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The Quality of Respirator Programs: An Analysis From OSHA Compliance Data

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The quality of respirator programs in typical workplaces was investigated by analyzing the history of compliance with OSHA Standard 29 CFR 1910.134 (respiratory protection). Analysis was focused on the approximately 47 000 health inspections conducted in the manufacturing industries [Standard Industrial Classification (SIC) Codes 2000-3999] in the period of October 1, 1976 to September 30, 1982. During this period, approximately 27% of inspections in which respirator programs were reviewed resulted in a citation for a specific program deficiency. Of inspected worksites in which respirators were in use to provide protection from concentrations of air contaminants in excess of OSHA Permissible Exposure Limits, 56% had deficiencies in at least one program area. Since the violations were of the type that have been shown to lower the level of protection provided by respirators, many workers may have been exposed to inhalation hazards as the result of ineffective respirator programs.

Introduction

Over two million American workers routinely depend on personal respiratory protection (respirators) to prevent the inhalation of toxic air contaminants.[1] Many others rely on respirators during short term or emergency operations. To ensure quality control in the selection, maintenance and use of respirators, it is universally accepted that the effectiveness of such protection depends upon the institution at each workplace of a "respirator program."

Elements of such a program include: selection of respirator according to hazard, fit testing of employees, routine cleaning and inspection of respirators, and medical screening to determine who may wear a respirator. A deficiency in any element may compromise program effectiveness and allow workers to be exposed to excessive concentrations of airborne contaminants.

Respiratory protective devices have been evaluated extensively in laboratory tests, and to a lesser extent in field studies. However, the protection afforded to workers may depend as much or more on the quality of the respirator program as on the device itself.

To evaluate the quality of respirator programs in typical workplaces we analyzed the history of compliance with

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TABLE I
Comparison of the Distribution of Industry Types in U.S. Manufacturing Workplaces and in Manufacturing Workplaces Inspected by OSHA Health Compliance Officers

SIC Code	Industry Type	% U.S. Manufacturing Workplaces	% U.S. Employees in in Manufacturing	% OSHA Health Inspections in Manufacturing
2000-2999	Food Products	7.2	8.8	5.2
2100-2199	Tobacco Products	0.1	0.4	0.0
2200-2299	Textile Mills	1.9	4.0	1.9
2300-2399	Textile Products	7.0	6.3	1.2
2400-2499	Wood Products	10.0	3.2	4.2
2500-2599	Furniture	2.8	2.3	2.3
2600-2699	Paper Products	1.9	3.5	3.5
2700-2799	Printing/Publishing	15.0	6.8	3.4
2800-2899	Chemical Products	3.5	5.8	10.1
2900-2999	Petroleum Refining	0.6	1.1	1.3
3000-3099	Rubber and Plastics	3.6	3.7	6.2
3100-3199	Leather Products	0.9	1.2	0.9
3200-3299	Glass and Concrete	4.6	3.1	4.9
3300-3399	Primary Metals	2.1	4.9	8.1
3400-3499	Fabricated Metals	10.0	7.6	14.1
3500-3599	Machinery	14.8	11.9	10.2
3600-3699	Electrical Equip.	4.7	10.8	9.1
3700-3799	Transport. Equip.	3.0	9.2	7.5
3800-3899	Instruments	2.4	3.8	2.4
3900-3999	Misc. Manufacturing	4.1	2.0	2.5

TABLE II
Establishment Size in U.S. Manufacturing Workplaces and in Manufacturing Workplaces Inspected by OSHA Health Compliance Officers

Workplace Size (Employees)	% U.S. Manufacturing Workplaces of Specified Size	% OSHA Health Inspections in Manufacturing Workplaces of Specified Size	% Manufacturing Employees in Workplaces of Specified Size	% Manufacturing Employees in OSHA Inspected Workplaces of Specified Size
0-3	27.0	0.4	0.7	0.0
4-9	22.2	3.3	2.4	0.1
10-19	16.3	13.5	4.0	0.6
20-49	15.9	24.8	8.8	2.3
50-99	7.9	16.8	9.8	3.8
100-249	6.4	19.4	17.4	9.9
250-499	2.4	10.3	14.7	11.5
500-999	0.9	5.8	13.0	12.8
1000 or over	0.7	5.6	29.2	58.7

OSHA standards concerning the use of respirators. In this paper we present an analysis of the frequency and distribution of these violations and discuss their implications for the effectiveness of respiratory protection programs.

The OSHA Compliance Data Base

Regardless of the initial purpose of an OSHA inspection, which may be general surveillance, response to a complaint, follow-up to a previous inspection or investigation of an accident, OSHA inspectors are instructed to report any violations of OSHA regulations that they observe. The results of each inspection are entered by OSHA in a computerized data system. The data include identifiers of the worksite and the inspector; the type of inspection; the violations of OSHA standards that are cited; and the fines which are levied. The distribution of general surveillance inspections is not random but rather reflects decisions of Area Directors based on local or national policy. Some of these policies have been indicated by OSHA as part of its "targeting strategy" to inspect workplaces in the most hazardous industries. Targeting is directed at general industrial categories rather than specific workplaces.

Most of our analysis is confined to health inspections conducted in the manufacturing industries during the period October 1, 1976 to September 30, 1982 (Fiscal Years 1977 through 1978). Manufacturing industries were defined as those industries classified by Standard Industrial Classification (SIC) Codes 2000 through 3999.[2] This subgroup of inspections was chosen because: 1) respirators are widely used in these industries, 2) health inspections more frequently investigate respirator programs, and 3) health compliance officers receive more specialized training than do safety compliance officers with regard to personal respiratory protection and the evaluation of respirator programs.

In terms of size and type of industry, the inspected workplaces in this subgroup can be compared to data recorded by the Bureau of Labor Statistics for U.S. Industry as a whole.[3,4] This comparison is shown in Tables I and II. Besides a somewhat higher inspection rate in the chemical and metal industries and a somewhat lower inspection rate in the textile and printing/publishing industries, the OSHA manufacturing health inspections cover a representative range of U.S. manufacturing industries. With respect to workplace size (Table II), the OSHA inspections clearly emphasize larger workplaces.

The distribution of inspections according to type changed substantially over the six year period as shown in Table III. To investigate the possibility of differences in violations cited in complaint *vs* general inspections, selected statistics were computed for each type of inspection separately.

The Relationship Between Citations and Program Deficiencies

We have used the issuance of a citation for a violation of OSHA's standard on personal respiratory protection (29

TABLE III
Number (%) of Safety and Health OSHA Inspections by Inspection Type

FY Year	Total Inspections	Accident	Complaint	General	Follow-Up
1977	60 004	1781 (3.0)	19 415 (32.4)	24 855 (41.4)	13 953 (23.3)
1978	57 278	2086 (3.6)	21 518 (37.6)	20 239 (35.3)	13 435 (23.4)
1979	57 734	2281 (4.0)	20 041 (34.7)	23 735 (41.1)	11 677 (20.2)
1980	63 404	2300 (3.6)	16 044 (25.3)	33 390 (52.7)	11 670 (18.4)
1981	56 994	2221 (3.9)	13 353 (23.4)	36 018 (63.2)	5402 (9.5)
1982	52 818	1184 (2.2)	6766 (12.8)	42 601 (80.7)	1567 (3.0)
All Years	348 232	12 553 (3.6)	91 137 (27.9)	180 838 (51.9)	57 704 (16.6)

TABLE IV
Distribution of Violations of 29 CFR 1910.134

Section	Description	Percent
(a)(1)	Failure to use feasible engineering controls	1.6
(a)(2)	Failure to provide suitable respiratory protection	16.7
(a)(3)	Employee shall use provided respiratory protection	0.7
(b)(1)	Written procedures required	12.2
(b)(2)	Proper respirator selection	3.1
(b)(3)	Employee instruction	6.5
(b)(4)	Individual respirators to be provided	0.2
(b)(5)	Cleaning and disinfection of respirators	7.4
(b)(6)	Proper storage of respirators	7.9
(b)(7)	Inspection during cleaning	3.9
(b)(8)	Maintenance of environmental surveillance	2.1
(b)(9)	Inspection of program	2.7
(b)(10)	Medical screening	3.7
(b)(11)	Approved respirators	5.0
(c)	Selection according to ANSI specifications	0.8
(d)	Quality of supplied air	3.9
(e)(1)	Standard procedures for use of respirators	0.5
(e)(2)	Correct respirator for the job	0.5
(e)(3)	Procedures for use in dangerous atmospheres	3.6
(e)(4)	Random inspections of program	0.7
(e)(5)	Instruction and training in respirator use	5.6
(f)(1)	Maintenance of respirators	2.0
(f)(2)	Inspection of respirators	6.4
(f)(3)	Cleaning and disinfection of respirators	1.0
(f)(4)	Replacement of parts and repair of respirators	0.2
(f)(5)	Storage of respirators	1.1
		100.0

CFR 1910.134) as an indicator that a respirator program was deficient in the particular aspect covered by the section of the standard cited. Table IV outlines these sections.[5]

Respirator violations may also be issued under OSHA standards for specific substances (*e.g.* asbestos, arsenic, lead); however, the ratio of such citations to 1910.134 citations is small, as indicated by summary data on standards available from OSHA.[6] For example during Fiscal Year 1979, citations of 1910.134 accounted for approximately 97% of all violations related to respirators.

Since the OSHA standard was adopted in 1971, the American National Standards Institute (ANSI) has published a revised standard (Z88.2-1980) for personal respiratory protection, with guidelines stricter than the OSHA standard in several areas[7] (See Table V). The ANSI standard, for example, requires the assignment of a single individual as responsible for the respiratory protection program. Thus, workplaces which are not citable under the OSHA standard may nevertheless be deficient with regard to current standards of professional practice, such as ANSI Standard Z88.2-1980.

Factors Influencing the Issuance of Citations

The OSHA data base only indicates situations in which a citation was actually issued. Thus, it underestimates the occurrence of program deficiencies due to underreporting in several circumstances:

1) a deficiency occurred but was not observed by the inspector due to temporal or spatial limitations of the inspection;
2) other observed hazards took precedence and directed attention away from the documentation of the observed respirator violation;
3) an error of omission was made on the part of the inspector due to insufficient knowledge of personal respiratory protection;
4) a deficiency was observed but a decision was made on site, or at the area or regional level not to issue a citation;
5) a deficiency was observed but was not covered by an existing OSHA standard.

It is very likely that the fourth factor is a substantial source of negative bias in the number of program deficiencies recorded, since OSHA specifically directs the inspector not to issue citations for observed violations, under certain conditions. In particular the Industrial Hygiene Field Operations Manual[8] requires that air contaminant levels must exceed OSHA limits before most respirator citations can be issued (See Appendix). In addition, citations are not issued for any violation considered *"de minimus"* (*i.e.* not involving a direct risk to safety or health).

Although positive bias in the number of respirator violations could result from incorrect citation (*i.e.* citing a deficiency where none existed), in a similar manner an inspector could incorrectly determine that a program was in compliance with the OSHA standard. There is no formal review process for citations that would determine their validity. However, the fraction of citations which are vacated by subsequent hearings is small, since in order to be vacated, a citation must first be contested; during the period Fy 1977 through Fy 1982, less than 15% of all inspections had any contested citations.[6]

Results

Distribution of Violation Types

Table IV shows the distribution of violations of 1910.134 by

TABLE V
Elements of a Respirator Program
(American National Standards, Institute, 1980)

1. Written standard operating procedures
2. Responsibility for program assigned to a single individual
3. Annual review of employee suitability based on physicians guidelines
4. Use of approved respirators
5. Selection procedures for respirator type
6. Training of employees
7. Fit testing of employees
8. Policy on facial hair, contact lenses, eye and face protection
9. Procedures for issuing respirators
10. Procedures for pre-use inspection of respirator
11. Procedure for monitoring respirator use
12. Environmental monitoring of airborne concentrations
13. Medical surveillance and biological assay, where applicable
14. Procedures for cleaning, maintenance and repair of respirators
15. Annual program evaluation

section cited for both safety and health inspections in all industries for fiscal years 1977 through 1982. The distribution of violations into major categories is shown in Figure 1. The category with the most violations is "inadequate maintenance, cleaning or storage of respirators" which comprises 30% of all violations. Other major violation categories were "lack of standard procedures" (13%), "inadequate training" (12%), and "inappropriate or unapproved respirators" (9%). Altogether, specific program deficiencies [Sections (b) through (g)] accounted for 81% of the violations; while citations under Section (a)(2) of 1910.134, indicating a non-specific failure to provide suitable respiratory protection, accounted for 17%.

Prevalence of Violations

During the six year period studied, approximately 8000 OSHA health inspections in manufacturing industries were conducted during each fiscal year. In these inspections a total of approximately 20 000 violations of 29 CFR 1910.134 were cited. In inspections in which respirator violations were cited, the mean number of such violations cited was 3.4.

Table VI shows the number of inspections with at least one violation of 1910.134, during each fiscal year and for all years combined. For the six year period studied, 12.4% of the inspections resulted in citations for one or more sections of 1910.134. However, these citations may have been issued for reasons other than specific program deficiencies in the following situations (See Appendix):

1) an overexposure was documented and 1910.134 Section (a)(2) was issued because no respirators at all were provided,
2) an overexposure was documented and a citation for Section (a)(1) was issued because respirators were provided but engineering controls were considered feasible.

Because most overexposures to air contaminants are cited under OSHA Standard 29 CFR 1910.1000, the maximum number of such cases can be approximated by the number of inspections in which both citations for both 1910.1000 and either 1910.134 (a)(1) or 1910.134 (a)(2) [(and no other 1910.134 violations) were issued (Table VI, Column 4)]. Since this number is 2.4% of all inspections, a minimum of 10.0% of all health inspections found deficient respirator programs.

Table VII shows the number of inspections with at least one violation of 1910.134 broken down by inspection type. It is apparent that the results for complaint and general inspections are quite similar. Considerably fewer violations were cited in follow-up inspections; somewhat more violations were cited during accident investigations.

Since many health inspections do not evaluate respirator programs, it is of interest to evaluate the percentage of respirator programs *reviewed* that are deficient. Unfortunately, this statistic cannot be obtained from OSHA's computerized records. To estimate this statistic, a survey was conducted of all industrial hygiene compliance officers in two OSHA Area Offices (Boston and Cincinnati) to determine the percentage of health inspections in which respirator programs were evaluated during a recent one year period (May 1, 1983 to April 31, 1984). The results show that programs were reviewed in approximately 38% of the inspections in Cincinnati and 36% in Boston. Assuming a figure of 37% as characteristic of health inspections in general, an estimated 27.1% (4685/0.37×46708) of inspections in which respirator programs were *reviewed* resulted in a citation for a specific program violation. (See Table VI)

Association of Program Deficiencies with Overexposure to Air Contaminants

Respirator program deficiencies present the greatest potential risk to health when there are high environmental levels of air contaminants. We therefore examined the subgroup of inspections in which an overexposure to a substance listed under 29 CFR 1910.1000 was cited. Statistics on this subgroup of inspections are presented in Table VIII. With respect to this subset, 72.1% of the inspections resulted in citations for at least one violation of 29 CFR 1910.134, with 41.2% resulting in citations for specific program deficiencies. If we assume that the number of cases in which no respirators at all were provided is approximated by the number of inspections in which a citation for 1910.134 (a)(2) but no other section was issued, then the number of cases in which respirators *were* provided is 2641 (3567-926). Thus it follows

DISTRIBUTION OF VIOLATIONS
OF 29 CFR 1910.134 (RESPIRATORY PROTECTION)

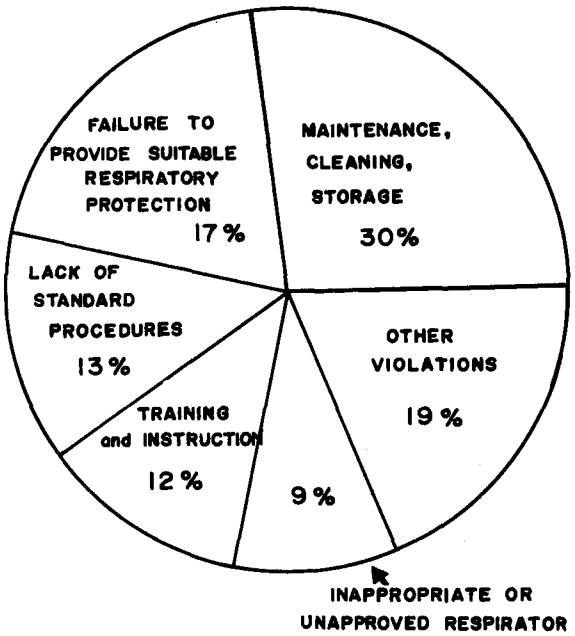

Figure 1 — Major Categories of Respirator Violations. Violations are grouped as follows: maintenance, cleaning and storage of respirators [(b)(5-7), (f)(1-5)]; lack of standard procedures [(b)(1), (e)(1)]; training and instruction [(b)(3), (e)(5)]; inappropriate or uncertified respirator [(b)(2), (b)(11), (c), (e)(2)]; failure to provide suitable respirator protection [(a)(2)].

TABLE VI
Statistics on Violations Cited in Manufacturing Health Inspections

FY Year	Number of Inspections	Number (%) of Inspections with Violations of: 1910.134	1910.134 A Only and 1910.1000	1910.134 (Program Deficiencies)[1]
1977	6983	798 (11.4)	201 (2.9)	597 (8.5)
1978	7932	991 (12.5)	225 (2.8)	766 (9.7)
1979	7930	1027 (13.0)	191 (2.4)	836 (10.5)
1980	8667	1153 (13.3)	213 (2.5)	940 (10.8)
1981	7840	930 (11.9)	173 (2.2)	757 (9.7)
1982	7356	912 (12.4)	123 (1.7)	789 (10.7)
Totals	46 708	5811 (12.4)	1126 (2.4)	4685 (10.0)

[1]estimated, see text for explanation

that in workplaces where respirators were provided, at least 55.6% (1469/2641) had deficient respirator programs. (See Table VIII)

Discussion

The workplaces inspected by OSHA form a sample of U.S. manufacturing workplaces which is representative with respect to industry type, but somewhat emphasize larger establishments. Little difference was found in the number of respirator violations cited between complaint and general inspections indicating that the method of selecting a workplace for these inspections was not a significant factor in influencing our results. Since most potential sources of bias tend to lead to underreporting of program deficiencies, our results (Tables VI, VII and VIII) may be considered minimum prevalences of inadequate respirator programs in the manufacturing industries.

A higher prevalence of respirator program deficiencies was found in the subgroup of inspections in which overexposures were documented (41.2%), compared to the prevalence in inspections in which respirator programs were reviewed (27.1%). This result may be attributed to the OSHA policy of usually issuing respirator citations, in most cases, only when overexposure has been documented.

Our finding of a higher incidence of respirator violations cited during accident investigations suggests that workplaces in which accidents occur may have less adequate respirator programs. However, this conclusion must be made with caution since the possibility of other systematic differences between these workplaces and workplaces as a whole was not investigated.

Previous studies have also noted the inadequacy of respirator programs in various workplaces. A 1972 survey by Toney *et al.*, which investigated 159 companies using respirators during paint spraying operations, found that 94% had no formal respirator training program.[9] The same authors found that 82% of the respirators in use for organic solvents were unapproved, 35% of the wearers had "unacceptable" fits and 28% of the respirators were in "unacceptable" condition. A more recent (1978) study on foundry conditions found that 32% of the respirators used for metal fumes and 7.5% of the respirators used for silica were not NIOSH approved.[10]

Few studies have investigated the effects of deficient respirator programs on the protection actually obtained by employees. Toney *et al.* determined protection factors on site at several paint spraying operations and found that low levels of protection correlated highly with both poor respirator condition and poor fit, with respirator condition being the more important factor.[9]

Section 1910.134 (a)(3), which mandates employee wear, was found to account for only 0.7% of violations of 1910.134, in all OSHA inspections. However, the limited data which are available indicate that this problem is much more extensive.[11,12] Several of the program deficiencies identified in this study — particularly inadequate training, inappropriate respirator selection and lack of program surveillance — contribute to the "non-wearing" of respirators, and thus potentially to employee exposure.

TABLE VII
Percent Manufacturing Health Inspections With at Least One Violation of 29 CFR 1910.134 by Inspection Type

FY Year	Accident	Complaint	General	Follow-Up	All Inspections
1977	21.2	13.9	14.3	3.9	11.4
1978	29.0	15.6	13.7	3.8	12.5
1979	20.0	15.3	15.8	4.6	13.0
1980	18.7	15.2	16.6	4.2	13.3
1981	22.1	11.8	13.7	6.6	13.7
1982	20.7	9.6	14.1	5.7	12.4
All Years	21.7	14.0	14.6	4.6	12.4

TABLE VIII
Statistics on Health Inspections with Violations of 1910.1000

FY Year	Inspections With Violations of 1910.1000	Number (%) of Inspections With Violations of 1910.1000 and: 1910.134	1910.134 (b)-(g)	1910.134 (a)(1) Only	1910.134 (a)(2) Only	1910.134 (a)(1) & (a)(2) Only
1977	605	393 (65.0)	196 (32.4)	47 (7.8)	148 (24.4)	2 (0.3)
1978	697	501 (71.9)	281 (40.3)	42 (6.0)	176 (25.3)	2 (0.3)
1979	607	467 (76.9)	280 (46.1)	31 (5.1)	155 (25.5)	1 (0.2)
1980	721	508 (70.5)	302 (41.9)	15 (2.1)	188 (26.1)	3 (0.4)
1981	567	396 (69.8)	224 (39.5)	12 (2.1)	156 (27.5)	4 (0.7)
1982	375	307 (81.9)	186 (49.7)	17 (4.5)	103 (27.5)	1 (0.3)
All Yrs.	3567	2572 (72.1)	1469 (41.1)	164 (4.6)	926 (26.0)	13 (0.4)

The effectiveness of respirator programs can be assessed directly by determining the inhalation exposure of individuals in the program. Two possible ways of performing such an assessment are biological monitoring for selected substances and in-mask respirator sampling during actual workshifts. However, there currently are serious limitatons to each method.

Biological monitoring can be used only for a restricted group of substances for which clinical tests are available. In addition, for substances in which skin exposure or ingestion are alternate routes of entry, biological monitoring may not be a true index of *inhalation exposure.* Furthermore, individuals may differ in their rates of accumulation and clearance of the monitored substance, thus making inter-subject comparisons difficult.

In-mask sampling over entire workshifts can provide an objective means of evaluating respirator program effectiveness. This approach is currently limited by: 1) lack of an agreed upon protocol for sampling from within the respirator facepiece; and 2) lack of practical sampling devices compatible with currently used respiratory protective devices.

Conclusions

In most cases (55.6%) where respirators were used to protect employees from excessive levels of air contaminants, respiratory protection programs were deficient in one or more elements, thus increasing the potential for employee exposure. The trends in compliance *vs.* fiscal year suggest that despite extensive activity by OSHA in enforcing the respirator standard, the overall level of compliance with the standard in the manufacturing industries did not improve significantly during the period of study. The lower citation rate in follow up inspections, however, indicates that compliance activity is effective in improving respirator programs in the workplaces where violations are cited.

These results suggest a need for: 1) increasing the surveillance of respirator programs through employer initiatives as well as OSHA enforcement and consultative activities, and 2) objectively evaluating respirator program effectiveness by monitoring the inhalation exposure of respirator users where possible.

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APPENDIX

29 CFR 1910.134 (a)(1)

"In the control of those occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, the primary objective shall be to prevent atmospheric contamination. This shall be accomplished as far as feasible by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used pursuant to the following requirements."

29 CFR 1910.134 (a)(2)

"Respirators shall be provided by the employer when such equipment is necessary to protect the health of the employee. The employer shall provide the respirators which are applicable and suitable for the purpose intended. The employer shall be responsible for the establishment and maintenance of a respiratory protective program which shall include the requirements outlined in paragraph (b) of this section."

29 CFR 1910.134 (a)(3)

"The employee shall use the provided respiratory protection in accordance with instructions and training received."

OSHA Industrial Hygiene Field Operations Manual, Chapter III, "OSHA Standard Method for Determination of Respirator Program Acceptability," Section (A5)

"Situations Where Overexposure Does Not Occur

"a. Where an overexposure has not been established but where an improper respirator is being used (*e.g.* a dust respirator being used to reduce exposure to organic vapors), a citation under 29 CFR 1910.134 (b)(2) shall be issued as other than serious, provided the Industrial Hygienists document that an overexposure is possible.

"b. Where employee overexposure has not been established, and one or more of the other requirements of 29 CFR 1910.134 is not being met; *e.g.* an unapproved nuisance respirator is being used to reduce exposure to toxic dusts, a *de minimis* violation(s) shall be recorded in accordance with OSHA procedures. (Note that this policy does not include emergency use respirators). The Industrial Hygienist shall advise the employer of the elements of a good respirator program as required under 29 CFR 1910.134."

27 July 1984; Revised 15 July 1985