

Minimum Passing Fit Factor

Ching-tsen Bien

LAO Consulting, Inc.
Crofton, MD 21114 USA

There is a proposal that an APF of 10 can be assigned to any half-mask respirator if the respirator can achieve a minimum fit factor of 100. To ensure that any wearer can achieve a minimum fit factor of 100, the fit factor value should be set at a 95% confidence limit.

The value of 100 is a product of the protection factor (PF) of 10 and a safety factor of 10. The PF of 10 is based on the quantitative fit testing (QNFT) study conducted by Edwin Hyatt of the Los Alamos Scientific Laboratory (LASL) in the early seventies (Hyatt 1976). Hyatt selected a variety of half-masks in his study. Fit factors were measured on the 25 member anthropometric test panel with facial characteristics that represents the American work population. The test results indicate that a properly trained and fitted wearer can obtain an average efficiency of 90% which corresponds to a PF of 10. All tested respirators had only one size and none of these masks is available today.

Warren Myers has conducted a QNFT study for MSA on commonly used half-mask elastomeric facepiece respirators (Myers 1993). Facepieces manufactured by Aerro, MSA, North, Survivair, 3M, and Willson were selected for testing. MSA has submitted the study report to the OSHA respiratory protection docket. A total of 13 facepieces was tested. Each mask has three sizes. Fit factors were measured on a 25-member test panel. Test subjects both male and female were selected to fit the facial characteristics of the Los Alamos half-mask anthropometric test panel. The following exercises were performed by the test subject:

1. Normal breathing
2. Deep breathing
3. Head up-and-down
4. Head side-to-side
5. Reading
6. Normal breathing.

Each exercise lasted one minute. The fit tests were performed on the TSI Portacount. The test

results are shown in Table 1. The results indicated fit factors varied between 100 and 61,000. The geometric mean of each mask varied between 1,400 and 6,600. The fifth percentile fit factor varied from 100 to 1,150. Fit factors reported from this study would be representative for the half-masks available today.

The current PF of 10 for the half-mask respirator is based on the test results of respirators that are no longer available. We should consider the passing fit factor derived from the currently available half-mask respirators. The currently available half-masks are made of very pliable silicone rubber that would achieve a much higher fit factor. It is very common to achieve fit factors more than 1,000. The Myers study indicates that respirator A-2 has the lowest fifth percentile value of 100 and respirator C-3 has the highest fifth percentile value of 1,150. The current 42 CFR 84 regulation has no fit testing requirement for respirator certification. To ensure that approved respirators would provide adequate fit, the Z88.2 Subcommittee should require a minimum passing fit factor based on the currently available information. There are two approaches in assigning the minimum passing fit factor. The first one is to require a minimum factor of 1,000 which is based on the lowest fifth percentile fit factor of 100 and a safety factor of 10. The second approach is to require that QNFT be performed on the respirator. If the respirator achieves a fifth percentile fit factor of 100 on the Los Alamos 25 subject anthropometric test panel, it can be assigned a protection factor of 10. The N95 respirators are used mainly for protection against TB bacteria and the TB bacteria have a MMAD of 0.9 μm . This size should be used for performing fit testing for the N95, R95, and P95 respirators. To avoid excessive filter penetration by the ambient aerosol, the generated test aerosol should be used. It should have a geometric MMAD of 0.9 μm and a standard deviation less than two. The aerosol concentration inside the test chamber should be 10-15 mg/m^3 .

Table 1. Fit factors of elastomeric facepieces. Manufacturers: Aearo, MSA, North, Survivair, 3M, and Willson.

Respirator	Fit factor	Geometric mean	Geo. std. deviation	Fifth % value	95%conf. limit on GM	Lower 95-95 tol limit
A-1	100-61000	3000	7.03	120	1350-6740	30
A-2	100-20600	1400	5.04	100	740-2800	40
B-1	100-44400	4700	3.95	490	2660-8270	200
B-2	1000-35550	4800	2.58	1000	3230-7070	540
C-1	100-11500	3200	2.94	540	2040-4960	240
C-2	200-42900	6000	3.36	810	3610-9830	370
C-3	500-29800	6600	2.89	1150	4240-10170	580
D-1	100-19300	2800	3.07	440	1760-4430	210
D-2	200-51100	4600	3.58	560	2700-7730	250
E-1	100-43400	3300	3.56	410	1970-5630	180
E-2	300-41500	4600	3.72	530	2690-7960	230
F-1	200-21500	2000	3.27	290	1250-3320	130
F-2	100-81300	5800	3.76	660	3360-10010	280

References

Hyatt, E.C., "Respirator Protection Factors," Los Alamos Scientific Laboratory, UC-41 (1976).

Myers, W.R., "Fit Testing Quality Assurance Report for MSA on Half Facepiece Respirators: Phase II Report," prepared for Mine Safety Appliances Co., Pittsburgh, PA (March 1993).