Which Substances Prompt Respirator Use?

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ABSTRACT

The National Institute for Occupational Safety and Health (NIOSH) and the Bureau of Labor Statistics (BLS) conducted a survey of respirator use and practices of U.S. private sector employers in 2001-2002. The survey results showed that respirators are reported to be used to protect against biological substances (HIV and TB were listed as examples) and a wide variety of chemicals. Air-purifying respirators (APRs) were most frequently used by establishments to protect against dusts n.e.c. (n.e.c. = not elsewhere classified), paint vapors, solvents, silica dust, and welding fumes. Air-supplied respirators were used most frequently by establishments to protect against paint vapors, solvents, dusts n.e.c., silica dust, and carbon monoxide. Generally, the smallest establishments (10 or less employees) made up the greatest number of establishments where APRs were used, although their percentage use was the least. Among the major industry divisions, services, construction, and manufacturing had the greatest number of establishments where APRs were used for protection against substances including dusts n.e.c., paint vapors, solvents, silica dust, welding fumes, lead, acid gasses, and asbestos. Among the significant findings was the surprisingly large number of estimated establishments that used APRs for carbon monoxide (24,497 establishments). At least 40% of establishments had no known air sampling to aid in selecting APRs to protect against each of pesticides, dusts n.e.c., paint vapors, coal mine dust, coal tar pitch volatiles, coke oven emissions, and welding fumes.

Keywords: respirator, survey, substances, private-sector

INTRODUCTION

Limitations of previous surveys of respirator use (NIOSH, 1978; NIOSH, 1988; NCHS, 1994; Federal Register, 1994; NIOSH, 1996; Eastern Research Group, 1999) led the National Institute for Occupational Safety and Health (NIOSH) and the Bureau of Labor Statistics (BLS) to design and conduct a survey of respirator use and practices among U.S. private sector employers. The results were recently published as a joint BLS/NIOSH report, (U.S. Bureau of Labor Statistics, 2003). This paper provides a summary and discussion of information from that report pertaining to 1) substances that were reported to prompt use of air-purifying and air-supplied respirators, (2) the distribution of reported substances by establishment size and industry, and, (3) likely inadequacies in respirator selection methods and use with respect to different substance types.

METHODS

In 2001, the Survey of Respirator Use and Practices was mailed by BLS to 40,002 U.S. private sector business establishments. The survey closed in February 2002 with a response rate of 75.5%. The results of the survey are national estimates based on a selected probability sample, rather than a census of the entire population. The survey generated estimates of respirator use and practices at the major industry division level, the two-digit Standard Industrial Classification (SIC) (Office of Management and Budget 1987) level, and for establishment employment size groups. The respirator use discussed in this paper is based on requirements of regulations (CFR 2002a, CFR 2002b, CFR 2002c, CFR 2002d) or the employer in the 12 months prior to the survey. Further details of the methods are provided in the BLS/NIOSH report (U.S. Bureau of Labor Statistics, 2003).

The survey questionnaire requested information as to whether any of 26 listed categories (24 specific and "other dust" and "other vapors") that contained one or more substances had prompted the establishment to use air-purifying respirators (APRs) and whether exposure assessment by air sampling had been conducted for those categories. In addition, the response "other" was included to allow respondents to write in additional substances. After reviewing the additional substances, sufficient information was available to add the following six categories for a more detailed tabulation: acetone, ammonia, formaldehyde, isocyanate, man-made fibers, and pesticides. The categories are not mutually exclusive, and some substances could be put into several categories. For example, an establishment using a listed substance such as toluene could have classified it into a more generic category such as paint vapors or solvents, particularly if toluene is one ingredient of many in a paint or solvent.

Rules were also established to reclassify write-in substances to a specific listed category including:

- classify the substance into one of the listed categories where appropriate. For example hydrogen chloride was moved to "acid gases";
- classify as "dusts n.e.c." (dusts not elsewhere classified), all recorded "other dust" and any particulate and mist substances in the "other" category that do not fit into other specific categories;
- classify as "vapors n.e.c." all recorded "other vapors" and any other organic compounds in the "other" category that have structures similar to compounds used as solvents but are not commonly known to be used as solvents;
- classify a substance as "unknown other" if it cannot be classified as one of the original or added categories;
- exclude substances that were not written in frequently enough to meet publication guidelines established by BLS (U.S. Bureau of Labor Statistics, 2003); and
- with substances that did not fit in the classification rules above, use professional judgment.

The air-supplied respirator (ASR) section of the survey is similar to the air-purifying respirator (APR) section with the exception that the ASR section addressed oxygen deficiency whereas the APR section addressed cotton dust.

To understand whether employers used the NIOSH-recommended method for respirator selection, the survey queried "How do you decide which respirator is appropriate for the substance(s) faced by your employees?" Categories included material safety data sheets, respirator manufacturers' literature, and air sampling at the surveyed facility or at another facility with very similar operations. The respondents were allowed to choose more than one option.

Finally, to evaluate appropriate respirator use, a survey question elicited information about the different types of respirators used to protect against particulate or gas/vapor substances.

RESULTS

Summary of APR Use

Of all private sector establishments using APRs for any substance, those with ten or fewer employees accounted for 43%, those with 11-49 accounted for 30%, those with 50-249 accounted for 17%, those with 250-999 accounted for 8%, and those with over 1,000 employees accounted for 3% (Table I). However, of all private sector establishments, those with ten or fewer employees had the lowest percentage using APRs, at 2.5%; with 11 to 49 employees at 6.0%; 50 to 249 employees at 12.1%; 250 to 999 employees at 28.6%; and 1,000 or more employees at 54.9% (U.S. Bureau of Labor Statistics, 2002).

Among the major industry divisions, the services industry had the greatest number of establishments where APRs were used to protect against any substance. This pattern across industries was reflected for most of the substances (dusts n.e.c., paint vapors, solvents, silica dust, welding fumes, lead, acid gases, and asbestos - Table II). The two exceptions were the construction industry, which had the greatest number of establishments using APRs to protect against silica dust, hydrogen sulfide, and chlorine, and the manufacturing industry, which had the greatest number of establishments using APRs to protect against acid gases and toluene.

However, the highest percentages of APR use were found in 'manufacturing' (12% of establishments), 'mining' (12%), 'agriculture, forestry, and fishing' (9%), and 'construction' (9%) (U.S. Bureau of Labor Statistics, 2003). Categories of substances that prompted APR use are listed in Table III. The top five categories noted were dusts n.e.c., paint vapors, solvents, silica dust, and welding fumes. About a third or more of establishments reporting using respirators for any reason were using them for the generic categories of dusts n.e.c., for paint vapors, and for solvents. The most common APR write-in categories were ammonia (4% of APR-using establishments), pesticides (3%), and formaldehyde (2%); man-made fibers, isocyanate, and acetone, were each at less than 1%.

Air sampling is recommended as an objective and necessary criterion for use in the selection of an appropriate respirator (NIOSH, 1987). Table III shows the percentage of establishments using APRs with no known indication of air sampling being used as a means to APR selection. Percentages range from over 50% for dusts n.e.c., and pesticides, down to about 10% for carbon monoxide and hydrogen sulfide, which are potentially improper usages.

Appropriate use of respirators is a critical issue impacting worker safety. The number of establishments and employees who used respirators to protect against particulates or gases/vapors is reported in Table IV. Thirteen percent of establishments and 6% of employees apparently use dust masks improperly to protect against gases and vapors.

Summary of ASR Use

The categories of substances that prompted ASR use are listed in Table V. The top five categories were paint vapors, solvents, dusts n.e.c., silica dust, and carbon monoxide. The ASR write-in categories included ammonia (5% of ASR-using establishments), isocyanate (3%), acetone (1%), and formaldehyde (less than 1%). Also presented in the table is the percentage of establishments which had no known air sampling for selection of respirator type. Percentages range from about 33% (paint vapors, dusts n.e.c., and iron oxide) down to about 3% (carbon monoxide).

ASR use by substance, employment size group, and industry division was largely similar to that for APRs, and is not presented separately for that reason.

Table I. National Estimates of the Number and Percent[1] of Establishments Where an APR was Used, by Substance Category and Employment Size Group

Substance Categories	Total	Employment Size Group				
		1-10	11-49	50-249	250-999	1000+
Dusts n.e.c.[2]	133,271	**55,808 (42%)**	43,449 (33%)	22,074 (17%)	9,039 (7%)	2,901 (2%)
Paint Vapors	111,768	**51,929 (46%)**	31,781 (28%)	17,760 (16%)	6,507 (6%)	3,882 (3%)
Solvents	86,393	**41,700 (48%)**	20,352 (24%)	14,304 (17%)	7,049 (8%)	2,989 (3%)
Silica Dust	47,785	**15,766 (33%)**	13,968 (29%)	10,331 (22%)	6,034 (13%)	1,687 (4%)
Welding Fumes	46,508	**17,447 (38%)**	12,408 (27%)	9,541 (21%)	4,997 (11%)	2,115 (5%)
Vapors n.e.c.[2]	40,183	9,485 (24%)	**14,987 (37%)**	8,873 (22%)	3,725 (9%)	3,113 (8%)
Lead	31,290	**14,183 (45%)**	4,708 (15%)	6,157 (20%)	3,585 (11%)	2,657 (8%)
Acid Gas	27,999	**9,464 (34%)**	5,334 (19%)	7,324 (26%)	2,983 (11%)	2,894 (10%)
Asbestos	27,878	**14,282 (51%)**	4,345 (16%)	3,787 (14%)	3,631 (13%)	1,834 (7%)
Toluene	27,219	7,711 (28%)	**8,174 (30%)**	6,432 (24%)	2,706 (10%)	2,198 (8%)
Carbon Monoxide	24,497	**8,973 (37%)**	5,350 (22%)	5,193 (21%)	3,364 (14%)	1,617 (7%)
Biologicals (i.e. TB & HIV)	23,283	**11,139 (48%)**	4,278 (18%)	3,681 (16%)	1,662 (7%)	2,521 (11%)
Hydrogen Sulfide	18,898	**8,598 (45%)**	2,771 (15%)	4,148 (22%)	2,217 (12%)	1,165 (6%)
Zinc Oxide	15,258	**7,642 (50%)**	3,103 (20%)	2,587 (17%)	1,152 (8%)	773 (5%)
Chlorine	15,009	3,739 (25%)	3,295 (22%)	**4,456 (30%)**	2,210 (15%)	1,255 (8%)
Any Substance	267,467	**113,797 (43%)**	80,249 (30%)	44,247 (17%)	20,865 (8%)	8,309 (3%)

(1) Percents are calculated using the estimated number of establishments with APR use listed in the "Total" column as the denominator for each substance.
(2) The category "Dusts n.e.c." includes "Other Dust" and "Other" write-in substances that were determined to be in the form of dusts. The category "Vapors n.e.c." includes "Other Vapors" and "Other" write-in substances that were determined to be in the form of vapors. n.e.c. equals "not elsewhere classified."
(3) Percentages of APR use across substance categories may not sum to 100% due to rounding. Some substance categories are not listed because the number of establishments using APRs in specific employment size groups could not be estimated because the data did not meet publication guidelines established by BLS. The highest number and percent are in bold.

Table II. National Estimates of the Number and Percent[1] of Establishments Where an APR was Used, by Substance Category and Industry Division

Substance Categories	Total	Industry Division							
		Agriculture, forestry, fishing	Mining	Construction	Manufacturing	Transportation & public utilities	Wholesale trade	Retail trade	Services
Dusts n.e.c.[2]	133,271	7,807 (6%)	1,818 (1%)	30,640 (23%)	23,303 (17%)	5,134 (4%)	13,259 (10%)	5,621 (4%)	**44,516 (33%)**
Paint Vapors	111,768	3,577 (3%)	1,209 (1%)	28,028 (25%)	21,812 (20%)	2,508 (2%)	10,965 (10%)	9,405 (8%)	**33,385 (30%)**
Solvents	86,393	1,077 (1%)	1,039 (1%)	17,372 (20%)	17,032 (20%)	2,587 (3%)	10,011 (12%)	4,605 (5%)	**31,722 (37%)**
Silica Dust	47,785	1,807 (4%)	2,267 (5%)	**15,263 (32%)**	9,268 (19%)	3,630 (8%)	4,159 (9%)	1,322 (3%)	9,823 (21%)
Welding Fumes	46,508	1,897 (4%)	853 (2%)	5,339 (11%)	12,364 (27%)	1,953 (4%)	5,416 (12%)	2,757 (6%)	**15,725 (34%)**
Vapors n.e.c.[2]	40,183	4,117 (10%)	834 (2%)	5,600 (14%)	8,468 (21%)	1,792 (4%)	7,823 (19%)	1,939 (5%)	**9,287 (23%)**
Lead	31,290	1,124 (4%)	311 (1%)	7,879 (25%)	5,510 (18%)	1,367 (4%)	3,694 (12%)	614 (2%)	**10,783 (34%)**
Acid Gas	27,999	1,147 (4%)	586 (2%)	4,115 (15%)	**7,687 (27%)**	1,151 (4%)	5,556 (20%)	594 (4%)	7,163 (26%)
Asbestos	27,878	1,163 (4%)	371 (1%)	5,981 (21%)	3,997 (14%)	2,151 (8%)	2,623 (9%)	278 (1%)	**8,716 (31%)**
Toluene	27,219	1,424 (5%)	490 (2%)	5,283 (19%)	**8,109 (30%)**	432 (2%)	5,579 (20%)	1,408 (5%)	4,495 (17%)
Carbon Monoxide	24,497	1,070 (4%)	436 (2%)	5,747 (23%)	5,302 (22%)	713 (3%)	2,897 (12%)	840 (3%)	**7,366 (30%)**
Biologicals (i.e.TB/HIV)	23,283	1,556 (7%)	368 (2%)	2,875 (12%)	1,155 (5%)	830 (4%)	1,129 (5%)	NA[3]	**15,308 (66%)**
Hydrogen Sulfide	18,898	1,035 (5%)	563 (3%)	**6,010 (32%)**	2,498 (13%)	1,356 (7%)	1,908 (10%)	94 (<1%)	5,357 (28%)
Zinc Oxide	15,258	1,360 (9%)	155 (1%)	1,766 (12%)	3,487 (23%)	188 (2%)	2,641 (17%)	853 (6%)	**4,809 (32%)**
Chlorine	15,009	1,236 (8%)	211 (1%)	**5,289 (35%)**	2,574 (17%)	445 (3%)	2,209 (15%)	NA[3]	2,452 (16%)
Any Substance	267,467	13,167	3,453	60,012	46,232	9,718	27,966	16,107	**86,610**

(1) Percents are calculated using the estimated number of establishments with APR use listed in the "Total" column as the denominator for each substance.
(2) "Dusts n.e.c." includes "Other Dust" and "Other" write-in substances that were determined to be in the form of dusts. "Vapors n.e.c." includes "Other Vapors" and "Other" write-in substances that were determined to be in the form of vapors. n.e.c. equals "not elsewhere classified."
(3) NA - Data did not meet publication guidelines established by BLS.
(4) The highest number and percent are in bold.

Table III. National Estimates of the Number and Percent of Establishments Where an APR was Used, by Substance Category

Substance Categories	Establishments Using APRs for Category of Substance		Percent No Known Air Sampling[2]
	Number	Percent[1]	
Dusts n.e.c.[3]	133,271	49.8	52.2
Paint Vapors	111,768	41.8	46.7
Solvents	86,393	32.3	32.8
Silica Dust	47,785	17.9	31.8
Welding Fumes	46,508	17.4	40.2
Vapors n.e.c.[3]	40,183	15.0	33.3
Lead	31,290	11.7	12.8
Acid Gas	27,999	10.5	19.1
Asbestos	27,878	10.4	14.4
Toluene	27,219	10.2	22.6
Carbon Monoxide	24,497	9.2	10.9
Biologicals (i.e. TB & HIV)	23,283	8.7	33.3
Hydrogen Sulfide	18,898	7.1	9.9
Zinc Oxide	15,258	5.7	22.8
Chlorine	15,009	5.6	26.8
Chromium	11,824	4.4	15.9
Styrene	11,502	4.3	25.6
Copper	11,377	4.3	27.9
Iron Oxide	11,324	4.2	26.2
Ammonia[4]	11,173	4.2	>35.7[5]
Cadmium	10,744	4.0	20.0
Arsenic	10,193	3.8	39.5
Manganese	8,083	3.0	26.7
Cotton Dust	7,201	2.7	29.6
Pesticides[4]	7,102	2.7	>63.0[5]
Coal Tar Pitch Volatiles	6,915	2.6	42.3
Coal Mine Dust	6,613	2.5	44.0
Coke Oven Emissions	5,827	2.2	40.9
Formaldehyde[4]	5,388	2.0	NA[6]
Man-made Fibers[4]	2,003	0.7	28.6
Isocyanate[4]	1,810	0.7	NA[6]
Acetone[4]	828	0.3	NA[6]

(1) Percents are calculated using the estimated number of establishments with APR use (n=267,467) as the denominator (U.S. Bureau of Labor Statistics, 2003) and do not sum to 100% because an establishment could use APRs to protect against more than one substance.
(2) Denominator is the total number of establishments that used APRs to protect against the identified substance. The numerator consists of establishments which did not conduct air sampling for that substance or did not know if air sampling was conducted.

(3) "Dusts n.e.c." includes "Other Dust" and "Other" write-in substances that were determined to be in the form of dusts. "Vapors n.e.c." includes "Other Vapors" and "Other" write-in substances that were determined to be in the form of vapors. n.e.c. equals "not elsewhere classified."
(4) The substance was written in the questionnaire 'Other" category.
(5) At least 35.7 and 63.0 percent of establishments using APRs for ammonia and pesticides did not conduct air sampling. The number of establishments that did not know if air sampling was conducted did not meet publication guidelines established by BLS.
(6) NA - The number of establishments with no known air sampling could not be estimated because the data did not meet publication guidelines established by BLS.

Table IV. National Estimates of the Number and Percent[1] of Establishments and Employees Using Non-powered Air-purifying Respirators (NPAPRs) to Protect Against a Hazard, by Selected Type of Respirator and Hazard

Type of Respirator		Type of Hazard		
		Particulate	Gas/Vapor	Combination Particulate + Gas/Vapor
Dust masks: (disposable)	worn at establishments	181,021 68.5%	35,699 13.5%	24,964 9.4%
	worn by employees	1,881,408 61.3%	192,948 6.3%	157,069 5.1%
Half-mask: (other than disposable)	worn at establishments	66,232 25.1%	49,126 18.6%	60,974 23.1%
	worn by employees	598,118 19.5%	320,425 10.4%	510,638 16.6%
Full-facepiece:	worn at establishments	24,921 9.4%	23,966 9.1%	28,806 10.9%
	worn by employees	197,257 6.4%	211,033 6.9%	244,840 8.0%
Mouth-piece:	worn at establishments	5,022 1.9%	4,329 1.6%	2,379 0.9%
	worn by employees	63,591 2.1%	15,111 0.5%	10,241 0.3%

(1) Percents are calculated using the estimated number of establishments (n=264,366) or employees (n=3,067,325) with NPAPR use as the denominator (U.S. Bureau of Labor Statistics, 2003).

(2) The percentages do not sum to 100% because an establishment could use NPAPRs to protect against more than type of hazard.

Table V. National Estimates of the Number and Percent[1] of Establishments Where an Air-supplied Respirator (ASR) was used, by Substance Category

Substance Categories	Establishments Using ASRs for Category of Substance		Percent No Known Air Sampling[2]
	Number	Percent[1]	
Paint Vapors	21,593	45.7	33.3
Solvents	13,393	28.3	20.9
Dusts n.e.c.[3]	11,330	24.0	34.6
Silica Dust	9,007	19.0	19.0
Carbon Monoxide	7,932	16.8	3.0
Welding Fumes	7,843	16.6	26.5
Oxygen Deficiency	7,279	15.4	>1.3[5]
Hydrogen Sulfide	7,266	15.4	>2.0[5]
Acid Gas	7,045	14.9	8.7
Vapors n.e.c.[3]	6,495	13.7	13.1
Toluene	6,310	13.3	18.8
Lead	5,195	11.0	8.2
Chlorine	5,051	10.7	16.8
Asbestos	3,104	6.6	4.6
Chromium	3,014	6.4	9.4
Cadmium	2,408	5.1	11.8
Ammonia[4]	2,292	4.8	>6.3[5]
Arsenic	2,257	4.8	6.3
Styrene	2,157	4.6	>6.5[5]
Zinc Oxide	2,048	4.3	27.9
Copper	2,047	4.3	>9.3[5]
Isocyanate[4]	1,652	3.5	>17.1[5]
Manganese	1,599	3.4	>11.8[5]
Iron Oxide	1,561	3.3	36.4
Biologicals (i.e. TB & HIV)	1,492	3.2	12.5
Acetone[4]	659	1.4	NA[6]
Coal Tar Pitch Volatiles	508	1.1	27.3
Coal Mine Dust	401	0.8	25.0
Coke Oven Emissions	320	0.7	>14.3[5]
Formaldehyde[4]	201	0.4	NA[6]

(1) Denominator is the total number of establishments that used ASRs (n = 47,290). The percentages do not sum to 100% because an establishment could use ASRs to protect against more than one substance.
(2) Denominator is the total number of establishments that used ASRs to protect against the identified substance. The numerator consists of establishments which did not conduct air sampling or did not know if air sampling was conducted.
(3) "Dusts n.e.c." includes "Other Dust" and "Other" write-in substances that were determined to be in the form of dusts. "Vapors n.e.c." includes "Other Vapors" and "Other" write-in substances that were determined to be in the form of vapors. n.e.c. equals "not elsewhere classified."
(4) The substance was written in the questionnaire "Other" category

(5) The percent of ASR-using establishments with no known air sampling may be greater since the number of establishments that did not conduct air sampling or the number of establishments that did not know if air sampling was conducted could not be estimated because the data did not meet publication guidelines established by BLS.
(6) NA - Data did not meet publication guidelines established by BLS.

DISCUSSION

The survey provided estimates of APR and ASR use for common substances encountered in the workplace. Overall, APRs were used in many more establishments than were ASRs. Among both APRs and ASRs the predominant applications among all categories were for dusts n.e.c.; solvents; and, paint vapors. Use of respirators for most of the other categories was reported by less than 10% of all establishments with any respirator use. The greatest number of establishments using APRs and ASRs were small establishments, but the percentage of all small establishments using them was the least among the establishment size groups. For most substance categories, the services, construction, and manufacturing industries had the most establishments using APRs (Table II).

APRs were often used to protect against biologicals (i.e. tuberculosis and HIV), which can cause illness or death if exposure occurs without adequate controls or worker respiratory protection. Biologicals prompted APR use in 9% of establishments using APRs, and ASR use in 3% of establishments using ASRs (Tables III and V). For biologicals, the employment size group with ten or fewer employees had 48% (11,139 of 23,283) of the APR use (Table I), and the services industry accounted for 66% (15,308 of 23,283) of the APR use (Table II).

In addition to providing information about the use of APRs and ASRs to protect workers against various airborne substances, the survey furnished critical information concerning activities with potential to put workers at risk of illness or death. Among these were the use of improper methods to select respirators for use, and the reported use of the wrong type of respirators for respiratory protection. These could lead to only partial protection or absence of protection, and also provide a false sense of security, with injurious or fatal consequences.

NIOSH recommends that the selection of respirators be guided by the NIOSH Respirator Decision Logic (NIOSH, 1987). The Decision Logic indicates that respirator selection, except in the cases of fire fighting, oxygen deficiency, emergencies, and carcinogenic substances, should begin with a comparison of the contaminant concentration to the exposure limit for the contaminant. The contaminant concentration can only be determined by air sampling either on site or at a similar operation.

Based on the overall survey responses, air sampling at the facility or at another facility was used by a minority of establishments (24% and 6%, respectively) (U.S. Bureau of Labor Statistics, 2003). In contrast, material safety data sheets were employed by 57% of establishments, and respirator manufacturers' literature by 45%. Therefore, the majority of establishments may be operating in a manner contrary to NIOSH recommendations.

Of particular note in Table IV are the number and percentage of establishments that reported their employees were required to use dust masks (disposable) as protection for gas/vapor substances. Since dust masks only protect against particulate substances, of 200,995 establishments using dust masks (U.S. Bureau of Labor Statistics, 2003), 35,699 used them to protect employees against a gas or vapor; and 24,964 (including some already counted for gas or vapor only) used dust masks to protect employees from a combination of particulates and gas or vapor. At least 35,699 establishments have at least 192,948 employees who used dust masks for protection against gases and/or vapors (Table IV). Dust masks should not be the type of respirator used for gases or vapors.

APRs were often used to protect against carbon monoxide (CO) (9%) (Table III). However, only certain APRs (canister gas masks) provide protection against carbon monoxide (CO), and the protection is limited to an atmosphere containing less than 1200 ppm CO, or escape only from hazardous atmospheres containing adequate oxygen to support life (NIOSH, 1987; NIOSH, 2003). APRs were also used to protect against hydrogen sulfide (7%), which can cause paralysis of the breathing center.

Hydrogen sulfide may not have adequate warning properties because of olfactory fatigue. The fact that forty-five fatalities of respirator-wearers caused by asphyxiation or chemical poisoning were found in OSHA investigation reports from 1984 through 1995 (Suruda, 2003), suggests that improper use of APRs and ASRs may be occurring.

CONCLUSIONS AND RECOMMENDATIONS

APRs were most frequently used by establishments to protect against dusts n.e.c., paint vapors, solvents, silica dust, and welding fumes. Air-supplied respirators were estimated to be used most frequently by establishments to protect against paint vapors, solvents, dusts n.e.c., silica dust, and carbon monoxide. An important finding of the survey is that a large number of establishments are estimated to be using respirators without air sampling for some of the substances that prompt respirator use. For example, 52% of 133,271 establishments that used APRs to protect against dusts n.e.c. had no known air sampling for that substance. Misunderstanding of protection type and level of protection provided could be endangering workers, if air sampling showed respirators were actually needed.

The high percentages of establishments using respirators without benefit of air sampling indicates a need for better targeting of educational efforts on the part of regulators, distributors, and manufacturers to ensure appropriate methods for respirator selection by using NIOSH's recommended respirator decision logic. Employees should be informed of the limitations of certain types of respirators, so that they do not work under the mistaken assumption that they are protected while wearing improperly selected respirators.

REFERENCES

American National Standards Institute, Inc. (1969): *American National Standard Practices for Respiratory Protection* (ANSI Z88.2). New York, NY.: ANSI, 1969.

Code of Federal Regulations. (2002a) *Respiratory Protection.* U.S. Government Printing Office, Officer of the Federal Register, Washington, DC. Title 29, CFR , Part 1910.134.

Code of Federal Regulations. (2002b) *Health Standards for Coal Mines – Selection, Fit, Use and Maintenance of Approved Respirators.* U.S. Government Printing Office, Officer of the Federal Register, Washington, DC. Title 30, Part 72.710.

Code of Federal Regulations. (2002c) *Safety and Health Standards Surface Metal and Nonmetal Mines – Control of Exposure to Airborne Contaminants.* U.S. Government Printing Office, Officer of the Federal Register, Washington, DC. Title 30, Part 56.5005.

Code of Federal Regulations. (2002d) *Safety and Health Standards Underground Metal and Nonmetal Mines – Control of Exposure to Airborne Contaminants.* U.S. Government Printing Office, Officer of the Federal Register, Washington, DC. Title 30, Part 57.5005.

Eastern Research Group (1999) *PPE Cost Survey Final Report (Task Order 3, Contract J-9-F-0010).* Prepared for the Office of Regulatory Analysis, OSHA, Washington, DC. June 23, 1999.

Federal Register (1994) *Respiratory Protection," (Compliance Cost Analysis: Current and Proposed Respiratory Protection Standards).* Office of the Federal Register, Washington, DC. Federal Register 59, p. 58892.

National Center for Health Statistics (1994) *Plan and Operations of the Third National Health and Nutrition Examination Survey. DHHS*/National Center for Health Statistics, Washington, DC. No. PHS 94-1302.

National Institute for Occupational Safety and Health. (1978) *National Occupational Hazard Survey Volume III Survey Analysis and Supplemental Tables.* DHHS/National Institute for Occupational Safety and Health, Cincinnati, OH. No. 78-114.

National Institute for Occupational Safety and Health (1987) *NIOSH Respirator Decision Logic.* DHHS/National Institute for Occupational Safety and Health, Cincinnati, OH. No. 87-108.

National Institute for Occupational Safety and Health (1988) *National Occupational Exposure Survey Volume I Survey Manual.* DHHS/National Institute for Occupational Safety and Health, Cincinnati, OH. No. 88-106.

National Institute for Occupational Safety and Health (1996) *Results from the National Occupational Health Survey of Mining (NOHSM).* DHHS/National Institute for Occupational Safety and Health, Cincinnati, OH. No. 96-136.

National Institute for Occupational Safety and Health (2003) *NIOSH Pocket Guide to Chemical Hazards.* DHHS/National Institute for Occupational Safety and Health, Cincinnati, OH. No. 97-140.

Office of Management and Budget (1987) *Standard Industrial Classification Manual.* Executive Office of the President Office of Management and Budget, U.S. Government Printing Office, Washington, DC.

U.S. Bureau of Labor Statistics (2002) *Survey of Programs Using Respirators (SPUR) database.* Washington, DC. (*database* accessed March 14, 2002).

U.S. Bureau of Labor Statistics/National Institute for Occupational Safety and Health (*2003*) *Respirator Usage in Private Sector Firms, 2001.* Washington, DC.