before the workshop. When asked to say what they understood by the three protection factor definitions identified by the European Section, the delegates came up with some very divergent answers—and

these were supposed to be the experts! The best reply was the simplest, if not the most scientific:

Nominal PF:	What the Standard says
Assigned PF:	What the Lawyers expect
Workplace PF:	What happens

The Vancouver meeting concluded that the AIHA definitions for the various protection factor terms were to be re-endorsed and that their use, as published, should be encouraged. To the AIHA list was added the European term "Nominal Protection Factor", as defined in the revised version of EN 132.

However, the workshop also concluded that the definition was only the starting point. Confusion and differences emerged once people began to derive numbers to set against the various definitions. For example, it was known that the methodology and statistics applied to workplace protection factor

studies varied widely, with the consequence that the answer to the question "what happened?" could be very different from workplaces which should have been quite similar, because of how the data was processed.

Further Actions

Two actions emerged from the Vancouver Conference:

1. The Board of Directors of ISRP set up a working party, headed by Dr. Andrew Capon, to follow up topics of most concern in the area of protection factors. The working party's first task is to attempt to gather information from around the world on how regulatory and advisory bodies derive the values that they publish for assigned protection factors, (i.e., how was the decision made on what the lawyers should expect?). This work is ongoing.
2. The Board endorsed efforts to establish a common set of guidelines for best practice when conducting and reporting workplace protection factor studies. The first step has been taken through AIHA sponsoring a Technical Workshop on workplace protection factor studies, with the aims of developing model protocols, establishing higher confidence in studies, and identifying evaluation tools for past work. The workshop took place in February 1996, and further details may be obtained from AIHA.

Reporting Back

Progress made by the Working Party on protection factors will be reported back to ISRP at the Eighth Biennial Conference to be held in Amsterdam 22-25 September 1997. The session will include the latest information on how assigned protection factors are calculated around the World, research on the

relationships between the measurement of protection in the laboratory and at the workplace, and recommendations on "good practice" when conducting workplace protection factor studies. It should be a lively meeting.

Published Definitions

In order to help those who might not be familiar with the original AIHA protection factor definitions, or that for Nominal Protection Factor (A European term), the attached Table reproduces the definitions

as originally published. Additionally, the table includes a column which attempts to explain the intended use of each of the terms. It is hoped that readers will find the notes useful.

Starting to Understand

To start off ISRP's wish to promote a deeper understanding of what is behind the definitions, the section below makes some further comments about the three terms, nominal, assigned, and workplace protection factors identified as needing most attention.

Nominal Protection Factor (NPF) is perhaps the easiest to understand, because no measurements are

involved in determining its value. It is merely an index of the maximum inward leakage permitted for a given class of respirator in a given standard, expressed as a ratio. For example, the maximum permitted inward leakage for a class 3 powered air purifying respirator with hood in EN 146 is 0.2%, giving a nominal protection factor of 500—easy! (Still not finding it easy? . . . another way of looking at it is that the device has to show a protection factor

of at least 500 in all laboratory inward leakage tests before it can be awarded a class 3 EN 146 classification. Of course lab measurements may be considerably better, but the NPF is still 500).

The difficulties arise when the NPF value, which *must* be achieved or exceeded in the laboratory is taken as the value which *should be expected* when the respirator is used for real. This may or may not be the case. However, as a shorthand way of expressing what the standard says, NPF is very useful.

Assigned Protection Factor (APF) perhaps causes the most controversy. The APF value is *not* a direct measurement: it is derived from other measurements, coupled with opinion, to arrive at a value of what protection factor should be expected in the workplace. It is extremely important because it can form the basis of respirator selection procedures, and perhaps, regrettably, could be used in litigation. But . . . are they right? . . . are they consistent? . . . For the same type of respirator, are they different in

different countries? . . . If so, why? It is precisely because ISRP attaches such great importance to improving the understanding of APFs that the Protection Factor Working Party is embarking on its information gathering exercise. ISRP will also be asking why are they different in different countries, if this turns out to be the case.

Workplace Protection Factors (WPF) are derived from direct measurements. On the face of it they should be easy to understand. After all, you just measure what is inside and outside the respirator at the workplace. Easy to say, but not easy to do, and there is always the danger of placing too much reliance on the "quick look-see". Any investigation involving human factors is beset with unknowns and must be carefully thought out and controlled. Statistics are involved in the analysis of results and these must be presented in ways which are easy to understand. ISRP will fully support all activities relating to the goal of producing a common code of practice for workplace protection factor studies.

Conclusions

"Protection Factors" are too important not to be understood properly. They are the basis of helping to ensure the health of workers by placing numerical values on the ability or expectation of respiratory protective devices to protect and thus enhance the

confidence of those who wear them. The ISRP, as the professional body for experts in this field, has a duty to do all that is within its power to promulgate a proper understanding of the term PROTECTION FACTOR.

Table 1. Published protection factor definitions.

Definition	Perceived use
NOMINAL PROTECTION FACTOR (NPF) (European Standard) prEn132 Rev. 1994 Ratio of the concentration of test substance present in the ambient atmosphere to concentration in the air inhaled by the wearer of a respiratory protection device. The Nominal Protection Factor is calculated from the permitted total inward leakage values derived from criteria specified in European Standards. $\text{NPF} = 100 \times \frac{1}{\text{max TIL allowed by class}}$	Alternative method of expressing class of protection in European Standard. Used in some manufacturers' literature to indicate maximum use concentrations for a device, i.e., maximum use concentration = NPF x Occupational Exposure Standard (OES). Used in Germany, together with a "correction factor" to calculate assigned protection factors.
ASSIGNED PROTECTION FACTOR (APF) <i>/ Am. Ind. Hyg. Assoc. (46) May 1985</i> The minimum expected workplace level of respiratory protection that would be provided by a properly functioning respirator or class of respirators, to a stated percentage of properly fitted and trained users. The maximum use concentration for a respirator is generally determined by multiplying a contaminant's exposure limit by the protection factor assigned to the respirator.	The APF is used to derive the maximum use concentration, i.e., the maximum use concentration for a respiratory protection device is derived by multiplying the contaminants maximum exposure limit by the assigned protection factor for the device. The "stated percentage" is generally taken as 95%.
QUANTITATIVE FIT FACTOR (QNFF) (C_o/C_i) <i>/ Am. Ind. Hyg. Assoc. (46) May 1985</i> A quantitative measure of the fit of a particular respirator facepiece to a particular individual. It is defined under the conditions of quantitative fit testing as the test agent concentration in the test chamber (C_o) divided by the concentration inside of the respirator facepiece due to leakage (C_i). In order for C_i to reflect only facesal leakage, high efficiency filters (greater than 99.97% efficient against 0.3 μm aerodynamic mass median diameter dioctylphthalate aerosol) have to be used on the respirator when an aerosol test agent is used.	To determine the effectiveness of the fit of a given device to a given individual under given conditions. This may be in the laboratory or at the place of work, e.g., using TSI Portaccount. It does not calculate the actual protection the individual will achieve under different conditions of use but may act as a general indicator.

Table 1. Continued.

Definition	Perceived use
QUALITATIVE FIT FACTOR (QLFF) <i>/Am. Ind. Hyg. Assoc. (46) May 1985</i> A qualitative measure of the minimum assured fit of a specific respirator to a particular individual, when a validated qualitative fit test is used. A validated qualitative fit test is one for which an acceptable lower cut off has been demonstrated by an evaluation against workplace protection factors or quantitative fit factors.	Means of boosting confidence in the ability of a device to provide a given level of protection if it is properly used.
FILTER EFFICIENCY FACTOR (FEF) (C_o/C_i) <i>/Am. Ind. Hyg. Assoc. (46) May 1985</i> A number inversely related to the fraction of air contaminant passing through the respirator filter when tested in the workplace. It is the ratio of the concentration of air contaminant outside of the respirator (C_o) to that inside (C_i). It is measured with the respirator sealed to a mannequin head or other suitable mount at specified conditions, e.g., flow rate, flow pattern, temperature, humidity, container characteristics.	Provides comparison between filter performance against specified workplace contaminants and performance against laboratory test aerosols, e.g., salt, paraffin oil, or DOP, either through actual test or by reference to the definitions of filter class in a published Standard.
WORKPLACE PROTECTION FACTOR (WPF) (C_o/C_i) <i>/Am. Ind. Hyg. Assoc. (46) May 1985</i> A measure of the protection provided in the workplace, under the conditions of that workplace, by a properly selected, fit tested and functioning respirator, when correctly worn and used. It is defined as the workplace contaminant concentration which the user would inhale if he were not wearing the respirator (C_o) divided by the workplace contaminant concentration inside the respirator facepiece (C_i). Both C_o and C_i are determined from samples taken simultaneously only while the respirator is properly worn and used during normal work activities.	Means of demonstrating the best possible protection that a device can provide under the best possible working conditions with the best possible workers.

Table 1. Continued.

Definition	Perceived use
EFFECTIVE PROTECTION FACTOR (EPF) <i>J. Am. Ind. Hyg. Assoc.</i> (46) May 1985 A measure of the workplace protection provided by a properly selected, fit tested and functioning respirator when it is worn for only some fraction of the total exposure period in the workplace. It is the ratio of the contaminant concentration outside the respirator to that in the air actually inhaled. It is determined by sampling outside the respirator and in the breathing zone during the total exposure period, regardless of whether the respirator is being worn. While the respirator is worn, breathing zone sampling is done from within the respirator. Alternatively, effective protection factors may be determined by correcting workplace protection factors (WPF) for the time that the respirator is not worn during the exposure period using the following formula. It can be validly applied only if the air contaminant concentration is relatively constant over that exposure period. $EPF = Ts / [(Tw / WPF) + Tnw]$ Where: Ts = Shift or exposure duration (hours) Tw = Number of hours respirator is worn Tnw = Number of hours that respirator is not worn.	Means of demonstrating the difference between what protection is achieved and what <i>might be</i> achieved through correct training, fit testing, use and supervision programmes in the workplace.

Table 1. Continued.

Definition	Perceived use
PROGRAMME PROTECTION FACTOR (PPF) (C_o/C_i) <i>/ Am. Ind. Hyg. Assoc. (46) May 1985</i> A measure of the respiratory protection provided to a worker by an established respirator programme. It is defined as the contaminant concentration which the user would inhale if he were not wearing the respirator (C_o), divided by the contaminant concentration inside the respirator facepiece measured as the respirator is used in the context of the existing respirator programme (C_i). The inside of the respirator facepiece concentration may be estimated indirectly from biological monitoring as the airborne concentration expected to produce the measured biological index. The programme protection factor is a measure of the effectiveness of the complete respirator programme. Factors which may effect the wearer in that setting, the motivation of the wearer, the fit of the respirator, respirator selection, the respirator design, training, maintenance, storage, supervision, programme administration and monitoring, and any other variable that affects programme effectiveness. If any of these programme elements are deficient, the programme protection factor will be adversely affected.	As a management tool for evaluating the effectiveness of its respiratory protection programme and identifying deficiencies.
SIMULATED WORKPLACE PROTECTION FACTOR (SPF) (C_o/C_i) <i>/ Am. Ind. Hyg. Assoc. (46) May 1985</i> A surrogate measure of the workplace protection provided by a respirator, which is done in a laboratory simulation which has been shown to have a stated correlation of workplace protection factors. It is the contaminant concentration which the user would inhale if he were not wearing a respirator (C_o) divided by the concentration inside the respirator facepiece (C_i). It is determined by measuring the concentration inside and outside the facepiece while the respirator is worn.	Cost effective method of attempting to determine likely workplace protection factors.