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A nationwide field survey of abrasive blasting practices revealed equipment deficiencies and lack of maintenance to be the rule, with workers exposed to extreme noise environments and above TLV quartz exposures.

Abrasive blasting protective practices study—field survey results

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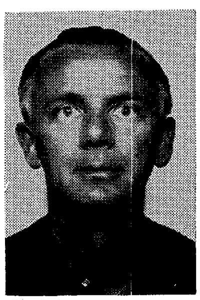
Introduction

A preliminary nationwide survey of abrasive blasting using industries conducted by Boeing under National Institute for Occupational Safety and Health (NIOSH) sponsorship has been previously described.[1] In that survey approximately 4% of the national firms doing blasting were contacted by mail. The six survey areas selected contained approximately 4% of the national population. From the replies received, a representative population was selected for on-site field questioning and monitoring. Working blasters were monitored for respirable dust and noise exposures.

Analytical equipment and procedures

Sound levels during blasting were measured by use of a system which employed a General Radio sound level meter coupled to a match box, from which four fifty-foot impedence matched cables led to four Sony ECM-16 midget microphones. A General Radio calibrator, modified to accept the microphones, was used for daily calibration. The set-up performed faultlessly throughout the entire test period providing invaluable inside and outside the helmet sound level comparisons. Octave band analyses were performed from time to time to discern any helmet frequency shift, but the majority of measurements were straight dBA scale.

Several instruments and combinations of instruments were used to provide a measure of respirable dust. A Thermo-Systems (T-S)[2] piezoelectric-electrostatic mass monitor was modified so that it would be useful for field operational conditions. These modifications included: (1) placing the sampling head in a dust-tight case which can be operated remotely from the measuring device, (2) raising the precipitator voltage to improve collection efficiency, and (3) raising the instrument flow-rate to a useful value so that a 10-mm cyclone can be employed. In addition, we found it necessary, in the course of our laboratory and in-shop evaluation of the instrument, to make several circuit modifications in order to provide needed RFI suppression. We also employed the GCA 101 and 201 beta absorption mass monitors. These instruments were the "work horses" of our analytical procedure. The 101 is a beta-absorption impactor device[3] which has an effective cut-off for spherical particles of unit density in the order of 0.3 micron. We did not feel this would hurt our program greatly, as most of our particles are of considerably higher density. The instrument was programmed to



Mr. Blair is an industrial hygienist and chemist with considerable experience in analytical, atmospheric, and liquid propelland chemistry as well as in the general industrial hyginene and safety engineering disciplines. He has done extensive research and testing of protective clothing and respiratory devices.

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TABLE I
Some Selected Variations in Various Mass Monitors Used in the Field

READINGS (mg/m³)			
101	201	TS	CHEM ANAL
	6.87	7.81	7.71
.06		.06	.17
1.96		2.10	2.30
5.00	6.25	6.50	6.30
.08		.21	.26
.17		.18	.17
.19		.18	.17
	1.89	2.00	1.89
	8.76	8.23	10.0
	2.51	2.83	2.87
1.40		.93	1.44
.88		.86	.87
1.60		1.14	1.40
	12.5	9.0	14.0

run for an 8-minute cycle, thus giving us the best possible sensitivity consistent with the work pattern of an average abrasive blaster. This instrument was normally used to provide inside the mask readings where a mask or helmet was worn and breathing zone measurements where no respiratory protection was provided. The GCA 201 is a beta-absorption filtration device with no practical lower particle size cut off limit. It has about 1/60 the sensitivity of the 101, and we used it to measure outside the mask or very dusty environments. It is also programmed to run for an 8-minute cycle. We used the Bendix UNICO Micronair personnel sampler modified to accept a Millipore filter. With this set up we were able to collect samples for subsequent emission spectrographic analysis, microchemical analysis, X-ray diffraction analysis, electron microphotography, and for oil mists in supplied air.

In all cases, with the exception of hydrocarbon analyses, all instruments were run at 2 L/min with 10-mm nylon cyclones especially fitted with a tangential tubular opening so as not to restrict flow. Sampling lines were kept to minimum length, usually 12 inches at most of ¼ inch i.d. tygon. Exactly equal sampling lines were always employed on the inside and outside the respirator samplers to offset line loss. Where it was necessary to penetrate a tight mask or half-mask respirator a #13 needle of normally ½″ length was used, both pentrating and outside the respirator. Calcium, copper, chromium, manganese, magnesium, lead and zinc were determined by standard micro atomic absorption techniques. High silica samples were similiarly analyzed where free quartz wasn't needed. Regular silica (total)[4] and aluminum and iron[5] were performed colorimetrically. Where free quartz was desired a large grab sample, a sample of the grit, or a sample from outside the respirator was used and tested by the methods of Talvitie.[6-8] In the case where a quartz value was determined for the outside the respirator atmosphere the same proportion of quartz in total silica was assumed for the inside the respirator atmosphere so that adequate TLV's could be assessed. Hydrocarbons (specifically the CH_2 group) were determined by solution in pure CCl_4 and comparison of the 2930 cm^{-1} band.

A simple elutriation column was constructed so that some sort of calibration could be performed on a number of dusts against microgravimetric procedures. The fine dusts employed were tantalum powder (ρ16.6), molybdenum powder (ρ10.2), molybdenum disulfide (ρ4.8), and silica (ρ2.6).

Table I gives some comparative results obtained in the field using different instrumentation. Data are given only where three or more methods were used to sample the same atmosphere. It should be noted that the detection limit of the 101 and 201 do no overlap well.

Noise level measurements

The degree of worker noise exposure has proved to be the real surprise in the program. The noise hazard has been found to be almost universally ignored. Of 112 individuals monitored for noise data:

a. 15 were required by company work rules to wear hearing protection;

TABLE II
Noise Exposure Summary

PROCESS/BUSINESS/EQUIPMENT	TOTAL NUMBER	AVE. EXPOSURE TIME (HRS/DAY)	AVE. SOUND PRESSURE LEVEL (DBA)	MAXIMUM SOUND PRESSURE LEVEL (DBA)
Air-fed helmets	56	5.3	100.5	126
Non air-fed hoods	15	5.3	106.1	126
Monument shops	13	4.8	101.3	112
Shipyards	16	6.0	104.8	126
Painting/sandblasting contractors	32	5.6	105.4	118
Primary metals industries				
airless process	14	3.5	95.5	114
dry process	22	4.2	99.1	112

TABLE III
Working Area of Employees Monitored

AREA	NUMBER	%	PRELIMINARY QUESTIONNAIRE %
Outdoors	47	42	35.5
Cabinet (Rotoblast, Tumbleblast, other airless process)	17	15	13.8
Special room			
monument blast room	13		
regular blast room	12		
total	25	22	22.2
General work area			
open shop	3		
glove box	10		
total	13	12	15.9
Other			
tank or other confined space	8		
not elsewhere classified	3		
total	11	9	12.6
Total	113	100	100

b. 9 actually were observed wearing hearing protection where required;
c. 3 wore hearing protection where not required by their employer; and
d. 76 (or 68%) needed and did not have hearing protection (based upon time-weighted measurements actually made).

One of the most interesting facets of the blasting noise level problems is that of the air turbulance noise within air-fed helmets. The mean absolute background (no blasting noise) sound pressure level in the helmets measured was 92 dBA. The mean noise above ambient (no blasting) was 12 dB.

The outside the helmet noise level of hand held hose blasting operations is very high. The mean for 56 air-fed helmeted operations was 114 dBA with extremes of 98-126 dBA. Attenuation afforded by the helmet ranged from 0 to 23 dBA with a mean of 11.

Table II gives the exposure norms of workers in several industries employing differing processes. It can be seen that airless processes generally do not generate a noise exposure hazard. Painting and sandblasting contractors, due to their high use of non air-fed hoods, and shipyards, due to their high use of tight masks and air line respirators, both have extreme average noise hazard levels. While shipyards are far superior to painting/sandblasting contractors in general respirable dust exposure levels there is little to choose between them in average sound pressure level exposures. The average sound pressure levels were calculated by averaging a continual tabulation of the noise levels within the helmets during the test period and assuming that this was representative of the general noise level during the number of nozzle hours reported. When the average sound pressure level and average exposure time data from Table II are compared with the OSHA permissible exposures, it can be seen that hearing protective equipment use is dictated in every category except the airless processes. As previously noted, essentially no job requirement for or use of hearing protection was observed. In virtually every case, management assumed that the helmets they provided afforded adequate hearing protection. In only 3% of the cases studied have regular audiometric tests been required, and two of these involved exposure to the less severe condition of the airless process.

Respirable dust measurements

This section of the report will describe the respirable dust measurement results, with protection factors and exposures vs. threshold limit values (TLV) observed.

Where respirators were found to be worn no suggestions as to proper fitting were made prior to measurement. The data that was wanted was the protecion afforded by the respirators as normally worn.

Table III summarizes the working areas monitored. The nationwide percentage of such work areas as defined by the preliminary questionnaire phase are included for comparison purposes. Numerous cases of inadequate or inappropriate respiratory protection were observed. Table IV summarizes the general types of respiratory protection observed.

In many instances the management of the visited firms were unaware of the inadequacy of their equipment. Many expressed thanks that the deficiencies were found at this time rather than by an insurance inspector or OSHA compliance officer at a later date. A number of firms have promised to obtain approved respiratory devices and to set up positive hearing loss prevention programs as a result of this survey.

As was done in the noise data presentation, we propose to divide the blasting population into five logical segments:

a. Memorial monument makers
b. Shipyards
c. Painting/sandblasting contractors
d. Primary metals industries (dry blasting)
e. Primary metals industries (airless blasting)

Each of these industrial segments have peculiar problems and procedures. These peculiarities warrant their individual treatment. This does not say that a particular segment may not comprise many industries. Primary metals industry includes everything from basic steel, forge shops, foundries, to commercial heat treat shops—the common denominator being common practices and procedures.

A summary table is presented giving the average exposures for each industrial segment showing the protection factors and assigned TLV's for each monitored exposure. The table will be divided into seven columns:

a. Column 1 is the respirator code, as follows:
   - None — none worn
   - NDR — nuisance dust respirator only
   - Ric — ricochet hood only
   - Ric/N — ricochet hood over NDR
   - Air — air supplied helmet only
   - Air/N — air supplied helmet over NDR
   - ALR — air line respirator only
   - R/ALR — ricochet hood over air line respirator
   - HM- — prefix implying homemade
   - Shield/N — face shield over NDR
   - Shield — face shield only
b. Column 2 is the breathing zone respirable dust measured in mg/m^3.
c. Column 3 gives the ambient respirable dust concentration outside the respirator.
d. Column 4 gives the protection factor calculated where a respirator was worn using the formula:

$$PF = \frac{\text{ambient respirable dust } (mg/m^3)}{\text{BZ (in mask) respirable dust } (mg/m^3)}$$

TABLE IV
Respiratory Protection Observed

	NUMBER
Air-fed helmet plus nuisance dust respirator	3
Homemade air-fed helmet plus nuisance dust respirator	1
Air-fed helmet only	42
Homemade air-fed helmet only	1
Richochet hood plus air line respirator (includes tight mask blasting helmets)	6
Ricochet hood plus nuisance dust respirator	6
Ricochet hood plus rag over mouth and nose	1
Ricochet hood only	8
Air line respirator plus sweat shirt hood	2
Chemical workers' face shield only	1
Face shield plus nuisance dust respirator	1
Goggles plus nuisance dust respirator	1
Nuisance dust respirator only (required by nature of operation)	3
Nuisance dust repirator only (not required by nature of operation)	4
No respiratory protection worn nor required by nature of operation	26
No respiratory protection worn although nature of operation indicates the need for protection	7

e. Column 5 lists symbols for the predominant respirable dust contaminants as measured chemically. Calculations were made on the basis of the most likely oxide.
f. Column 6 lists the exposure hours per day for each monitored workman. Some of these are startling.
g. Column 7 is the assigned TLV based upon the chemical and x-ray diffraction analyses of the dusts collected.

MONUMENT SHOPS

This segment of the abrasive blasting industry is basically one of the cleanest and best studied[9-11] of all.

Respirators are only used about half the time and are seldom necessary due to the inward suction through the curtain. Safety glasses are universally ignored, but the Ruemelin window above the opening offers reasonable protection. Old time stone blowers do tend to have frosted spectacles due to the ricochet of the media (usually alumina) from the rubber masking. The normal pot size is 300-600#, the normal nozzle, a nominal 3/16″ at 85 psig. Modern shops have installed automatic blasters which continually pass back and forth and up and down over the marker face. This allows a blower to handle two rooms or to experience less noise while cutting stencils. Also, he gets less dust exposure. The prime dust exposure during monument making is sweeping, coating, grinding and cutting, and tooling, which are not blasting procedures per se. Table V gives the dust data observed.

TABLE V
Summary of Average Respiratory Protection Observed

RESP CODE AND SAMPLE NUMBER (1)	BZ MG/M3 (2)	AMBIENT MG/M3 (3)	PROTECTION FACTOR (4)	CONTAMINANTS (5)	HRS. (6)	ASSIGNED TLV MG/M3 (7)
Monument industry						
None (7)	1.02			Si-Al-Fe	4.0	1.93
NDR (5)	.78	2.38	3.05	Si-Al	5.8	2.06
Ric/N (1)	.14	2.45	17.5	Si	6.0	.10
Shipyards						
Air (12)	.59	26.5	45.0	Al-Si-Pb	6.6	2.64
Ric (1)	.69	2.50	3.63	Si	4.0	.11
R/ALR(3)	.56	15.9	28.4	Pb-Si-Fe	6.3	.41
Painting/sandblasting contractors						
Air (14)	.93	13.9	15.0	Si-Pb	5.6	.55
Ric (5)	2.89	6.13	2.13	Si-Pb	4.8	.14
Ric/N (3)	3.52	8.09	2.29	Si-Fe	7.0	1.69
Air/N (3)	.12	19.5	163.	Si	5.3	.14
R/ALR (4)	.20	14.5	72.5	Si-Al-Fe	4.8	1.34
HM-Ric (1)	2.15	7.24	3.3	Si	6.0	.10
HM-Air (1)	.17	10.0	58.0	Si-Pb	6.0	.22
HM-Air/N (1)	.79	5.60	7.10	Si	5.0	.24
Shield/N (1)	.18	9.00	50.0	Si-Pb	6.0	.10
Primary metals industries (dry process)						
Air (13)	6.59	26.4	4.02	Al-Si-Fe	4.8	2.45
None (6)	7.70			Al-Fe	3.8	4.39
Ric (1)	2.73	8.45	3.10	Si	2.0	.11
NDR (2)	1.04	3.09	2.96	Al	4.0	5.00
Ric/N (1)	1.22	Lost	....	Si-Mg	6.0	.23
Air/N (1)	.13	82.0	630.	Si-Fe	5.0	.10
Shield (1)	.55	1.55	2.80	Al	1.0	5.00
R/Rag (1)	4.90	42.5	8.70	Si-Cu	6.0	.11
Primary metals industries (airless process)						
Air (1)	.39	84.0	215.	Fe	6.0	5.00
None (20)	2.78			Fe	3.5	4.11

SHIPYARDS

Shipyards have better equipment on the whole although they do precisely the same work as painting/sandblasting contractors. They have active safety programs *and* Navy inspectors. Shipyards were included in this study to start with to provide an internal control wherein good safety practices might be expected to be found. By and large we were not too disappointed, with exception of the noise level data. Table V gives the dust data observed.

PAINTING/SANDBLASTING CONTRACTORS

Few firms do sandblasting exclusively. This investigator has visited some firms where 100 were employed more or less full time, but, frankly, most of these people normally take a blasting job to get the painting contract. Their equipment and working conditions are the most primitive of all categories mentioned in this report. They are after all a construction trade, and construction workers are accustomed to putting in a full eight hour shift with an element of risk.

Pots will normally vary from a 300# one man operation to a one ton with hopper to the Key 40 Ton.

Equipment varies from the very good air fed helmets to many ricochet helmets often worn alone or over an inadequate dust respirator. This last and quite prevalent case is a clear violation of the law where sand is the blasting media, and in this category sand is the universal media. Table V gives the dust data observed.

PRIMARY METALS INDUSTRY (DRY BLASTING)

Here we find a great deal of variety of conditions. Much work is done in glove boxes where no respirators are required if the gloves don't leak. Other work may be done in blast rooms where very good heavy duty equipment is required to protect the blaster from the steel shot usually used under such conditions. Some small marginal foundries use very worn out helmets, and the classic of all, a dirty undershirt worn bandit fashion and covered by a tattered ricochet hood while sandblasting copper (33X TLV). Table V gives the dust data collected.

PRIMARY METALS INDUSTRY (AIRLESS BLASTING)

Here we discuss rotoblasts, tumbleblasts, large head mills, and other processes where the blast grit (usually steel shot) is confined, the workers are outside, and no respiratory protection is dictated. These are fairly safe operations if one ignores ricochet through poorly closed doors and ball bearings all over the floor. The operator station dust data is given in Table V.

FIELD SURVEY DUST DATA SUMMARY

Protection factors were determined where respiratory protection was found to be worn. Where nuisance dust respirators alone were worn, factors from 2.0 to 38.0 were found. Where ricochet hoods alone were worn, factors from 1.6 to 5.6 were found. Where a combination of a nuisance dust respirator plus a ricochet hood was found to be worn, factors from 1.7 to 122. were found. Where air supplied helmets were used, protection factors from 1.9 to 3750 were noted. The remarkable range of these latter figures is attributable to the condition of the individual equipment rather than to any particular brand superiority. Very high values are also associated with very high helmet inlet air flow rates with resultant high air turbulence noise levels.

Where respirators are provided, the average protection factors afforded workers in the various industrial segments (excluding two unrepresentative data points) are: monument making, 5.3; shipyards, 235.1; painting/sandblasting contractors, 60.6; primary metals (dry blasting), 128.2 and; primary metals (airless blasting), 215.0.

General observations

The amount of blasting media purchased per year was obtained where possible in order to gauge the extent of each blasting operation. Figures varied from 200 pounds/year to 372,000 tons/year. About 90% of the media reported purchased was sand.

Observations indicated only four conscious attempts to offer the wearer a reasonable selection of respirators so that one more nearly providing a face fit could be obtained. Helmets are made in one universal size which seems to please no wearer. Where half masks were worn in low dust operations, no attempt to ascertain fit was observed.

Maintenance was universally poor to nonexistent. Helmets were observed in use with missing face piece seals and protective collars. Such poor maintenance invariably leads to poor protection factors.

Helmets are not well designed from the wearer's standpoint. Many provide poor visibility. Those with screens over the windows are impossible to see out of when the sun catches the screen. Air inlets are far too noisy.

The average blaster seems unconcerned by equipment deficiencies. His trade has always been dusty and noisy.

Safety devices, such as dead-man switches, are items to be ignored or circumvented by wiring open.

Lines and fittings are universally interchanged. The interviewer did not see one case or meet one person that was aware that Schedule 19B certifies type CE respirators and air lines as an assembly. When used separately the certification is void.

Expansion valves are commonly used (usually in violation of 19B) in order to keep the air breathable in hot climates. These vortex tubes are well accepted by the workers.

Water condensate in air supply lines far outstrips oil mist as a nuisance value, especially in warm climates. Reasonable amounts of oil mists (0.5-7.8 mg/m^3 with a mean of 2.5) were found, but compared to air hoses that behaved like garden hoses this was nothing.

Aprons are commonly dispensed with in favor of coveralls.

Grit is normally allowed to accumulate on the floor of a blast room until it is needed to refill the pot.

All wheelabrators leak to some degree and the danger of eye damage from this is always present. The floor in front of the average wheelabrator is a sea of ball bearings making walking hazardous.

By and large, when other means of control, such as local exhaust, glove boxes, and monument rooms are used, respirators are neither worn nor needed to maintain below TLV exposures.

References

1. BLAIR, A. W.: Abrasive Blasting Protective Practices Study-Preliminary Survey Results. *Amer. Ind. Hyg. Assoc. J. 34:*61 (1973).
2. OLIN, J. G., et al: Piezoelectric-Electrostatic Aerosol Mass Concentration Monitor. *Amer. Ind. Hyg. Assoc. J. 32:*209 (1971).
3. LILIENFELD, PEDRO: Beta-Absorption Impactor Aerosol Mass Monitor. *Amer. Ind. Hyg. Assoc. J. 31:*722 (1970).
4. ASTM D859
5. ASTM D857

6. TALVITIE, N. A.: Determination of Quartz in Presence of Silicates Using Phosphoric Acid. *Anal. Chem. 23:*623 (1951).
7. TALVITIE, N. A.: Determination of Free Silica: Gravimetric and Spectrophotometric Procedures Applicable to Air-Borne and Settled Dust. *Amer. Ind. Hyg. Assoc. J. 25:*169 (1964).
8. TALVITIE, N. A. and L. W. BREWER: X-Ray Diffraction Analysis of Industrial Dust. *Amer. Ind. Hyg. Assoc. J. 23:*214 (1962).
9. PORTER, H. G.: Survey of Cemetary Memorial Industry in Indiana. *Amer. Ind. Hyg. Assoc. Quart. 10:*68 (1949).
10. West Virginia State Health Department, Bureau of Industrial Hygiene: Industrial Hygiene Survey of the Granite and Marble Memorial Industry in West Virginia. 1940. *Pneumoconiosis Absts. 11:*408 (1954).
11. YEE, H. T. and H. G. BOURNE: Survey of Monument Industry in Ohio. *Amer. Ind. Hyg. Assoc. J. 31:*503 (1970).

corrected recommendation . . .

In the article *Recommended Procedures for Sampling and Counting Asbestos Fiber* authored by the Joint AIHA-ACGIH Aerosol Hazards Evaluation Committee (*Am. Ind. Hyg. Assoc. J. 36:*83), an incorrect recommendation covering filter equipment was incorporated. The last two paragraphs in the first column on page 89 should read:

Millipore Corp. Aerosol Analysis Monitors are recommended. These are pre-loaded with 37mm cellulose backup pads and Type AA white filters that are either plain (catalog no. MAWP 037 AO) or gridded (catalog no. MAWG 037 AO). These pre-loaded Monitors are sold with a guaranteed average background particle count and can be used without additional background checks.

It is less expensive to purchase these pre-loaded Monitors than unloaded Monitor Cases (catalog no. MOOO 037 AO) to be loaded with 37mm pads and filters (catalog no. AAWP 037 OO plain filters, catalog no. AAWG 037 OO gridded filters). In addition, pre-loaded Monitors have an even, airtight seal around the rim. This seal cannot be duplicated by hand. Consequently, Monitor Cases should not be reused when the seal is not tight. Furthermore, it is necessary to clean carefully each empty Monitor Case and to check the background count on filters in the reloaded Monitors.