Workplace Protection Factor Study on a Half Mask Dust/Mist Respirator

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ABSTRACT

This study evaluated the effectiveness of half mask dust/mist respirators against aluminum dust. Workplace protection factors were determined on carbon changers at an aluminum smelter. Workers were trained in donning the respirator and passed a qualitative fit test before participating in the study. The workers were observed at all times to help ensure sample validity. Respirable dust samples were collected for the outside samples. Both outside and inside samples were analyzed for aluminum dust by proton induced x-ray emission analysis. Time weighted average concentrations were calculated and workplace protection factors determined for 24 workers. The results indicate that aluminum concentrations measured inside the respirators were significantly less than the TLV. The mean workplace protection factor was 27 with standard deviation of 1.5. The results support an assigned protection factor of 10 for this type of respirator.

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Study Objective

Determine a Workplace Protection Factor (WPF) for a half mask dust/mist respirator worn in an aluminum dust environment. WPFs were measured on carbon changers at an aluminum smelter.

The WPF is a measure of the protection provided in the workplace when correctly fitted, worn and used.

$$\text{WPF} = \frac{\text{Workplace Contaminant Concentration } (C_O)}{\text{Concentration Inside Respirator } (C_I)}$$

Both C_O and C_I are determined from samples taken simultaneously.

Respirator Evaluated

The respirator tested was the 3M 9906 Dust/Mist Respirator. The respirator is NIOSH/MSHA approved, TC-21C-224, for dusts and mists with a PEL $\geq$ 0.05 mg/m^3.

Experimental Design

Five workers were sampled daily for five days for the duration of the carbon changing tasks. All workers were trained in donning the respirator and passed a qualitative fit test. The workers were observed continuously to ensure proper use, sample validity and that the sampling equipment did not interfere with worker safety.

Outside samples were respirable dust samples. Area samples were collected with Marple Personal Cascade Impactors for particle size evaluation.

Sampling Procedure

Each worker wore two sampling pumps (MSA HD Flow Lite) calibrated with TSI Model 67 Mass Flow Meter. Calibration was performed before and after each sample.

Sample	Filter Size (mm)	Filter Type	Placement	Flow Rate LPM
Outside	25 mm (Placed after cyclone)	0.8 μm Polycarbonate	Breathing Zone	1.7
Inside	25 mm	0.8 μm Polycarbonate	Respirator Probe*	2.0

*The probe was designed to minimize particle entry losses. (> 95% efficiency for particulates $\leq$ 10 μm)[1]

Sampling time ranged from 67-315 min.

[1]Liu, B.Y.U., K. Sega, K.L. Rubow, S.W. Lenhart and W.R. Myers: In Mask Aerosol Sampling for Powered Air Purifying Respirators. *Am. Ind. Hyg. Assoc. J.* 45:278-283 (1984).

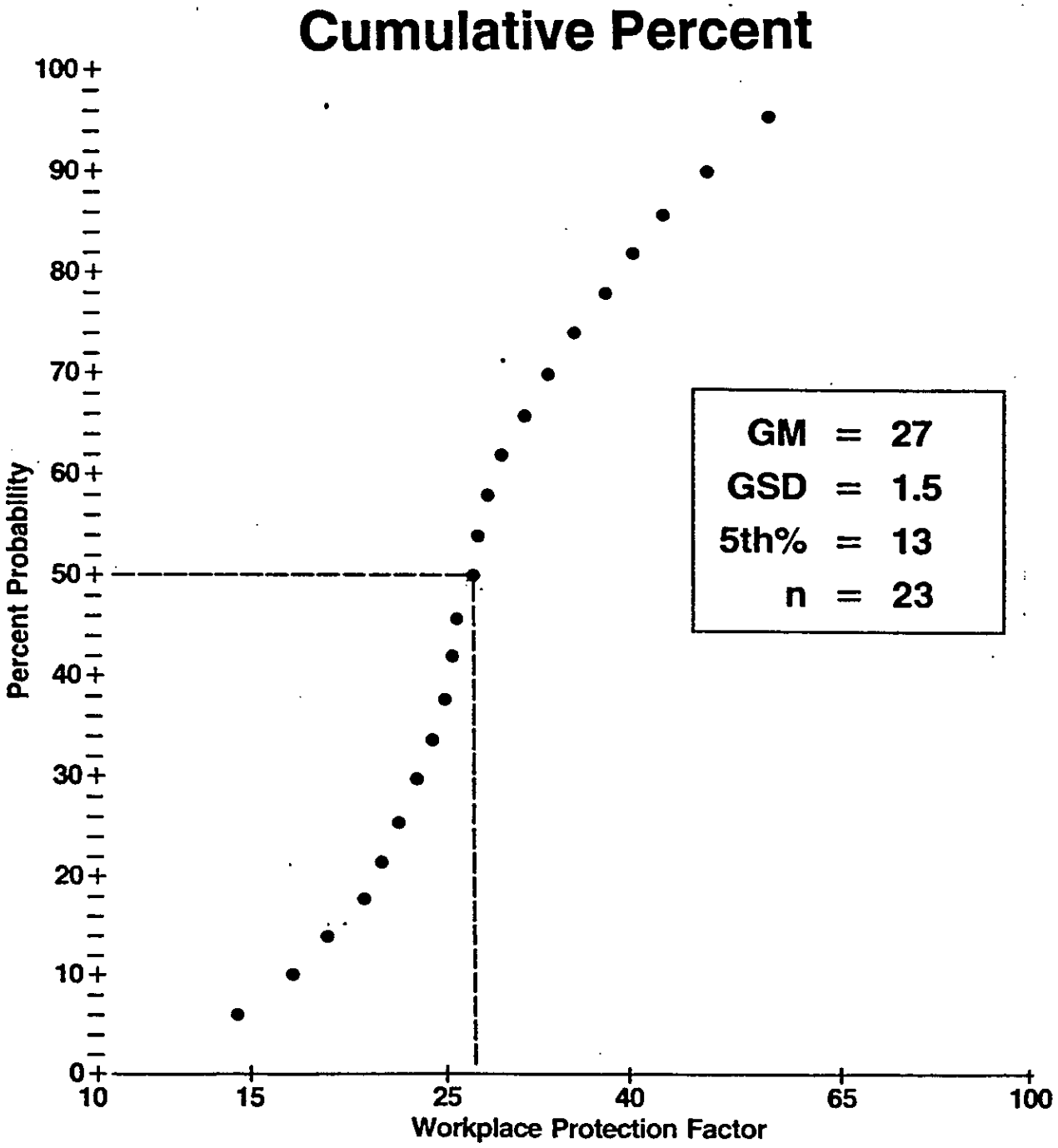
Sample Analysis

Personal and area samples were analyzed for aluminum by proton induced x-ray emission (PIXE). This method was chosen because of its good sensitivity. For PIXE analysis this is typically ~27 ng per sample. Other advantages include simultaneous analysis of multiple elements, nondestructive to sample and results include confidence levels.

Results

WPF results were derived by the following method:

1. Blank levels were determined by PIXE analysis.
2. The mean blank value was subtracted from inside and outside filter weights (mean blank value was zero).
3. Only outside sample weights greater than 11X detection limit used in final calculations.
4. Inside and outside concentrations calculated.
5. Time Weighted Average (TWA) concentrations were then calculated for both inside and outside samples for total sampling period.
6. WPFs calculated by dividing outside by inside TWA concentrations.
7. Data analyzed for outliers. (One found)


Cumulative Percent
100
90
80
70
60
50
40
30
20
10
0
Percent Probability
GM = 27
GSD = 1.5
5th% = 13
n = 23
10
15
25
40
65
100
Workplace Protection Factor

Conclusions

The disposable half mask dust/mist respirator tested in this study reliably provides workplace protection factors of 10. In this study the fifth percentile TWA WPF exceeds 10.

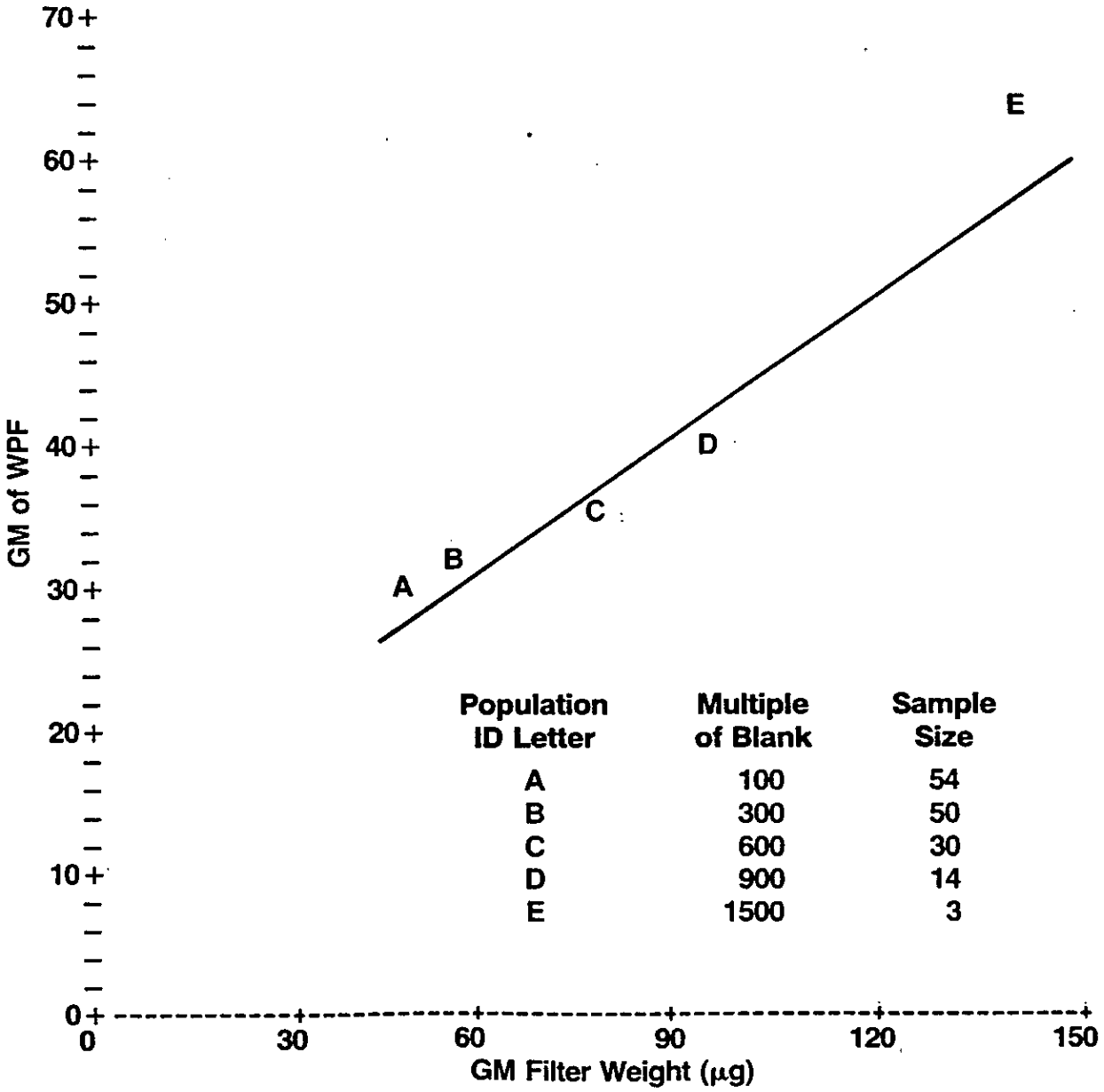
All aluminum concentrations measured inside the respirator were considerably less than the threshold limit value of 10.0 mg/m^3. The values ranged from 5.44 – 60.1 $\mu g/m^3$.

These WPFs represent conservative estimates of protection since respirable dust samples were used for the outside concentration measurement. When total protection is considered, a total dust concentration should be used for the outside concentration which most likely would result in higher WPFs.

These data support the ANSI Z88.2 Committee on Practices for Respiratory Protection proposal of an assigned protection factor of 10 for this type respirator.

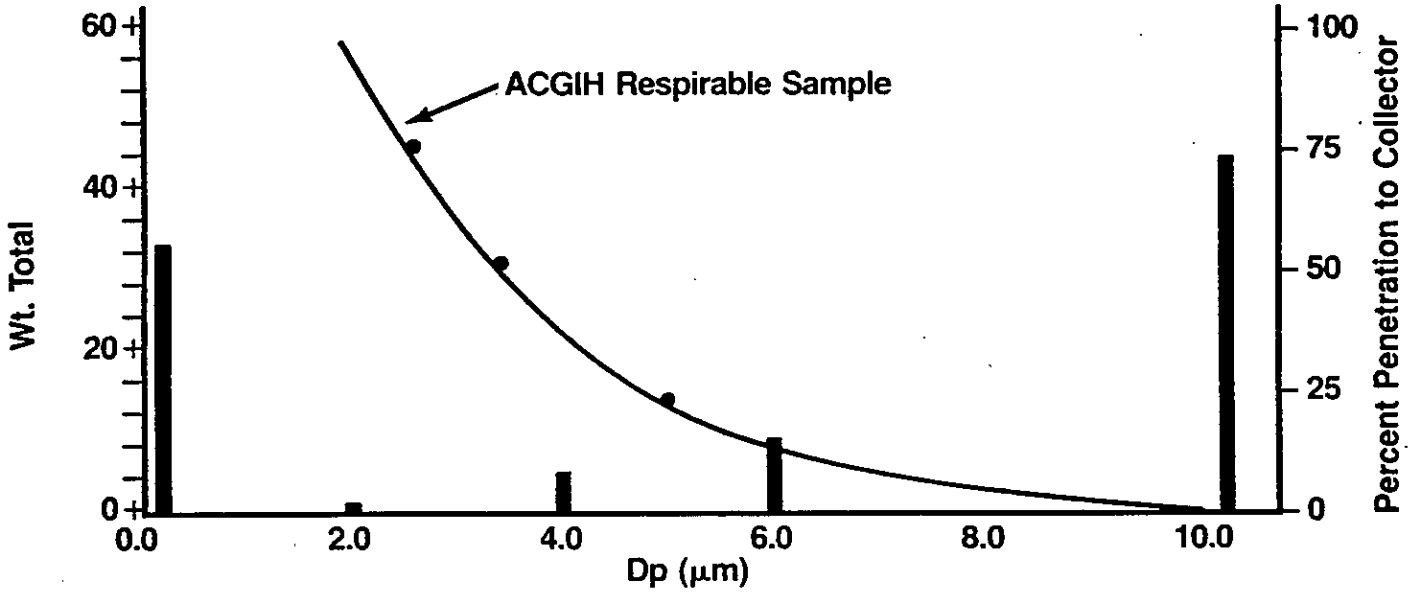
The assigned protection factor of 5 suggested by the OSHA draft of 29 CFR 1910.134 appears to be unnecessarily restrictive.

Effect of Filter Weight On Workplace Protection Factor



Population ID Letter	Multiple of Blank	Sample Size
A	100	54
B	300	50
C	600	30
D	900	14
E	1500	3

Cascade Impactor Results (12 Samples)



Optical Sizing Results (11 Respirable Dust Samples)

Particle Size and Distribution of Particulates Passing Cyclone Selector*

Weather Conditions	GM	GSD
Wet (Rain)	1.49	1.31
Dry	2.61	1.15

*Optical Microscopy (Transmitted Bright Field) using IBAS Image Analyzer.