PLAINTIFF'S
EXHIBIT
DUP-1021

RESPIRATOR WORKPLACE PROTECTION FACTORS FOR ASBESTOS

SUMMARY AND BACKGROUND

Workplace protection factors for elastomeric and single use half-mask respirators were measured during asbestos removal operations. The operations consisted of asbestos removal from a ceiling (fire proofing) and removal of pipe insulation. The use of water/surfactant solutions to spray fire proofing and insulation resulted in conditions of high humidity for in-doors operations. Out-of-doors operations were also under high humidity conditions since light rain occurred on two of four days of out-of-doors sampling. Temperatures for both operations were in the 65-85°F range.

The respirators were used in the context of a respirator program that followed the guidance in 29 CFR 1910.134 and ANSI Z88.2 (1980) including proper respirator selection and fit testing. A total of seventeen volunteers participated in the study. One or two workplace protection factors were determined for each respirator for which the fit test had been passed.

The respirators tested were:

- One successfully fitted elastomeric facepiece respirator chosen for comfort from six respirators (MSA Comfo II and Survivair 2000 brands - small, medium or large sizes). These respirators were tested using a dust, fume and mist type filter and a high efficiency filter.

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- Each of three disposable respirators successfully fitted (3M 9910, 3M 8710 and American Optical R1050).
- A successfully fitted North 7700 elastomeric facepiece respirator, chosen from the small, medium or large size facepieces.

In addition two workplace protection factor measurements were made for a self-contained breathing apparatus operated in the pressure-demand mode.

Results showed that, with the exception of the American Optical (AO) R1050, all respirators tested reliably provided workplace protection factors of ten or greater based on estimates of the lower 5th percentile. The AO R1050 reliably provided a protection factor of five or greater. These results are consistent with information supplied to the record by Los Alamos National Laboratory which reported on the penetration of asbestos through respirator filter media.(1)

Results for the self-contained breathing apparatus suggest that it may not provide appreciably better protection than the two better disposable respirators and the elastomeric facepiece respirators, though it creates significantly greater hazard of falling because of the weight and awkwardness of the tanks. Myhre et al.(2) and Raven(3) have shown that pressure-demand type respirators do not maintain positive pressure inside the facepiece when workloads are increased from rest conditions. This may explain in part why no significant difference exists between half facepiece negative pressure and pressure-demand respirators.

PROCEDURE

Prior to testing, each person was trained in the selection and fit testing of respirators using the National Paint and Coatings Association Training Program[4]. Each was then fit tested using the saccharin fit test[4]. Respirators selected for use by participants are listed above and in Table I.

Two individuals were also trained in use of a pressure-demand self-contained breathing apparatus. Fit testing was not done, as it is not required for pressure-demand equipment in the ANSI Z88.2 (1980) standard.

During sample collection, each participant was observed continually to ensure that the sample train remained intact and did not interfere with the respirator seal on the face, and to note occurances which might have affected respirator performance, such as movement of the respirator on the face. The participants were very busy with their work activities and soon ignored the presence of the researchers.

AIR SAMPLING AND ANALYSIS

To determine the workplace protection factors, concurrent samples were taken from inside the respirator (in-mask) at nose level and outside the respirator at the lapel (lapel). Closed-face Glasrock (#1505) cassette filter holders fitted with half inch extenders and probes developed by NIOSH[5] were used for both the in-mask and lapel samples. The sample probes are specially designed to minimize the loss of particulates. The cassettes contained 0.8 um, 25mm cellulose ester filters.

The sample trains were calibrated before and after taking each sample using a mass flow meter. The mass flow meter was calibrated against a bubble flow meter at the beginning and end of the study. A flow rate of 2 Lpm was used for in-mask samples. Lapel samples were taken at 0.5-1.0 Lpm to avoid overloading.

Samples were collected for a one to two hour period. Each sample represented a single wearing of the respirator.

Fiber counts were done per NIOSH procedure P&CAM 239[6] (phase contrast microscopy), except that the triacetin/acetone mounting method was used as described in NIOSH method 7400[7]. Counting was done according to the "A" counting rules in method 7400. Five hundred fields were counted for in-mask samples to increase analytical sensitivity. All analyses were done by one counter who participates successfully in the American Industrial Hygiene Association's Proficiency Analytical Testing quality assurance program. Concentrations were calculated from the actual number of fibers counted (even if fewer than 50 fibers were counted) per the formulas in the NIOSH method.

NIOSH method P&CAM 239 reports a coefficient of variation of 0.12 which applies to lapel samples in this study. We estimate that the coefficient of variation for the in-mask samples is 0.4 at the median in-facepiece concentration and fiber count (Table III).

SAMPLING AND ANALYSIS METHOD VERIFICATION

In-mask sampling required use of closed-face filter cassettes. The Glassrock #1505 25mm filter cassettes used have a unique tapered design for the outlet and a half inch extender which improves the deposition patterns[8]. To minimize sample loss, the NIOSH[5] probe was used to withdraw in-mask samples.

To eliminate possible bias, the same closed-face/probed cassette was used for both in-mask and lapel samples. To document whether concentrations determined from closed-face/probe cassette sampling differed from open-face sampling, twelve area samples were taken using both methods. Results are compared in Table II with Student's and Variance Ratio tests. The two sampling methods were found to give similar results with no significant bias or difference in precision.

RESULTS AND DISCUSSION

Transmission electron microscopic analyses were made on four lapel samples to document the distribution of fiber diameters and lengths. Distributions are shown in Figures 1 and 2. Fiber diameters and lengths covered a wide range.

The overall median concentrations of fibers for in-mask and lapel samples are given in Table III. The median number of fibers counted for in-mask (500 fields counted) and lapel ($\leq$100 field counted) samples are also given in Table III.

Cumulative distributions, geometric means, geometric standard deviations, best estimates of 5th percentiles and lists of workplace protection factors are given in Figures 3 through 8 for each respirator. The distributions of workplace protection factors were found to be approximately lognormal for all respirators studied. Therefore, logs were used for the plots, geometric means are reported as the proper measure of central tendancy and geometric standard deviations are reported as the proper measure of variability. Best estimates of 5th percentiles represent the workplace protection factors that most (95%) respirator users are expected to obtain from each respirator.

Distribution plots and geometric standard deviations include variability from the sampling and analytical method as well as from the workplace protection factors. The unavoidable inclusion of the sampling and analytical variability in the plots results in best estimates of 5th percentile protection factors which are conservative (lower than actual). This should be considered in evaluating results.

Workplace protection factors were determined for a self-contained breathing apparatus for two individuals. Results are reported in Table IV.

Table V gives geometric means and standard deviations for all respirators studied. A Bonferroni[9] test for differences (p=0.05) was done and results are given in Table V. Workplace protection factors for the 3M 9910 were found to be significantly higher than those for the AO R1050. No other significant differences were found.

The relatively low results for the AO R1050 are likely due to poorer filter efficiency for asbestos, reported by Dr. Ortiz of Los Alamos National Laboratory.[1] The unexpected comparability of the results from the 3M disposable respirators, and elastomeric facepiece respirators with both dust, mist and fume filters and high efficiency filters may be explained by several factors. First, the limiting factor in performance with the respirators is likely face fit, not filter efficiency (except for the AO R1050 as noted above). Since the same fit test was used to select good fitting respirators for the study, comparable results would be expected. In addition, the researchers noted a tendency for elastomeric respirators to slip around when some wearers' faces became wet with the water/surfactant spray. This did not occur with the disposable respirators because their fibrous material of construction clung to the skin.

It is particularly noteworthy that the workplace protection factors for the self-contained breathing apparatus were not superior to the better disposable and elastomeric respirators. Myhre[2] and Raven[3] have shown that at workloads exceeding approximately 35% of maximal aerobic capacity pressure inside the facepiece of pressure-demand type respirators does not remain positive with respect to the surrounding atmosphere. This would provide an opportunity for asbestos to be drawn into the facepiece.

The volunteers who wore the self-contained breathing apparatus complained of stress and discomfort due to its weight and bulk. Movement and balance were difficult and one volunteer almost fell from a step ladder as a result. Based on their observations, the researchers believe that routine use of self-contained breathing apparatus for asbestos removal in the chemical industry would likely result in injuries, in view of the large amount of climbing involved. Certainly, acceptance will be much poorer than for the other respirators studied, due to discomfort which would discourage respirator use.

Transmission electron microscopic analyses were done on in-mask and lapel samples. Resultant workplace protection factors are reported in Table VI. Results for small diameter fibers (<0.2um - the diameter below which fibers cannot be resolved with the standard optical microscopic method) do not appear to differ from those for large diameter (≥0.2um) fibers, for 5 um or longer lengths. Thus, results for fibers visible with the phase contrast method (≥0.2um diameter) appear to be representative of those for smaller diameter fibers for the 3M 8710 and 9910, and for elastomeric respirators with a dust, fume and mist filters and high efficiency filters.

CONCLUSIONS

1. All respirators tested provided protection against asbestos. The American Optical R1050 disposable respirator reliably provided workplace protection factors of 5 or greater. The 3M 9910, 3M 8710, and elastomeric half-face respirators with both dust, fume and mist and high efficiency filters reliable provided workplace protection factors of 10 or greater.
2. Use of higher efficiency filters did not appear to improve the workplace protector factors of the elastomeric respirators.
3. Workplace protection factor measurements for a pressure demand self-contained breathing apparatus were not significantly higher than those for the better disposable and elastomeric respirators. Comments from the test volunteers and observations indicate that acceptance of the self-contained breathing apparatus will be poorer than that of the other respirators tested. In addition, they present a significant risk of tripping or falling where removal work requires climbing ladders and working from scaffolding.
4. Transmission electron microscopic analyses indicate that overall workplace penetration of small diameter (<2um) fibers (longer than 5 um) is not discernibly higher than that of larger diameter fibers for the 3M 8710 and 3M 9910 disposable respirators nor for elastomeric respirators with dust, fume and mist or high efficiency filters.

REFERENCES

1. Ortiz, L. W. et al: "Interim Report: Penetration of Respirator Filters by an Asbestos Aerosol." May 2, 1984 (Los Alamos National Laboratory).
2. Myhre, L. G., R. D. Holden, F. W. Baumgardner and D. Tucker: Physiological Limits of Firefighters. Unclassified Report #ESL-TR-79-06, AFESC, Tyndall AFB, Florida (June 1979).
3. Raven, P. B. et al.: "Physiological Response to 'Pressure-Demand' Respirator Wear", Am. Ind. Hyg. Assoc. J. 43 (10): 773-781 (1982).
4. "Guide to Respirator Fit Testing" (1981), National Paint and Coating Association, Washington, D.C.
5. Liu, B. Y. U. et al: "In-Mask Aerosol Sampling for Powered Air Purifying Respirators," Am. Ind. Hyg. Assoc. J. 45(4):278-283 (1984).
6. U.S. Department of Health, Education and Welfare; NIOSH Manual of Analytical Methods, Second Edition, Volume I (April 1977).
7. National Institute for Occupational Safety and Health, Method 7400, February 15, 1984.
8. Adams, M. J. et al, "Cassette Extenders: Effects on Chrysotile Fiber Deposition and Concentration Measurements", Presented at the American Industrial Conference, May 24, 1983.
9. Snedecor, G. W. and W. G. Cochran: Statistical Methods, 7th Ed., Iowa State University Press, Ames, Iowa (1980).

TABLE I

Respirators Studied

Respirator Name	Type	Vendor
Survivair 2000	Elastomeric (silicone rubber) with dust, fume and mist and high efficiency filters	U.S.D. Corp.
Comfo II	Elastomer (neoprene) with dust, fume and mist and high efficiency filters	Mine Safety Appliance Co.
3M 8710	Disposable with nonadjustable straps	3M Company
3M 9910	Disposable with adjustable straps	3M Company
American Optical R1050	Disposable with nonadjustable straps	American Optical Company
North 7700	Elastomeric (silicone rubber) with high efficiency filters	North Company
Scott Air-Pak	Self-contained breathing apparatus, pressure-demand	Scott Aviation

TABLE II

COMPARISON OF ASBESTOS SAMPLING METHODS
(OPEN-FACE VERSUS CLOSED-FACE WITH PROBE)

Parameter	Value
Mean	2.2 fibers/mL - open face filter cassette 2.3 fibers/mL - closed face cassette with probe
Standard Deviation	0.264 fibers/mL - open face cassette 0.286 fibers/mL - closed face cassette with probe
T Statistic*	1.28
Variance Ratio**	1.17
Data	
Open-face cassette:	1.9, 1.9, 2.0, 2.1, 2.1, 2.1, 2.2, 2.2, 2.2, 2.2, 2.3, 2.9
Closed-face cassette:	2.0, 2.0, 2.0, 2.2, 2.3, 2.3, 2.3, 2.4, 2.4, 2.4, 2.5, 3.0

* 1.28 is less than a comparison t statistic of 1.78 ($p=0.05$). Therefore, the means do not differ significantly.

** 1.17 is less than a comparison F statistic of 2.69 ($p=0.05$). Therefore, the variances (precision) of the methods do not differ significantly.

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TABLE III

MEDIAN ASBESTOS CONCENTRATIONS AND COUNTS FOR WORKPLACE PROTECTION FACTOR STUDY FOR ALL RESPIRATORS COMBINED

Concentrations	
Inside Respirator	0.006 fibers/mL (8 HR. TWA $\simeq$ 0.003)*
Outside Respirator	2.6 fibers/mL (8 HR. TWA $\simeq$ 1.3)*
Counts	
Inside Filter	9 fibers
Outside Filter	130 fibers

* No more than four of eight work hours were spent doing asbestos removal. Therefore, a factor of 0.5 (4 HRS/8 HRS) was applied to concentrations to estimate 8 HR TWA concentrations.

TABLE IV

WORKPLACE PROTECTION FACTORS FOR
SELF-CONTAINED BREATHING APPARATUS (PRESSURE-DEMAND)

Workplace Protection Factors:	400
	880

Geometric Mean: 620

TABLE V

COMPARISON OF WORKPLACE PROTECTION FACTORS FOR SEVEN RESPIRATORS

Respirator	Number of Measurements	Workplace Protection Factor Geometric Mean (Geom. S.D.)	Significant Differences	Lower 5t Percentil
3M 8710	18	310 (5.3)		20
3M 9910	14	580 (4.2)	Higher than R 1050	55
American Optical R1050	7	52 (4.2)	Lower than 3M 9910	5
Elastomeric/Dust, Fume and Mist Filter	17	240 (6.3)		12
Elastomeric/High Efficiency Filter	14	94 (3.0)		16
North 7700 High Efficiency Filter	14	250 (6.9)		11
Self-Contained Breathing Apparatus Pressure-Demand	2	620		

* Based on a Bonferroni test(5) at a 0.05 level of significance, only the 3M 9910 and AO R1050 differed.

TABLE VI

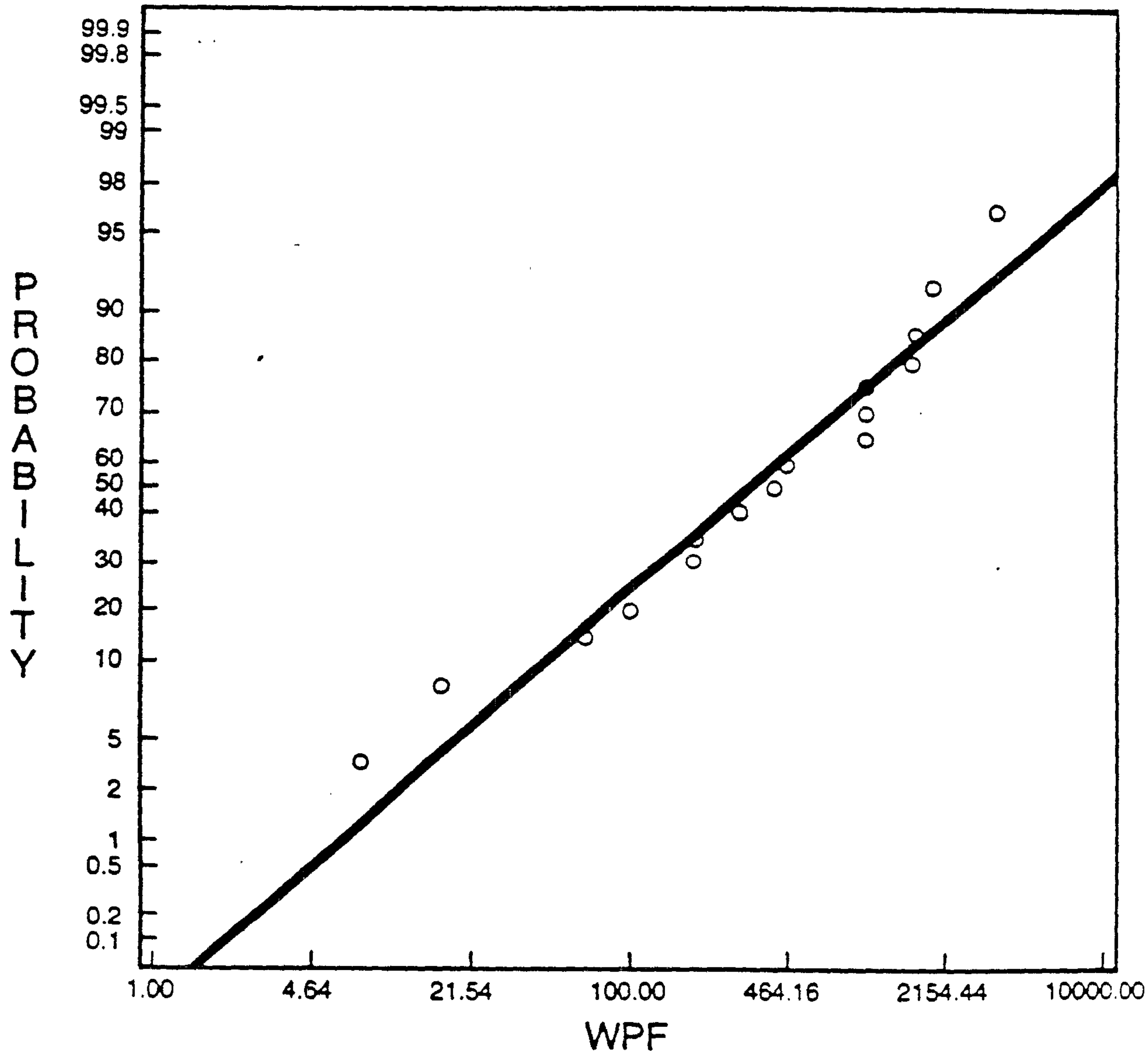
WORKPLACE PROTECTION FACTORS FROM TRANSMISSION ELECTRON MICROSCOPIC ANALYSES

Respirator	Workplace Protection Factor: Fibers Exceeding 0.2 um Diameter and 5 um Length*	Workplace Protection Factor: All Diameter Fibers Exceeding 5 um Length
3M 8710	330	120
3M 9910	47	41
Survivair 2000 with Dust, Mist and Fume Filter	28	29
Survivair 2000 with High Efficiency Filter	21	19

* Those which would be counted by the standard phase contrast microscopy method.

Figure 3 – Workplace Protection Factors for 3M 8710 Respirator

Cumulative Distribution: (Lognormal)



Geometric Mean: 310

Geometric Standard Deviation: 5.3

Best Estimate of 5th Percentile: 20

Data: 7.4, 15, 61, 110, 110, 180, 200, 310, 400, 420, 430, 1000, 1000, 1100, 1500, 1600, 1800, 3200

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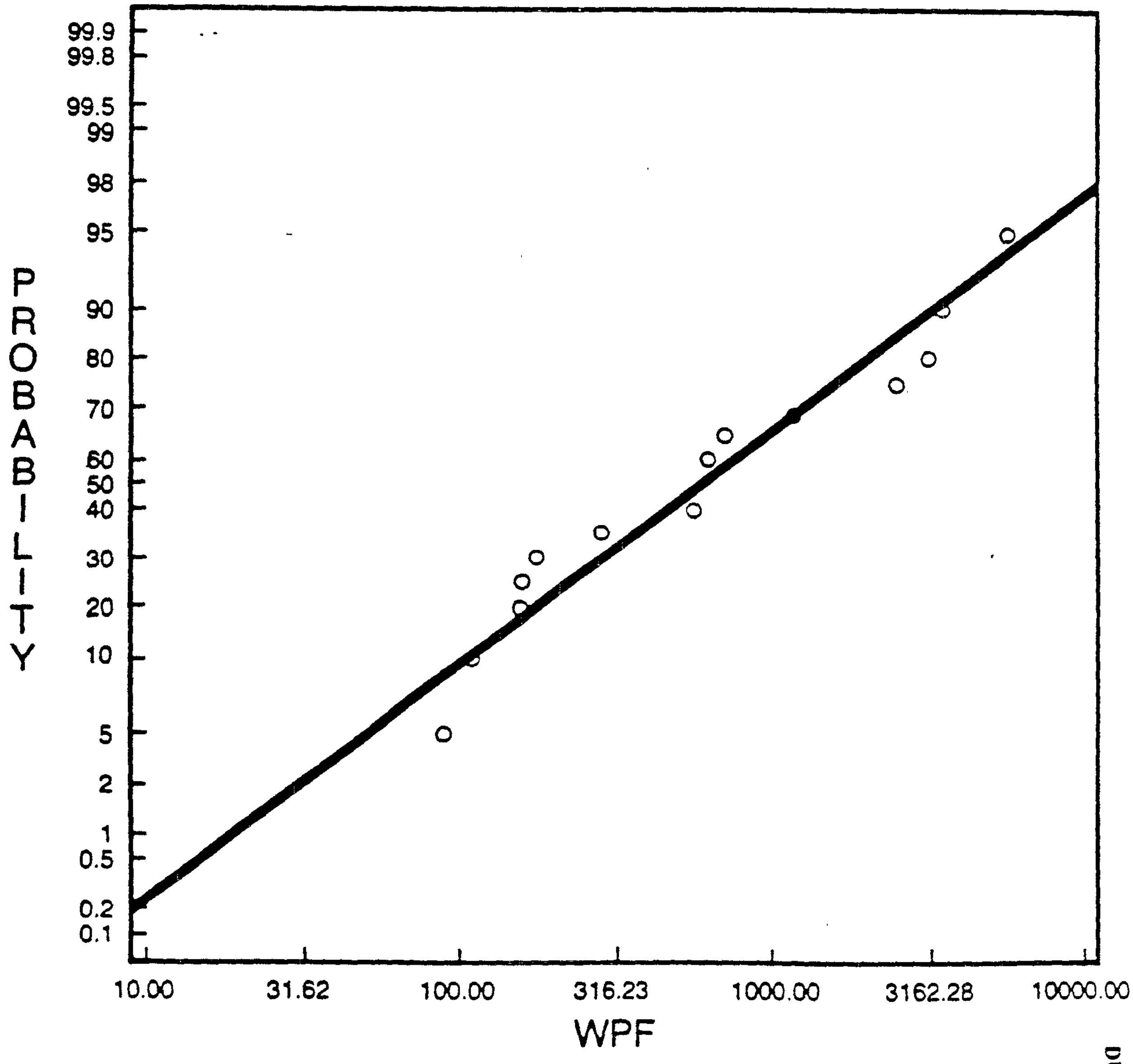
Figure 4 – Workplace Protection Factors for 3M 9910 Respirator

Cumulative Distribution: (Lognormal)



Geometric Mean: 580

Geometric Standard Deviation: 4.2

Best Estimate of 5th Percentile: 55

Data: 94, 110, 150, 150, 170, 280, 550, 630, 710, 1300, 2400, 3000, 3700. 5600

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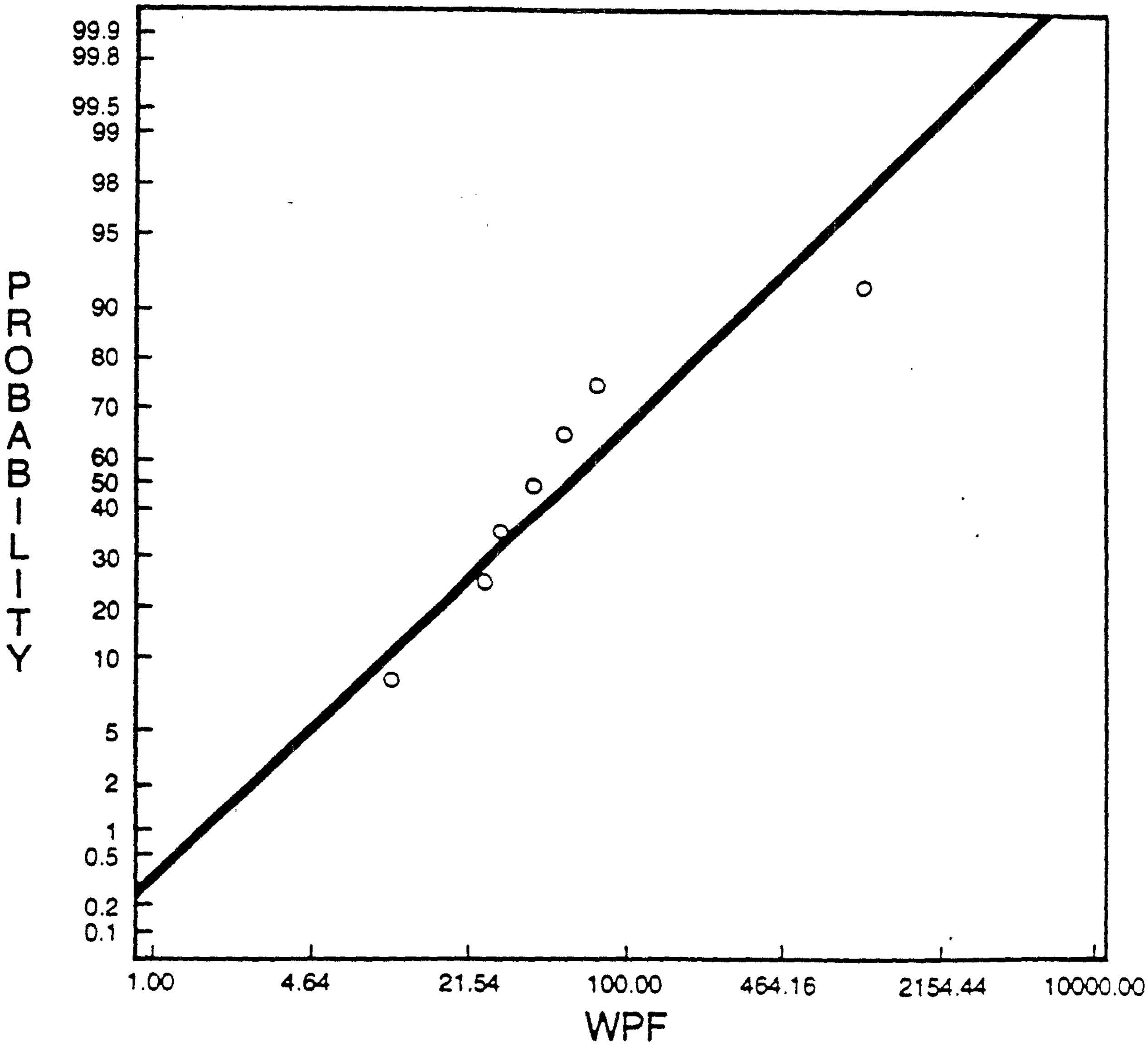
Figure 5 – Workplace Protection Factors for AO R1050 Respirator

Cumulative Distribution: (Lognormal)



Geometric Mean: 52

Geometric Standard Deviation: 4.2

Best Estimate of 5th Percentile: 5

Data: 9.7, 26, 28, 38, 52, 75, 970

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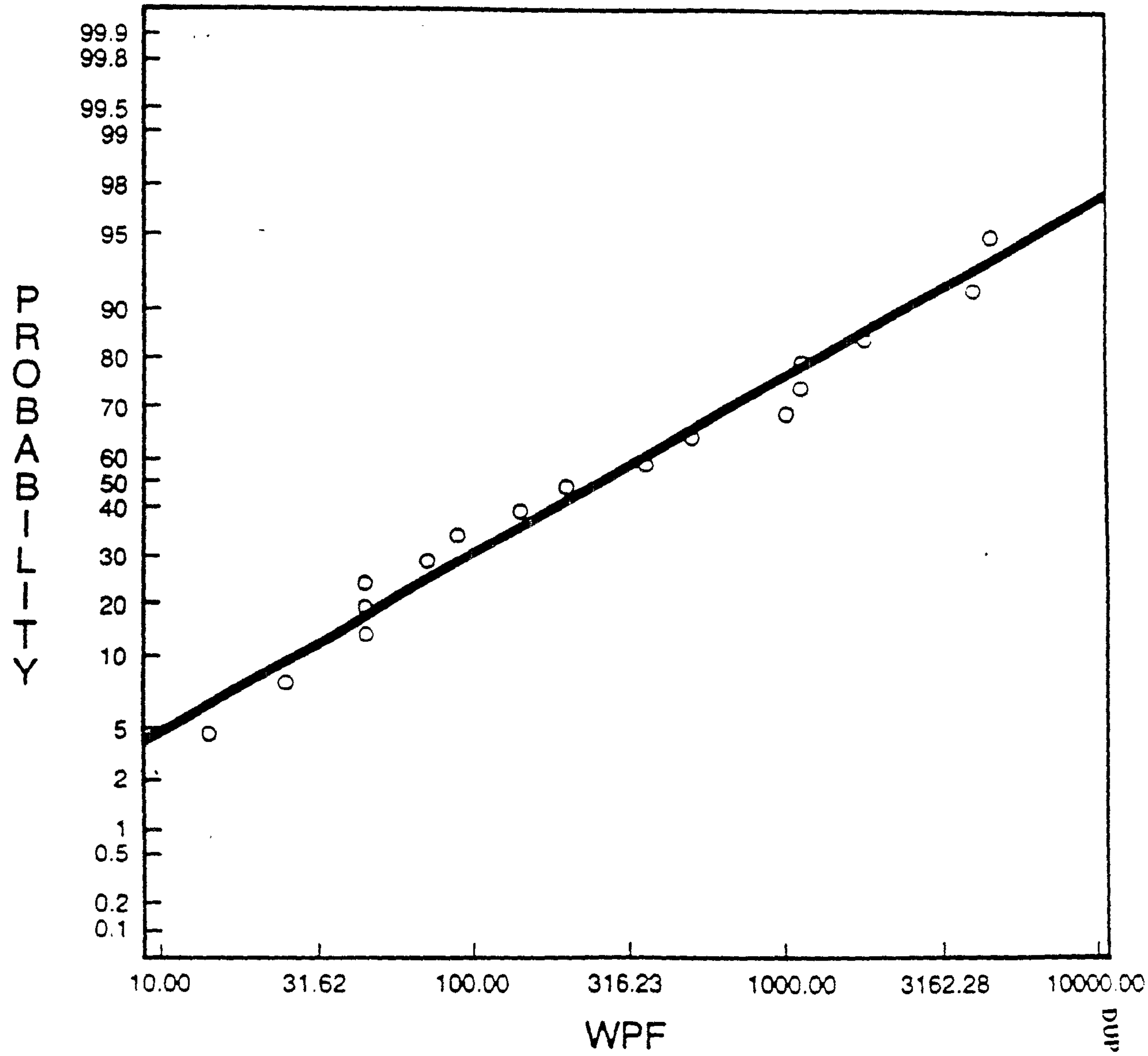
Figure 6 – Workplace Protection Factors for Survivair 2000 and MSA Comfo® Halfmask Respirators with Dust, Fume and Mist Filters

Cumulative Distribution: (Lognormal)



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Geometric Mean: 240

Geometric Standard Deviation: 6.3

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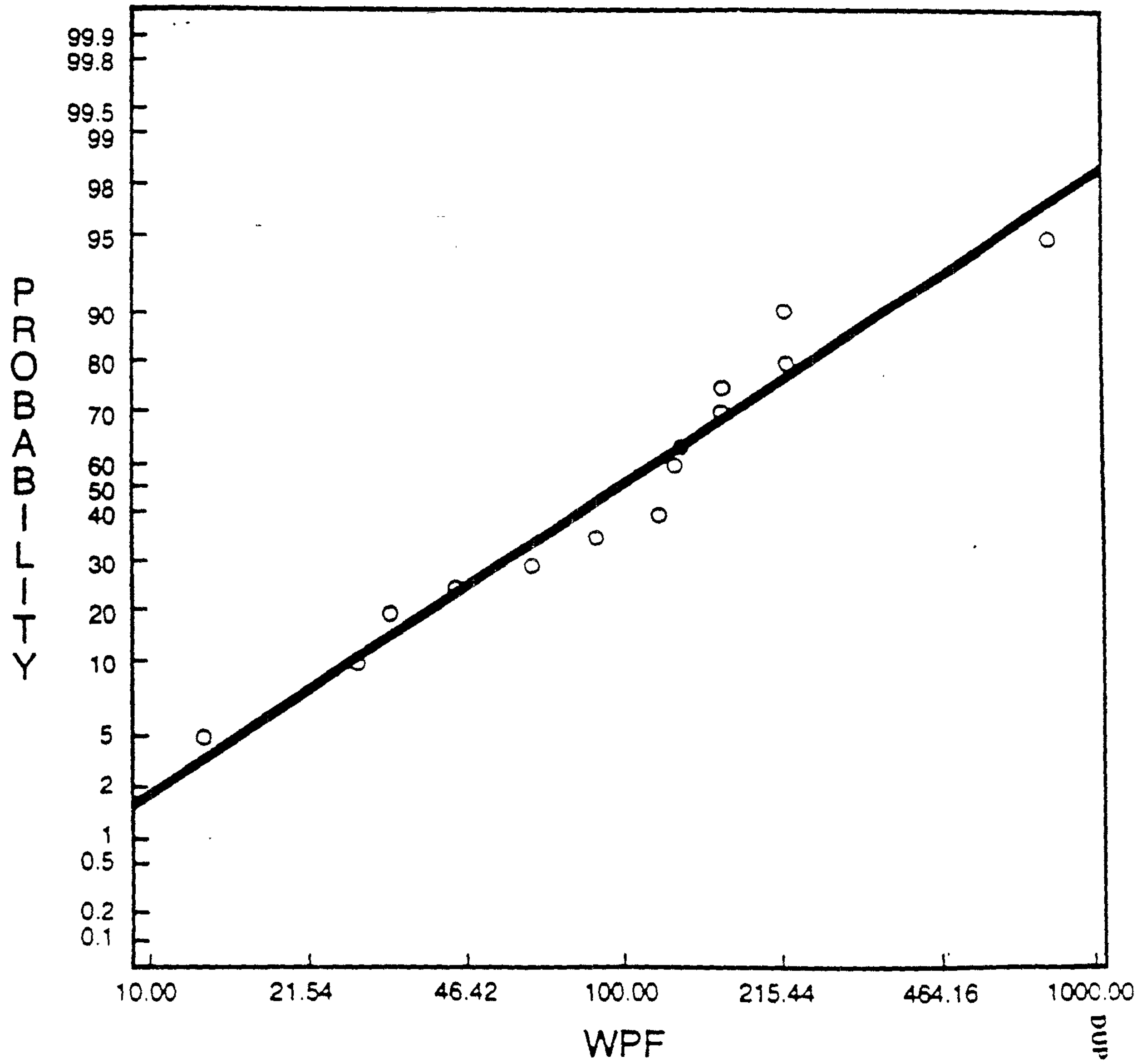
Best Estimate of 5th Percentile: 12

Data: 15, 24, 45, 46, 47, 74, 88, 140, 190, 370, 480, 1000, 1100, 1100, 1800, 4100, 4200

Figure 7 – Workplace Protection Factors for Survivair 2000 and MSA Comfo® Halfmask Respirators with High Efficiency Filters

Cumulative Distribution: (Lognormal)



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Geometric Mean: 94

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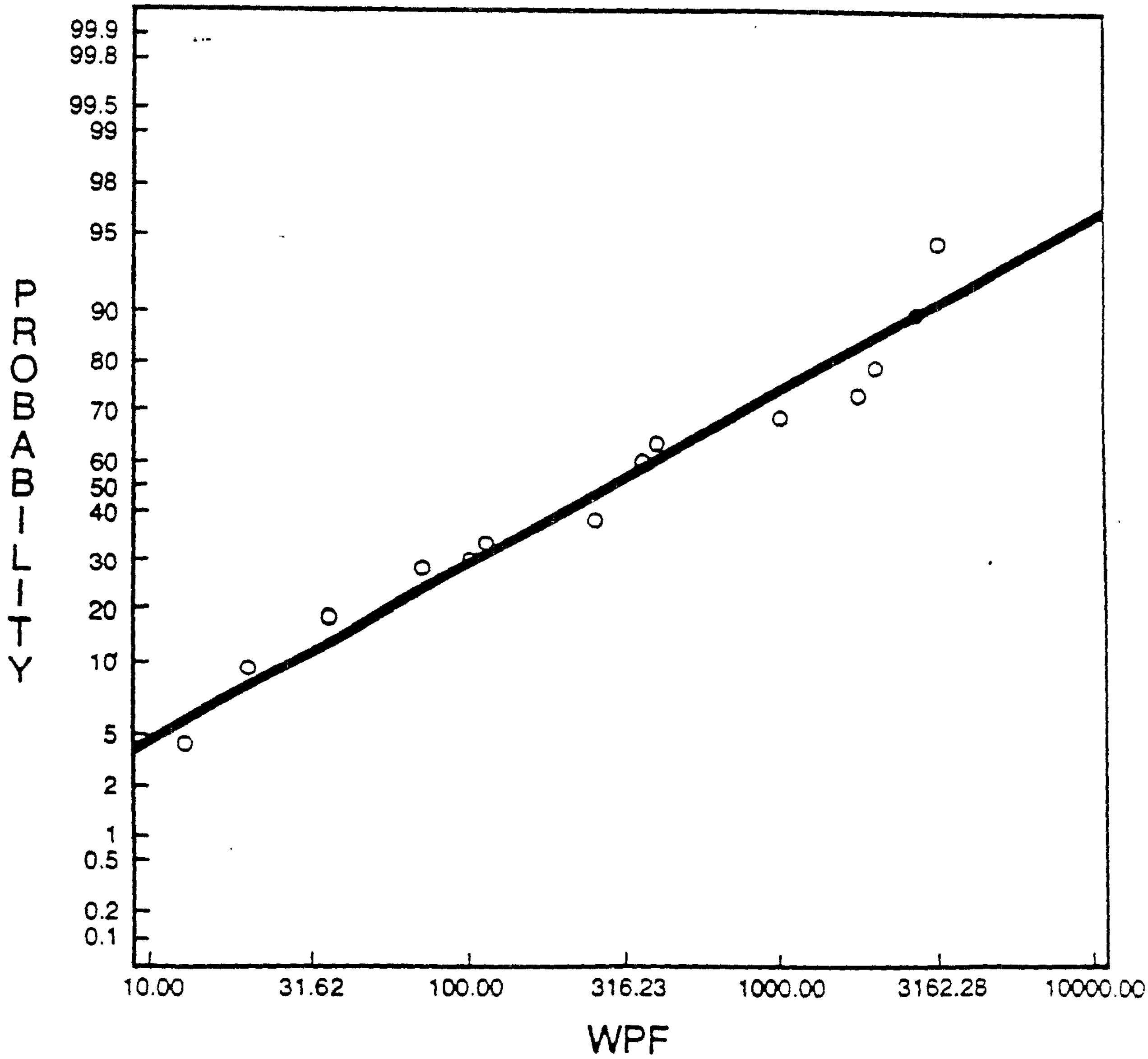
Geometric Standard Deviation: 3.0

Best Estimate of 5th Percentile: 16

Data: 12, 28, 32, 42, 65, 85, 110, 120, 140, 160, 160, 220, 220, 780, 7900*

Figure 8 – Workplace Protection Factors for North 7700 Halfmask Respirators with High Efficiency Filters

Cumulative Distribution: (Lognormal)



Geometric Mean: 250

Geometric Standard Deviation: 6.9

Best Estimate of 5th Percentile: 11

Data: 12, 20, 36, 60, 74, 110, 260, 350, 400, 1000, 1900, 2000, 2400, 3100

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INCORPORATED
WILMINGTON, DELAWARE

EMPLOYEE RELATIONS DEPARTMENT

CC: Asbestos Issue Coord. Comm.
Members
B. W. Karrh, M.D.
J. G. Page, Jr.

October 10, 1983

C. F. REINHARDT, M.D.
CHAIRMAN, AEL COMMITTEE
CR&D
HASKELL LAB

AEL DETERMINATION FOR ASBESTOS

The Asbestos Issue Coordinating Committee met on 10/7/83 to discuss the question of whether an AEL Determination for Asbestos should be initiated at this time. All members of the Asbestos Issue Coordinating Committee in attendance were unanimous in referring the question to your Committee for consideration.

Establishing an AEL for Asbestos is certainly not an emergent issue at this time. However, expeditious consideration of this subject before your Committee would be highly appreciated and does reflect the desires of many of the Asbestos Issue Coordinating Committee members.

Asbestos material in our Company has generally been determined to be chrysotile or a mixture of amosite and chrysotile. We are not aware of crocidolite asbestos being used in our plants with the possible exception of specialized gasketing material. I would hope that this impression is correct and would anticipate that your Committee's data and deliberations could confirm this impression.

Speaking for the Asbestos Issue Coordinating Committee, I would appreciate your prompt action in bringing this issue before the AEL Committee.

MEDICAL DIVISION

Burford W. Culpepper

Burford W. Culpepper, M.D.
Chairman
Asbestos Issue Coordinating Committee

DUP 116034

BWC/mch

EXPOSURE LIMITS FOR AIRBORNE CONTAMINANTS	SAFETY ENGINEERING STANDARD	
	ISSUED APRIL 1961	S 2 T
	THIS PAGE REVISED MARCH 1981	
	STANDARD REAFFIRMED MARCH 1981	Page 1 of 9

This standard includes requirements of the Occupational Safety and Health Act of 1970 (OSHA) as published in the Federal Register. OSHA information is printed in red.

1. SCOPE

1.1 This standard presents information and data sources on exposure limits of air contaminants to provide criteria for safe Company work environments. Guidance on application of exposure limits is provided.

1.2 The OSHA information presented is a legal requirement in the United States. Local regulations in other countries must be followed.

1.2.1 State and local regulations in the United States are not covered, but must be followed if applicable.

2. SOURCES OF EXPOSURE LIMIT INFORMATION

2.1 OSHA. Permissible Exposure Limits (PELs) from OSHA regulations. Section 1910.1000, Tables Z1, Z2, and Z3 are presented as Tables 1, 2, and 3. These tables are minimum legal requirements in the United States for the substances listed. The OSHA tables were originally based on the 1968 ACGIH TLV tables (see 2.2). OSHA has made some changes to the tables, but has not made all of the changes made by ACGIH.

2.1.1 OSHA Regulated Materials

2.1.1.1 Rules applying to the manufacture, processing, packaging, handling, and storage of these materials are specified in OSHA regulations 1910.1001 through 1910.1046 as listed below.

1910.1001 Asbestos
1910.1002 Coal tar pitch volatiles
1910.1003 4-Nitrobiphenyl
1910.1004 alpha-Napthylamine
1910.1006 Methyl chloromethyl ether
1910.1007 3, 3-Dichlorobenzidine (and its salts)
1910.1008 bis-Chloromethyl ether
1910.1009 beta-Naphthylamine
1910.1010 Benzidine
1910.1011 4-Aminodiphenyl
1910.1012 Ethyleneimine (Ethylenimine)
1910.1013 beta-Propiolactone
1910.1014 2-Acetylaminofluorene
1910.1015 4-Dimethylaminoazobenzene
1910.1016 N-Nitrosodimethylamine
1910.1017 Vinyl chloride
1910.1018 Inorganic arsenic
1910.1025 Lead
1910.1028 Benzene
1910.1029 Coke oven emissions
1910.1043 Cotton dust
1910.1044 1, 2-Dibromo-3-chloropropane
1910.1045 Acrylonitrile
1910.1046 Exposure to cotton dust in cotton gins

2.1.1.2 CAUTION. Regulations are frequently subject to litigation. At the time of this revision the benzene and lead regulations and parts of the arsenic regulation were under court review. Consult the Legal Department for latest information.

2.1.1.3 These OSHA regulations specify exact and demanding methodology for sampling, employee notification, training, record keeping, and protective equipment.

2.2 American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH annually publishes a booklet containing Threshold Limits Values for many chemical substances and physical agents. Copies of the booklet can be obtained from the Chemical Hazards Information Section, ISD, Centre Road Bldg. The updated booklet is usually available in October. ACGIH TLVs should be used where a Du Pont AEL (see 2.3) has not been established and the TLV is either lower than the OSHA PEL or the material is not listed by OSHA.

2.2.1 TLVs are intended to be used only as guidelines toward the establishment of safe working environments.

2.2.2 Du Pont Use of STEL Values. Short-term Exposure Limit (STEL) values are listed as "tentative values" in the ACGIH "Booklet" and may not have been acted upon by the TLV subcommittee of the parent body. STELs should be used as guides. In most cases STELs were derived by multiplying the TLV by an arbitrarily chosen factor ranging from 1.25 to 3.0. STEL values are subject to change or withdrawal. Consultation with Haskell Laboratory is recommended before a significant expenditure is made to meet STEL values.

2.3 Du Pont Sources

2.3.1 Haskell Laboratory has established Acceptable Exposure Limits (AELs) for some chemicals. Information on AELs can be obtained from Haskell Laboratory. Where they have been established, the AELs should be used instead of the ACGIH TLVs. If the AEL is lower than the OSHA PEL the AEL should be used.

Portions printed in red are from OSHA 1910.1000 through 1910.1046

2.3.2 A list, "Industrial Chemicals Designated as Requiring Special Control in Du Pont," is published quarterly by Haskell Laboratory.

2.3.3 A "Carcinogen Synonym List" is published annually by the Corporate Chemicals Information Section, ISD.

3. APPLICATION OF PELS

3.1 Many situations where toxic substances are handled may require detailed review by specialized engineers, industrial hygienists, and toxicologists to obtain the optimum in design controls. When additional information is needed on the toxicity of other materials and the health hazard that may be associated with them, consultation should be made with the Haskell Laboratory for Toxicology and Industrial Medicine.

3.2 Safety precautions in DR176X shall be followed when handling radioactive materials.

4. EXPOSURE LIMITS FOR NONTRADITIONAL WORK SCHEDULES

4.1 Exposure limits apply to the traditional 8-hour workday, 40-hour workweek including such variations as rotating shifts which may involve up to seven consecutive 8-hour workdays. Human data used for setting exposure limits have, in many cases, come from such rotating shifts and at least 20 years of experience with them has shown no special adverse health effects. Exposure limits do not apply to nontraditional schedules such as 10- or 12-hour workdays or a workweek which routinely exceeds 40 hours.

4.2 Reduction Factor Calculations. When nontraditional work schedules are used regularly, an uncertainty exists concerning the effects of greater employee time exposure to chemical agents. Reduced exposure limits should consider the nature of the air contaminant and the increased exposure hours per day, and the decreased hours per day outside the contaminated environment.*

4.2.1 The reduction factor calculations presented in this standard will satisfy OSHA requirements; however, OSHA personnel will use a less restrictive calculation procedure (see reference in 5.1).

4.2.2 In the absence of other guidelines, a reduction factor f is recommended, calculated as follows (see 4.4 for exceptions):

$$f = \left(\frac{8}{h}\right)\left(\frac{24 - h}{16}\right) \qquad (1)$$

where

f = Reduction factor for the nontraditional work schedule

h = Hours worked per day

and the reduced exposure limit is

$$L_{NT} = f L_8 \qquad (2)$$

where

L_{NT} = Exposure limit for nontraditional work schedule

L_8 = Exposure limit for 8-hour workday, e.g., PEL from Table 1

4.2.3 For the case of a 7-day workweek, the reduction factor is based on exposure hours per week and exposure-free hours per week.

$$f = \left(\frac{40}{\Sigma h}\right)\left(\frac{168 - \Sigma h}{128}\right) \qquad (3)$$

4.2.4 For work schedules less than 7 to 8 hours per day or 35 hours per week, Equations (1) and (2) are not applicable.

4.2.5 For 24-hour continuous exposure, Equations (1) through (3) are not applicable. Refer to the 90-day continuous exposure limits of the National Academy of Sciences where applicable.**

4.3 CAUTION: The reduction factor calculation is a theoretical estimate with no guarantee that an adequate safety margin is provided. Consult Haskell Laboratory prior to making significant changes in the workplace.

4.4 Exceptions. No adjustment of the exposure limit is necessary for the following:

a. Those substances whose exposure limits are based on short-term effects or rapid elimination.

b. Substances such as lead and mercury which accumulate in the body very slowly. Here, the daily exposure is unimportant as long as the average weekly length of exposure remains at 40 hours.

c. Substances for which a limit is set on the "lowest feasible level" concept.

* Brief, R. S. and Scala, R. A., "Occupational Exposure Limits for Novel Work Schedules," Amer Ind Hygiene Assoc J, 467 (June 1975).

** "Atmospheric Contaminants in Spacecraft," Report of the Panel on Air Standards for Manned Space Flight, Space Science Board, National Academy of Sciences, Washington, DC, 86 pages (October 1969).

4.5 **Examples**

4.5.1 For carbon monoxide exposure during a 10-hour workday, 4 days per week where L_8 = 50 ppm, the L_{NT} is calculated using Equations (1) and (2):

$$f = \left(\frac{8}{10}\right)\left(\frac{24 - 10}{16}\right) = 0.7$$

$$L_{NT} = (0.7)\ (50) = 35\ \text{ppm}$$

4.5.2 For methanol exposure during a 12-hour workday, 5 days per week where L_8 = 200 ppm, the L_{NT} is calculated using Equations (1) and (2):

$$f = \left(\frac{8}{12}\right)\left(\frac{24 - 12}{16}\right) = 0.5$$

$$L_{NT} = (0.5)\ (200) = 100\ \text{ppm}$$

4.5.3 For methanol exposure during an 8-hour workday, 7 days per week where the L_8 = 200 ppm, the L_{NT} is calculated using Equations (2) and (3):

$$f = \left(\frac{40}{8 \times 7}\right)\left(\frac{168 - (8 \times 7)}{128}\right) = 0.625$$

$$L_{NT} = (0.625)\ (200) = 125\ \text{ppm}$$

This calculation does not apply to normal rotating shift schedules. See 4.1.

5. OTHER REFERENCES

5.1 Employment Safety and Health Guide No. 419 May 24, 1979 "OSHA Industrial Hygiene Field Operations Manual."

This manual does not have the authority of a regulation. Its purpose is to guide OSHA industrial hygiene compliance officers. Du Pont disagrees with many important statements of fact and interpretations given in the manual. The manual should not be used as guidance in Du Pont but may be useful for determining how an OSHA compliance officer is likely to handle a situation.

Source: Commerce Clearing House, Inc. 4025 W. Peterson Avenue, Chicago, Il 60646

5.2 "NIOSH/OSHA POCKET GUIDE TO CHEMICAL HAZARDS"

DHEW (NIOSH) Publication No. 78-210.

This is a useful concise compilation of information on chemicals, including chemical and physical properties, permissible exposure limits, respirator selection, health hazards, etc. The book contains a number of errors. In addition, it defines "immediately dangerous to life and health" as the "maximum level from which one could escape within 30 minutes without any escape impairing symptoms or any irreversible health effects." The conventional definition (see ANSI Z88.2, 1980) is "any atmosphere that poses an immediate hazard to life or produces immediate irreversible effects on health that will be debilitating." In keeping with its definition the Guide's IDLH values are lower than those which correspond to the ANSI definition. This book may be useful but any information should be checked using a primary source.

Footnotes for Table 1:

a Parts of vapor or gas per million parts of contaminated air by volume at 25°C and 760 mm Hg pressure
b Approximate milligrams of particulate per cubic meter of air
No footnote c is used to avoid confusion with ceiling value notations
d An atmospheric concentration of not more than [illegible] ppm, or personal protection may be necessary to avoid headache

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DU 062520

EXPOSURE LIMITS FOR AIRBORNE CONTAMINANTS

TABLE 1 – OSHA TABLE Z – 1

Materials with Names Preceded by "C" – Ceiling Values. If the name of the material in Table 1 is preceded by a "C," the value in the table is a ceiling value. An employee's exposure to a material shall at no time exceed the ceiling value.

Other Materials – 8-Hour Time-Weighted Average. If the name of the material in Table 1 is not preceded by a "C," the value in the table is an 8-hour time-weighted average. An employee's exposure to a material in any 8-hour work shift of a 40-hour week shall not exceed the 8-hour time-weighted average.

Substance	ppm [a]	mg/M^3 [b]
Acetaldehyde	200	360
Acetic acid	10	25
Acetic anhydride	5	20
Acetone	1,000	2,400
Acetonitrile	40	70
Acetylene dichloride, see 1,2-Dichloroethylene		
Acetylene tetrabromide	1	14
Acrolein	0.1	0.25
Acrylamide – Skin		0.3
Aldrin – Skin		0.25
Allyl alcohol – Skin	2	5
Allyl chloride	1	3
C Allylglycidyl ether (AGE)	10	45
Allyl propyl disulfide	2	12
2-Aminoethanol, see Ethanolamine		
2-Aminopyridine	0.5	2
Ammonia	50	35
Ammonium sulfamate (Ammate)		15
n-Amyl acetate	100	525
sec-Amyl acetate	125	650
Aniline – Skin	5	19
Anisidine (o, p-isomers) – Skin		0.5
Antimony and compounds (as Sb)		0.5
ANTU (alpha naphthyl thiourea)		0.3
Arsine	0.05	0.2
Azinphos-methyl – Skin		0.2
Barium (soluble compounds)		0.5
p-Benzoquinone, see Quinone		
Benzoyl peroxide		5
Benzyl chloride	1	5
Biphenyl, see Diphenyl		
Boron oxide		15
C Boron trifluoride	1	3
Bromine	0.1	0.7
Bromoform – Skin	0.5	5
Butadiene (1,3-butadiene)	1,000	2,200
Butanethiol, see Butyl mercaptan		
2-Butanone	200	590
2-Butoxy ethanol (Butyl Cellosolve) – Skin	50	240
Butyl acetate (n-butyl acetate)	150	710
sec-Butyl acetate	200	950
tert-Butyl acetate	200	950
Butyl alcohol	100	300
sec-Butyl alcohol	150	450
tert-Butyl alcohol	100	300
C Butylamine – Skin	5	15
C tert-Butyl chromate (as CrO_3) – Skin		0.1
n-Butyl glycidyl ether (BGE)	50	270
Butyl mercaptan	10	35
p-tert-Butyltoluene	10	60

Substance	ppm [a]	mg/M^3 [b]
Calcium oxide		5
Camphor		2
Carbaryl (Sevin)		5
Carbon black		3.5
Carbon dioxide	5,000	9,000
Carbon monoxide	50	55
Chlordane – Skin		0.5
Chlorinated camphene – Skin		0.5
Chlorinated diphenyl oxide		0.5
C Chlorine	1	3
Chlorine dioxide	0.1	0.3
C Chlorine trifluoride	0.1	0.4
C Chloroacetaldehyde	1	3
α-Chloroacetophenone (phenacylchloride)	0.05	0.3
Chlorobenzene (monochlorobenzene)	75	350
o-Chlorobenzylidene malononitrile (OCBM)	0.05	0.4
Chlorobromomethane	200	1,050
2-Chloro-1,3-butadiene, see Chloroprene		
Chlorodiphenyl (42 percent Chlorine) – Skin		1
Chlorodiphenyl (54 percent Chlorine) – Skin		0.5
1-Chloro, 2, 3-epoxypropane, see Epichlorhydrin		
2-Chloroethanol, see Ethylene chlorohydrin		
Chloroethylene, see Vinyl chloride		
C Chloroform (trichloromethane)	50	240
1-Chloro-1-nitropropane	20	100
Chloropicrin	0.1	0.7
Chloroprene (2-chloro-1,3-butadiene) – Skin	25	90
Chromium, sol. chromic, chromous salts as Cr		0.5
Metal and insol salts		1
Coal tar pitch volatiles (benzene soluble fraction) anthracene, BaP, phenanthrene, acridine, chrysene, pyrene		0.2
Cobalt, metal fume and dust		0.1
Copper fume		0.1
Dusts and Mists		1
Cotton dust (raw)		1
Crag herbicide		15
Cresol (all isomers) – Skin	5	22
Crotonaldehyde	2	6
Cumene – Skin	50	245
Cyanide (as CN) – Skin		5
Cyclohexane	300	1,050
Cyclohexanol	50	200
Cyclohexanone	50	200

See page 3 for footnotes

Portions ... are from OSHA 1910.1000

(Cont'd on Page 5)

TABLE 1 – OSHA TABLE Z-1 (CONT'D)

Substance	ppm[a]	mg M³[b]
Cyclohexene	300	1,015
Cyclopentadiene	75	200
2, 4-D		10
DDT – Skin		1
DDVP – Skin		1
Decaborane – Skin	0.05	0.3
Demeton – Skin		0.1
Diacetone alcohol (4-hydroxy-4-methyl-2-pentanone)	50	240
1,2-diaminoethane, see Ethylenediamine		
Diazomethane	0 2	0.4
Diborane	0.1	0.1
Dibutyl Phosphate	1	5
Dibutylphthalate		5
C o-Dichlorobenzene	50	300
p-Dichlorobenzene	75	450
Dichlorodifluoromethane	1,000	4,950
1,3-Dichloro-5,5-dimethyl hydantoin		0 2
1,1-Dichloroethane	100	400
1 2-Dichloroethylene	200	790
C Dichloroethyl ether – Skin	15	90
Dichloromethane, see Methylenechloride		
Dichloromonofluoromethane	1,000	4,200
C 1,1-Dichloro-1-nitroethane	10	60
1,2-Dichloropropane, see Propylenedichloride		
Tetrafluoromethane	1,000	7,000
Dieldrin – Skin		0.25
Diethylamine	25	75
Diethylamino ethanol – Skin	10	50
Diethylether, see Ethyl ether		
Difluorodibromomethane	100	860
C Diglycidyl ether (DGE)	0.5	2.8
Dihydroxybenzene, see Hydroquinone		
Diisobutyl ketone	50	290
Diisopropylamine – Skin	5	20
Dimethoxymethane, see Methylal		
Dimethyl acetamide – Skin	10	35
Dimethylamine	10	18
Dimethylaminobenzene, see Xylidene		
Dimethylaniline (N-dimethylaniline) – Skin	5	25
Dimethylbenzene, see Xylene		
Dimethyl 1 2-dibromo-2 2-dichloroethyl phosphate Dibrom		3
Dimethylformamide – Skin	10	30
2 6-Dimethylheptanone, see Diisobutyl ketone		
1,1-Dimethylhydrazine – Skin	0 5	1
Dimethylphthalate		5
Dimethylsulfate – Skin	1	5
Dinitrobenzene (all isomers) – Skin		1
Dinitro-o-cresol – Skin		0 2
Dinitrotoluene – Skin		1 5

Substance	ppm[a]	mg M³[b]
Dioxane (Diethylene dioxide) – Skin	100	360
Diphenyl	0 2	1
Diphenylmethane diisocyanate (see Methylene bisphenyl isocyanate (MDI))		
Dipropylene glycol methyl ether – Skin	100	600
Di-sec, octyl phthalate (Di-2-ethylhexylphthalate)		5
Endrin – Skin		0 1
Epichlorhydrin – Skin	5	19
EPN – Skin		0 5
1,2-Epoxypropane, see Propyleneoxide		
2,3-Epoxy-1-propanol, see Glycidol		
Ethanethiol, see Ethylmercaptan		
Ethanolamine	3	6
2-Ethoxyethanol – Skin	200	740
2-Ethoxyethylacetate (Cellosolve acetate) – Skin	100	540
Ethyl acetate	400	1 400
Ethyl acrylate – Skin	25	100
Ethyl alcohol (ethanol)	1,000	1,900
Ethylamine	10	18
Ethyl sec-amyl ketone (5-methyl-3-heptanone)	25	130
Ethyl benzene	100	435
Ethyl bromide	200	890
Ethyl butyl ketone (3-Heptanone)	50	230
Ethyl chloride	1,000	2,600
Ethyl ether	400	1,200
Ethyl formate	100	300
C Ethyl mercaptan	10	25
Ethyl silicate	100	850
Ethylene chlorohydrin – Skin	5	16
Ethylenediamine	10	25
C Ethylene glycol dinitrate and/or Nitroglycerin – Skin	[d]0.2	1
Ethylene glycol monomethyl ether acetate, see Methyl cellosolve acetate		
Ethylene imine – Skin	0 5	1
Ethylene oxide	50	90
Ethylidine chloride, see 1,1-Dichloroethane		
N-Ethylmorpholine – Skin	20	94
Ferbam		15
Ferrovanadium dust		1
Fluoride (as F)		2 5
Fluorine	0 1	0 2
Fluorotrichloromethane	1,000	5 600
Formic acid	5	9
Furfural – Skin	5	20
Furfuryl alcohol	50	200
Glycidol (2,3-Epoxy-1-propanol)	50	150
Glycol monoethyl ether, see 2-Ethoxyethanol		
Guthion, see Azinphosmethyl		

(Cont'd on Page 6)

See page 3 for footnotes
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TABLE 1 – OSHA TABLE Z-1 (CONT'D)

Substance	ppm a)	mg/M³ b)
Hafnium		0.5
Heptachlor – Skin		0.5
Heptane (n-heptane)	500	2,000
Hexachloroethane – Skin	1	10
Hexachloronaphthalene – Skin		0.2
Hexane (n-hexane)	500	1,800
2-Hexanone	100	410
Hexone (Methyl isobutyl ketone)	100	410
sec-Hexyl acetate	50	300
Hydrazine – Skin	1	1.3
Hydrogen bromide	3	10
C Hydrogen chloride	5	7
Hydrogen cyanide – Skin	10	11
Hydrogen peroxide (90%)	1	1.4
Hydrogen selenide	0.05	0.2
Hydroquinone		2
C Iodine	0.1	1
Iron oxide fume		10
Isoamyl acetate	100	525
Isoamyl alcohol	100	360
Isobutyl acetate	150	700
Isobutyl alcohol	100	300
Isophorone	25	140
Isopropyl acetate	250	950
Isopropyl alcohol	400	980
Isopropylamine	5	12
Isopropylether	500	2,100
Isopropyl glycidyl ether (IGE)	50	240
Ketene	0.5	0.9
Lindane – Skin		0.5
Lithium hydride		0.025
L.P.G. (liquified petroleum gas)	1,000	1,800
Magnesium oxide fume		15
Malathion – Skin		15
Maleic anhydride	0.25	1
C Manganese		5
Mesityl oxide	25	100
Methanethiol, see Methyl mercaptan		
Methoxychlor		15
2-Methoxyethanol, see Methyl cellosolve		
Methyl acetate	200	610
Methyl acetylene (propyne)	1,000	1,650
Methyl acetylene-propadiene mixture (MAPP)	1,000	1,800
Methyl acrylate – Skin	10	35
Methylal (dimethoxymethane)	1,000	3,100
Methyl alcohol (methanol)	200	260
Methylamine	10	12
Methyl amyl alcohol, see Methyl isobutyl carbinol		
Methyl (n-amyl) ketone (2-Heptanone)	100	465
C Methyl bromide – Skin	20	80
Methyl butyl ketone, see 2-Hexanone		
Methyl cellosolve – Skin	25	80
Methyl cellosolve acetate – Skin	25	120
Methyl chloroform	350	1,900
Methylcyclohexane	500	2,000
Methylcyclohexanol	100	470

Substance	ppm a)	mg/M³ b)
o-Methylcyclohexanone – Skin	100	460
Methyl ethyl ketone (MEK), see 2-Butanone		
Methyl formate	100	250
Methyl iodide – Skin	5	28
Methyl isobutyl carbinol – Skin	25	100
Methyl isobutyl ketone, see Hexone		
Methyl isocyanate – Skin	0.02	0.05
C Methyl mercaptan	10	20
Methyl methacrylate	100	410
Methyl propyl ketone, see 2-Pentanone		
C α Methyl styrene	100	480
C Methylene Bisphenyl isocyanate (MDI)	0.02	0.2
Molybdenum:		
Soluble compounds		5
Insoluble compounds		15
Monomethyl aniline – Skin	2	9
C Monomethyl hydrazine – Skin	0.2	0.35
Morpholine – Skin	20	70
Naphtha (coaltar)	100	400
Naphthalene	10	50
Nickel carbonyl	0.001	0.007
Nickel, metal and soluble compounds, as Ni		1
Nicotine – Skin		0.5
Nitric acid	2	5
Nitric oxide	25	30
p-Nitroaniline – Skin	1	6
Nitrobenzene – Skin	1	5
p-Nitrochlorobenzene – Skin		1
Nitroethane	100	310
C Nitrogen dioxide	5	9
Nitrogen trifluoride	10	29
C Nitroglycerin – Skin	0.2	2
Nitromethane	100	250
1-Nitropropane	25	90
2-Nitropropane	25	90
Nitrotoluene – Skin	5	30
Nitrotrichloromethane, see Chloropicrin		
Octachloronaphthalene – Skin		0.1
Octane	500	2,350
Oil mist, mineral		5
Organic Arsenic compounds (as As)		0.5
Osmium tetroxide		0.002
Oxalic acid		1
Oxygen difluoride	0.05	0.1
Ozone	0.1	0.2
Paraquat – Skin		0.5
Parathion – Skin		0.1
Pentaborane	0.005	0.01
Pentachloronaphthalene – Skin		0.5
Pentachlorophenol – Skin		0.5
Pentane	1,000	2,950
2-Pentanone	200	700
Perchloromethyl mercaptan	0.1	0.8
Perchloryl fluoride	3	13.5
Petroleum distillates (naphtha)	500	2,000
Phenol – Skin	5	19

See page 3 for footnotes

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TABLE 1 - OSHA TABLE Z-1 (CONT'D FROM PAGE 6)

Substance	ppm[a)]	mg/M³[b)]
p-Phenylene diamine - Skin		0.1
Phenyl ether (vapor)	1	7
Phenyl ether-biphenyl mixture (vapor)	1	7
Phenylethylene, see Styrene		
Phenyl glycidyl ether (PGE)	10	60
Phenylhydrazine - Skin	5	22
Phosdrin (Mevinphos) - Skin		0.1
Phosgene (carbonyl chloride)	0.1	0.4
Phosphine	0.3	0.4
Phosphoric acid		1
Phosphorus (yellow)		0.1
Phosphorus pentachloride		1
Phosphorus pentasulfide		1
Phosphorus trichloride	0.5	3
Phthalic anhydride	2	12
Picric acid - Skin		0.1
Pival (2-Pivalyl-1,3-indandione)		0.1
Platinum (Soluble Salts) as Pt		0.002
Propane	1,000	1,800
n-Propyl acetate	200	840
Propyl alcohol	200	500
n-Propyl nitrate	25	110
Propylene dichloride	75	350
Propylene imine - Skin	2	5
Propylene oxide	100	240
Propyne, see Methylacetylene		
Pyrethrum		5
Pyridine	5	15
Quinone	0.1	0.4
Rhodium, Metal fume and dusts, as Rh		0.1
Soluble salts		0.001
Ronnel		15
Rotenone (commercial)		5
Selenium compounds (as Se)		0.2
Selenium hexafluoride	0.05	0.4
Silver, metal and soluble compounds		0.01
Sodium fluoroacetate (1080) - Skin		0.05
Sodium hydroxide		2
Stibine	0.1	0.5
Stoddard solvent	500	2,900
Strychnine		0.15
Sulfur dioxide	5	13
Sulfur hexafluoride	1,000	6,000
Sulfuric acid		1
Sulfur monochloride	1	6
Sulfur pentafluoride	0.025	0.25
Sulfuryl fluoride	5	20
Systox, see Demeton		
2,4,5T		10
Tantalum		5
TEDP - Skin		0.2
Tellurium		0.1
Tellurium hexafluoride	0.02	0.2
TEPP - Skin		0.05
C Terphenyls	1	9
1,1,1,2-Tetrachloro-2,2-difluoroethane	500	4,170

Substance	ppm[a)]	mg/M³[b)]
1,1,2,2-Tetrachloro-1,2-difluoroethane	500	4,170
1,1,2,2-Tetrachloroethane - Skin	5	35
Tetrachloromethane, see Carbon tetrachloride		
Tetrachloronaphthalene - Skin		2
Tetraethyl lead (as Pb) - Skin		0.075
Tetrahydrofuran	200	590
Tetramethyl lead (as Pb) - Skin		0.075
Tetramethyl succinonitrile - Skin	0.5	3
Tetranitromethane	1	8
Tetryl (2,4,6-trinitrophenylmethylnitramine) - Skin		1.5
Thallium (soluble compounds) - Skin as Tl		0.1
Thiram		5
Tin (inorganic compounds, except oxides)		2
Tin (organic compounds)		0.1
C Toluene-2,4-diisocyanate	0.02	0.14
o-Toluidine - Skin	5	22
Toxaphene, see Chlorinated camphene		
Tributyl phosphate		5
1,1,1-Trichloroethane see Methyl chloroform		
1,1,2-Trichloroethane - Skin	10	45
Titaniumdioxide		15
Trichloromethane, see Chloroform		
Trichloronaphthalene - Skin		5
1,2,3-Trichloropropane	50	300
1,1,2-Trichloro 1,2,2-trifluoroethane	1,000	7,600
Triethylamine	25	100
Trifluoromonobromomethane	1,000	6,100
2,4,6-Trinitrophenol, see Picric acid		
2,4,6-Trinitrophenylmethylnitramine, see Tetryl		
Trinitrotoluene - Skin		1.5
Triorthocresyl phosphate		0.1
Triphenyl phosphate		3
Turpentine	100	560
Uranium (soluble compounds)		0.05
Uranium (insoluble compounds)		0.25
C Vanadium:		
V_2O_5 dust		0.5
V_2O_5 fume		0.1
Vinyl benzene, see Styrene		
Vinylcyanide, see Acrylonitrile		
Vinyl toluene	100	480
Warfarin		0.1
Xylene (xylol)	100	435
Xylidine - Skin	5	25
Yttrium		1
Zinc chloride fume		1
Zinc oxide fume		5
Zirconium compounds (as Zr)		5

See page 3 for footnotes
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TABLE 2 – OSHA TABLE Z-2

Material	8-Hour Time Weighted Average	Acceptable Ceiling Concentration*	Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift.	
			Concentration	Maximum Duration
Benzene (Z37.4 – 1969)**	10 ppm	25 ppm	50 ppm	10 minutes
Beryllium and beryllium compounds (Z37.29 – 1970)	2 $\mu g/M^3$	5 $\mu g/M^3$	25 $\mu g/M^3$	30 minutes
Cadmium dust (Z37.5 – 1970)	0.2 mg/M^3	0.6 mg/M^3		
Cadmium fume (Z37.5 – 1970)	0.1 mg/M^3	0.3 mg/M^3		
Carbon disulfide (Z37.3 – 1968)	20 ppm	30 ppm	100 ppm	30 minutes
Carbon tetrachloride (Z37.17 – 1967)	10 ppm	25 ppm	200 ppm	5 minutes in any 4 hours.
Chromic acid and chromates (Z37.7 – 1971)		1 $mg/10M^3$		
Ethylene dibromide (Z37.31 – 1970)	20 ppm	30 ppm	80 ppm	5 minutes.
Ethylene dichloride (Z37.21 – 1969)	50 ppm	100 ppm	200 ppm	5 minutes in any 3 hours.
Fluoride as dust (Z37.28 – 1969)	2.5 mg/M^3			
Formaldehyde (Z37.16 – 1967)	3 ppm	5 ppm	10 ppm	30 minutes.
Hydrogen fluoride (Z37.28 – 1969)	3 ppm			
Hydrogen sulfide (Z37.2 – 1966)		20 ppm	50 ppm	10 minutes once only if no other measurable exposure occurs
Mercury (Z37.8 – 1971)		1 $mg/10M^3$		
Methyl Chloride (Z37.18 – 1969)	100 ppm	200 ppm	300 ppm	5 minutes in any 3 hours.
Methylene Chloride (Z37.23 – 1969)	500 ppm	1,000 ppm	2,000 ppm	5 minutes in any 2 hours.
Organo (alkyl) mercury (Z37.30 – 1969)	0.01 mg/M^3	0.04 mg/M^3		
Styrene (Z37.15 – 1969)	100 ppm	200 ppm	600 ppm	5 minutes in any 3 hours.
Tetrachloroethylene (Z37.22 – 1967)	100 ppm	200 ppm	300 ppm	5 minutes in any 3 hours.
Toluene (Z37.12 – 1967)	200 ppm	300 ppm	500 ppm	10 minutes.
Trichloroethylene (Z37.19 – 1967)	100 ppm	200 ppm	300 ppm	5 minutes in any 2 hours.

* The "acceptable ceiling concentration" shall not be exceeded during an 8-hour shift except for the time period indicated and the concentration allowed under "acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift."

** Occupational exposures to benzene are subject to the requirements of Section 1910.1028 except as specifically exempted by Section 1910.1028(a)(2). Exposures exempted by Section 1910.1028(a)(2) are covered by this Section 1910.1000.

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TABLE 3 – OSHA TABLE Z-3

Mineral Dusts		
Substance	8-Hour Time-Weighted Averages	
	Mppcf*	Mg/M³
Silica:		
Crystalline:		
Quartz (respirable)	$\frac{250^{**}}{\%SiO_2 + 5}$	$\frac{10\ mg/M^3\dagger}{\%SiO_2 + 2}$
Quartz (total dust)		$\frac{30\ mg/M^3}{\%SiO_2 + 2}$
Cristobalite: Use ½ the value calculated from the count or mass formulae for quartz.		
Tridymite: Use ½ the value calculated from the formulae for quartz.		
Amorphous, including natural diatomaceous earth	20	$\frac{80\ mg/M^3}{\%SiO_2}$
Silicates (less than 1% crystalline silica):		
Mica	20	
Soapstone	20	
Talc (non-asbestos – form)	20††	
Talc (fibrose). Use asbestos limit		
Tremolite (see talc, fibrous)		
Portland cement	50	
Graphite (natural)	15	
Coal dust (respirable fraction less than 5% SiO_2)		2.4 mg/M^3 or
For more than 5% SiO_2		$\frac{10\ mg/M^3}{\%SiO_2 + 2}$
Inert or Nuisance Dust:		
Respirable fraction	15	5 mg/M^3
Total dust	50	15 mg/M^3

Note: Conversion factors mppcf × 35.3 = million particles per cubic meter = particles per c.c.

* Millions of particles per cubic foot of air, based on impinger samples counted by light-field techniques

** The percentage of crystalline silica in the formula is the amount determined from air-borne samples, except in those instances in which other methods have been shown to be applicable

† Both concentration and percent quartz for the application of this limit are to be determined from the fraction passing a size-selector with the following characteristics

†† Containing < 1% quartz if > 1% quartz, use quartz limit

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