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WORKER EXPOSURE TO VINYL CHLORIDE IN VINYL CHLORIDE AND POLYVINYL CHLORIDE PRODUCTION AND FABRICATION

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to VC exposure. Besides angiosarcoma of the liver, excesses of lung cancer, brain cancer and lymphoma have been found. In addition, Rannug et al[101] have reported that VC shows mutagenic activity when metabolically activated in a microbial system. Chromosome aberrations in workers exposed to VC have been reported by Funes-Cravioto et al[41] and Purchase et al.[99] Infante[52] has reported an increased prevalence of congenital malformations in communities surrounding polyvinyl chloride polymerization plants.

REPORTED WORKER EXPOSURE

The first report in the literature of VC exposure levels for workers appears in the Russian literature. Filatova and Gronsberg[39] in 1957 reported on VC levels in a Russian PVC polymerization plant using the emulsion process to produce PVC. They found that levels in the reactor areas varied from 15 to 16,000 ppm, but the most frequently found concentrations varied from 38 to 310 ppm. In the precipitator and centrifuge area levels were 8 to 3050 ppm and in the drying oven area 4 to 15 ppm. An evaluation of different types of driers used in the PVC industry was reported in 1959 by Gavruseyko and Filatova.[43] VC concentrations up to 27 ppm were found in areas near chamber-type driers. They also reported on PVC dust concentrations varying from 100 to 248 mg/m^3 during drying operations and from 725 to 1200 mg/m^3 during unloading. Levels of 257 to 417 mg/m^3 were found while unloading vacuum-rabble driers. PVC dust levels encountered in screening operations varied from 72-170 mg/m^3. In 1965, Filatova et al[40] reported that levels of VC

in a PVC latex polymerization plant as high as 115 ppm were found and 75% of their measurements were above the maximum allowable concentration (MAC) of 12 ppm. PVC dust concentrations varied from 1 to 6.5 mg/m^3 except at the bagging station where levels as high as 78 mg/m^3 were found.

Filatova and Antonyuzhenko[38] have reviewed the changes in worker VC exposure in the Russian PVC industry from 1953 to 1969. From 1953 to 1958 the percentage of samples exceeding the MAC reduced from 80% to 2%. Also the maximum concentration of VC was reduced by a factor of 900. Increasing production rates brought an increase in levels of VC until in 1969, 76% of samples exceeded the MAC. However, maximum VC concentrations were 8-40 times lower than in 1954.

There have also been a few reports from other countries. Suciu et al[115] reported in 1967 that VC levels in a Romanian plant ranged as high as 2/20 ppm. Anghelescu et al[5] in 1969 reported that levels of VC at work stations in a Hungarian plant ranged from 43 to 213 ppm. Gitsios[46] reported that peak levels as high as 10,000 ppm were found in a Greek plant. Drums containing waste polymer were found to have VC levels as high as 600 ppm. Byren and Holmberg[21] reported in 1974 that VC levels in Swedish plants averaged 18-20 ppm in reactor rooms and less than 5 ppm in drying and packing areas.

Cook et al[25] reported that levels of VC present during reactor cleaning were usually 50-100 ppm with peaks of 600 to 1000 ppm close to the

workers hand during scraping. The remainder of the published data on workspace air concentrations of VC are from one plant. Baretta et al[10] reported extensive exposure data in 1969 showing peak levels above 1000 ppm. Levels of exposure for different jobs exceeded 50 ppm from 5 to 65% of the time. Time weighted average (TWA) exposures ranged from about 5 to over 200 ppm. TWA exposures to VC for one job category showed a daily and shift variation of 105 to 240 ppm. Kramer and Mutchler[63] reported on this same plant in 1972. TWA VC exposures from 1950 through 1965 had been determined. TWA's ranged from less than 10 ppm to 300 ppm. The average TWA exposure in 1950 was 155 ppm while the average in 1965 was 30 ppm. Ott et al[93] provide yet another source of information on VC levels at this plant. TWA's during the period 1950-1959 range from 5 to 825 ppm, but only one job class was above 385 ppm. From 1960 to 1966 TWA's ranged from 5 to 240 ppm with only two job categories above 100 ppm. TWA's were reduced further until at the time of the report in 1975 they were approximately 10 ppm.

Description of the processes involved, the jobs associated with each process and the VC exposures found for each are described in the remainder of this report.

DESCRIPTION OF PRODUCTION PROCESS

Vinyl Chloride Process

At the present time, VC is manufactured in the United States in 15 plants using three basic processes:

(1) Acetylene-hydrogen chloride process.

Table 5

Summary of Vinyl Chloride Sampling Data by Job
in All Monomer Plants Sampled

Job	n	$\bar{x}^*$ (ppm)	$\bar{x}_g$ (ppm)	Range (ppm)
Operator	95	0.64	0.21	0.01-18.2
Loader	37	8.04	1.67	0.06-84.77
Maintenance Worker	16	0.26	0.18	0.01-0.55
Lab Technician	36	0.28	0.09	<0.01-4.36
Foreman	7	0.10	0.08	0.03-0.21
Total of Personal Samples	191	1.89	0.26	<0.01-84.77
Composite of All Area Samples	40	1.09	0.30	<0.01-7.06

* $\bar{x}$ = TWA

Table 22

Summary of Vinyl Chloride Sampling Data by Job
— All Polymerization Plants Sampled

Job	n	$\bar{x}$* (ppm)	$\bar{x}_g$ (ppm)	Range (ppm)
Operator - RA***	241	9.1	4.2	ND-245.0
Helper - RA***	113	14.3	8.2	ND-160.5
Operator - DA**	37	5.4	2.7	ND-82.8
Helper - DA**	10	1.8	1.4	0.6-3.6
Bagger	35	1.9	1.5	ND-9.6
Foreman	5	3.5	1.0	0.1-22.0
Maintenance Worker	8	4.2	2.6	ND-12.8
Total of Personal Samples	449	8.4	3.8	ND-245.0
Control Room Area Samples	55	3.8	1.5	ND-96.5
Other Area Samples	13	4.4	3.3	0.9-15.9

* $\bar{x}$ = TWA

** Dryer Area

*** Reactor Area

Table 23

Summary of Polyvinyl Chloride Dust Sampling Data
Polymerization Plants

Job	n	$\bar{x}$
Bagger - S.R.	9	0.94
Bagger - St.R	2	1.01
Bagger - E.R.	9	8.88
Fork Lift Operator	1	0.82
Dryer Operator	1	0.73
Total of Personal Samples	22	4.18

S.R. = Suspension Resin
St.R. = Solvent Resin
E.R. - Emulsion Resin

Table 30

Polyvinyl Chloride Dust Sampling Data
Plant L

Location	Dust Concentration mg/m^3
Near Blender	12.5
"	7.22
"	6.67
"	8.75
"	11.67
Near Mixer	10.0
"	6.06
Near Calender	11.67
"	8.33

Table 32

Polyvinyl Chloride Dust Sampling Data
Plant M

Location	Dust Concentration mg/m^3
Mixing Area	6.67
Blender Area	1.67
Mill Area	6.67
Banbury Mixer Area	13.33
Calender Area	6.67
Plastisol Mixing Room	7.9
Cast Film Line	7.27

Table 33

Summary of Vinyl Chloride Sampling Data by Job
—All Fabrication Plants Sampled

Job	n	$\bar{x}^*$ (ppm)	$\bar{x}$ (ppm)	Range (ppm)
Calender Personnel	28	0.57	0.24	ND-2.44
Compounding Personnel	78	0.11	0.05	ND-0.69
Extrusion Personnel	58	0.09	0.04	ND-0.76
Lab Personnal	18	0.08	0.05	ND-0.68
Maintenance Personnel	10	0.01	<0.01	ND-0.02
Molding Personnel	16	<0.01	<0.01	ND-0.03
Plastisol Dipping Personnel	40	0.01	<0.01	ND-0.06
Miscellaneous Personnel	20	<0.01	<0.01	ND-0.01
Total of Personal Samples	268	0.14	0.03	ND-2.44
Composite of All Area Samples	32	0.04	0.05	ND-0.68

* $\bar{x}$ = TWA

CONCLUSIONS

Monomer Plants

Monomer plants had generally low concentrations of VC exposure for personnel. The only job category with a TWA higher than 1 ppm was that of loader. The work practices for this job were being modified to lower exposures. One plant had already lowered exposures below 1 ppm and plants were using self contained breathing apparatus or supplied air respirators to limit exposure to VC for this job. So the levels found are indicative of the potential exposure but not necessarily the actual exposure of these workers. These levels also suggest that this has been a high exposure job in the past, before respiratory protection was used.

Polymerisation Plants

Jobs requiring the most time in the reactor areas had, as would be expected, the highest exposure to VC. Reactor area helpers had the highest TWA and it was these workers who did the job of cleaning reactor vessels when necessary. Again these workers were using supplied-air respirators when inside vessels or performing other jobs, such as changing filters, that could have high exposures to VC, so the exposures may not be actual exposures. VC exposures in the past, though, were higher because vessels were not purged of VC nearly so well before workers entered. Reactor area operators also had high exposures. Baggers and dryer area helpers had the lowest TWAs, but were still not under 1 ppm.

The workers involved with the solvent process had the lowest TWAs, then the mass process workers, the emulsion process workers

and finally the suspension process workers had the highest TWA. One other variable which was impossible to measure was management attitude towards keeping VC exposures low. It was observed within plants that housekeeping and work practice procedures varied from area to area because of the attitude of foreman in the areas. Dust levels were relatively low for all jobs except the emulsion resin baggers. The high dust levels for this job are probably due to the small particle size of emulsion resin. Better dust control measures need to be initiated for this job.

Fabrication Plants

All job categories in the fabrication plants had TWA exposures that were quite low. Only calender personnel had a TWA above the required action level of 0.5 under the new OSHA standard. Working locations in almost every instance of exposure to VC were amenable to the application of standard control measures, such as local exhaust ventilation. Dust levels were uniformly high for the two plants where measurements were taken. However, the dust is probably not all PVC, since fillers and other additives are being used in the operations. Better dust controls should still be implemented in areas where dusty materials are handled.

Overall, polymerization plants had the highest TWA of 8.4 ppm and also the highest individual job TWA of 14.3 ppm. Also workers in polymerization plants had the widest range of VC exposures, with peaks as high as 245 ppm. Monomer plant workers had the next highest overall

TWA of 1.89 ppm, a factor of 4 lower than polymerization plant workers. The TWA for one job category was 8.04 ppm, almost the same as the polymerization plant workers, while the remaining workers were considerably lower. Fabrication plant workers had the lowest overall TWA of 0.14 ppm, a factor of 60 lower than polymerization plant workers and 13-1/2 lower than monomer plant workers. These results substantiate the initial emphasis of studies on polymerization plant workers as having the highest VC exposures.

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