

WORKING CONDITIONS AND MEASURES FOR THEIR IMPROVEMENT IN
PRODUCTION AND USE OF VINYLCHLORIDE PLASTICS.

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The production of vinylchloride plastics and also the different goods prepared from them gained in the last decade considerable importance. In the meanwhile from hygienical point of view, it was little studied.

The basic raw material for the preparation of vinylchloride plastics is vinylchloride resin, which is prepared from vinylchloride, a colorless gas, condenses at $12 - 14^{\circ}$ in liquid with a specific weight of 0.86 - 0.9. Vinylchloride, on its turn, is prepared by the reaction of gaseous decomposition products of petroleum vapors (vinyl) and gaseous chlorine. Subsequently, the vinylchloride condenses by using dichloroethane and is subjected to polymerization in autoclaves. In this way, polyvinylchloride resin is the product of vinylchloride polymerization. Due to the resistance to alkali, diluted acids, ethers, benzene and lubricating oil, polyvinyl chloride resin is used for the preparation of acidresistant fillers, fabrics for overalls, substituents to hides, etc.

At the preparation of various goods, the polyvinylchloride resin is plasticized with complex ethers of phthalic acid (dibutylphthalate), phosphoric acid (tricresylphosphate), mixture of diphenylchloride (sovol), or chlorinated naphthalenes (golowax). The selection of the plasticizer depends on the assigned use of the plastic to be prepared.

According to the data of the literature, vinylchloride belongs to narcotics. Its narcotic concentrations for humans are within the limits of 75 to 250 mg/l. According to the data by Petropavlovskii (1942), volatile substances, liberated, when vinylchloride resin and plasticizers are heated to $130-165^{\circ}$ cause in animals under the condition of one single inoculation, depending on the concentration, the following phenomena:

irritation of the ocular mucous membrane, respiratory disorders, damage of the central nervous system, breakdown in the coordination of movements, and death, after appearance of asphyxic convulsions.

Sovol and golowax, introduced into vinylchloride plastics, as plasticizers, have general and local toxic effect. In their overall action on the organism, sovol and golowax are close to chlorinated fatty hydrocarbon. Basically they attack the parenchymal organs. Severe toxic effect takes place in form of acute, or subacute yellow atrophy of the liver. In the literature, cases with lethal outcome are described, caused by the toxic effect during the production with vinylchloride naphthalenes (golowax) and diphenyls (sovol). The local action of sovol and golowax causes acne-type skin eruptions and erythematous-vesicular dermatitis.

We studied the working conditions at the finishing of vinyl chloride plastics under factory conditions in a vinylchloride plastic plant, using vinylchloride plastics as substituent for hides and for insulation of electric wires.

Production of vinylchloride plastics:- In the vinylchloride plastics plant, the vinylchloride resin (a white powdery mass) is mixed with dibutyl phthalate, or with sovol in mixing apparatus, at a temperature of 80-100°. Then, the compound is transferred onto rollers, the surface of which is heated to 130-160°V.

At the end of the rolling, the vinylchloride fabric is cut up in narrow tapes, which are further sorted and packaged in boxes.

During the hygienical inspection of the vinylchloride plastic plant, the air of the working place was examined on its sovol-, organochlorine compound-, and hydrochloric acid vapor content. The obtained results are plotted in Table 1.

Table 1:- Organochlorine compound, sovol and hydrogenchloride content in the air of vinylchloride plastic plant

Название отделения 1	Место взятия пробы 2	3 Концентрация в мг/л	
		хлороорганические соединения, в том числе совола 3а	хлористый водород 3б
Подготовительное	8 В шкафу для подогрева совола	0,005	15 Не обнаружен
4	9 В середине помещения на уровне дыхания рабочего	0,003	" "
5 Смешения и вальцовки	10 У смесителя во время смешения компонентов	0,06-0,08	0,005
6 То же	11 У смесителя во время выгрузки композиции	0,01-0,08	15 Не обнаружен
" "	12 На рабочем месте вальцовщика	0,2-0,97	0,005
" "	13 У стола для остывающего пластика	0,27	15 Не обнаружен
7 Сверловочное	14 У рабочего места сверловщика	0,005	" "

1. Name of the department; 2. Place of the sample taking; 3. concentration in mg/l; 3a. organochlorine compounds, included sovol¹; 3b. hydrogen chloride; 4. preparation; 5. mixing and rolling; 6. the same; 7. drilling; 8. in the exhaust hood of the heated sovol; 9. in the middle of the chamber, at the respiration level of the workers; 10. at the mixer at the time when the components were mixed; 11. at the mixture, at the time when the components were discharged; 12. at the working place of rolling; 13. at the deck for the cooled plastic compound; 14. at the working place of the drill operator; 15. not detected;.

In the air of the working places of the vinylchloride plastic plant, as one can see this from the data of Table 1, the concentration of organochlorine compounds fluctuated between 0,005 to 0,27 mg/l. In the preparation department sovol vapors formed at its heating, discharging and transportation. The concentrations of organochloride compounds, found in this place (0,005 mg/l) can be attributed, most likely, in great part to sovol

¹ On account of the insufficiently developed method to determine separate organochlorine compounds, they were determined summarily.

At the mixers the organochlorine compounds were found in an amount from 0,01 to 0,08 mg/l, and in the working place of the rolling - from 0,2 to 0,97 mg/l.

In the product sorting department the organichlorine compounds, usually, did not exceed 0,05 mg/l. We detected hydrogenchloride only in the different samples in amounts, not exceeding thousandth part of milligram.

In connection with the use of sovol, soiling the skin with ingredient in the composition of which sovol was introduced causes serious danger. On the skin of the hands of the workers we found organochlorine compounds.

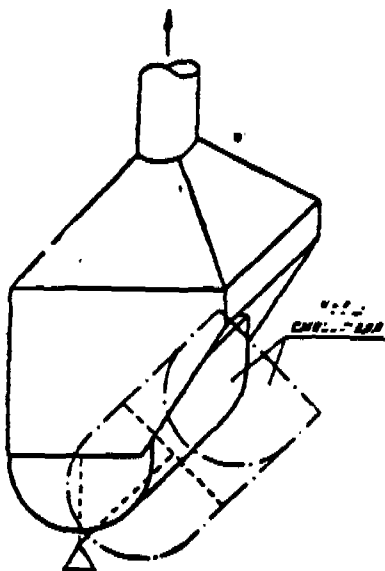
To fight the contamination of the air, the plant was mounted with influent and exhaust ventilation with automatic driving. The exhaust ventilation was constructed on the principle of local exhaust from the hoods, placed over the basic sources of gas evolution.

The efficiency of the ventilation, as this was demonstrated by the sanitary-technical inspection, was insufficient, on account of the fact, that the air-feed was carried out with a rate of only 7 - 8 m/sec on the level of the shoulders of the workers. The unpleasant sensation, caused by similar way of air feed, together with the infiltration and cooling of the compounds on the rollers forced the workers to overlay the damper of the sprinkling valves and already with this, the air current, escaping through the different leakages, decreased the work of the exhaust device, deviating the convective current, which got up from the rollers. Besides, the closing of the influx nozzle, disrupted the balance between the influx and the exhaust and attracted inorganized admission of contaminated air from the neighboring places.

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A significant defect of the ventilation system was the insufficient efficiency of the low-capacity hoods, arranged over the decks for the ready products and over the mixers. Much more effective are, according to our project executed orifices over the mixers in form of tents with open front wall (see the figure). At a productivity of 1 000 m³/hour these orifices practically completely localized the separation of noxious gas.



Scheme of the tentlike openings of the mixer.

Use of vinylchloride plastics as substituent for hides:- In the production of vinylchloride footwear, the basic raw material is polyvinyl chloride resin, which is prepared by the polymerization of vinylchloride in a water-emulsion method. The temperature of the decomposition of this resin is 130 - 150°. As plasticizer here dibutylphthalate and as stabilizer potassium stearate is used.

The compound for the sole is prepared by mixing textile scraps, saturated with dibutylphthalate, and vinylchloride resin in the mixer. The obtained compound is piled on the heater to 170 - 200° and rubbed through after this with Vaseline in the press mold. The, in this way filled press form is closed, it is maintained for a few minutes, and then is placed for a short time under the hot press.

The composition for the upper footwear is obtained by mixing a determined amount of polyvinylchloride resin and dibutylphthalate in the mixer. The mass is kept there for aging 12 hours at a temperature of 70°. After the aging the compound is rolled at a temperature of 120-140° with the addition of potassium stearate. The vinyl chloride plastic compound, obtained after the rolling is rapped in textile and pressed at a temperature of 160°.

The analysis of the air for noxious gas and vapor content in the plant of vinylchloride footwear production is plotted in Table 2.

Table 2:- Concentration of gases and vapors in the air of working places in vinylchloride footwear manufacturing plants in mg/l

Место взятия проб /.	Хлороорганические соединения 2					HCl			7 C (суммарно)			CO				
	6 концентрации в мг/л															
	3 мин. маленькая	4 макс. маленькая	5 макс. маленькая	5 средняя	3 мин. маленькая	4 макс. маленькая	5 макс. маленькая	5 средняя	3 мин. маленькая	4 макс. маленькая	5 макс. маленькая	5 средняя	3 мин. маленькая	4 макс. маленькая	5 макс. маленькая	5 средняя
1а У вальцов . .	0.14	0.48	0.35	0.028	0.036	0.032	0.07	0.35	0.2	—	—	—	—	—	—	0.022
1б У прессов . .	0.25	1.13	0.65	0.008	0.036	0.055	0.21	2.61	1.23	—	—	—	—	—	—	0.019
1с В помещении сварочной	0.53	1.2	0.92	0.03	0.17	0.23	0.10	0.68	0.23	—	—	—	—	—	—	0.01

1. place of the sample taking; 1a. at the rollers; 1b. at the press; 1c. at the welding place; 2. organochlorine content; 3. minimum; 4. maximum; 5. average; 6. concentration in mg/l; 7. total.

The organochlorine compounds, which evolve at the thermal finishing of vinylchloride resins, represent cleaved molecules of vinylchloride in different quantitative chain compound compositions. In the air of the working places at the manufacturing of vinylchloride footwear, we found these compounds in an amount from 0.14 to 1.2 mg/l. Here we found also vapors of hydrochloric acid in concentrations from 0.008 to 0.17 mg/l, hydrocarbon vapors (determined summarily) from 0.21 to 2.61 mg/l and carbon monoxide vapors within the limits of 0.01 to 0.022 mg/l.

The contamination of the atmosphere by organochlorine compounds and vapors of hydrochloric acid increases in proportion with the temperature increase at the heating during the different manufacturing operations.

The ventilation of the working place was carried out by means of a few exhaust devices, originally destined for local exhaustion. In spite of the comparatively high frequency of air exchange (10 - 20), the efficiency of the ventilation was insufficient. Its basic imperfection was the lack of local removal of the gas, evolved during the work at the pressing, rolling and welding of the footwear.

The hood over the welding working benches, usually used in this kind of production, was not efficient and could not be considered as a local exhaust device, because at the welding of the vinylchloride footwear, the gases evolved on the level of the knee of the seated welder, in the immediate closeness to his face. A more radical device in the given case is a vertical exhaust channel against each working place. The removal of the air can be carried out through orifices in the platform of the working bench, the upper part of which, thus, should be used as planar exhaust channel.

Satisfactory effect can be observed also in case of exhaust through a horizontal box, arranged on the surface of the working bench. The rate of suction through the exhaust orifices should not be less than 6 m/sec.

Use of vinylchloride plastics for the insulation of electric wires:-

In the factory, where vinylchloride plastics are used as insulating material for electric wires, the covering of the wires with vinylchloride envelope is carried out on extruders.

During the time, when the vinylchloride plastic compound is dried in the drying chambers, and also at its fusion and at the discharge of the wires from the hot envelope from the head of the extruder, in the air of the working space we found the following volatile substances (Table 3).

Tabl 3

Место взятия проб 1.	Хлороорганические соединения 2.		HCl		C (суммарно) 4.		CO	
	3. концентрация в мг/л							
	минимальная 4.	максимальная 10	минимальная 9.	максимальная 10	минимальная 9.	максимальная 10	минимальная 9.	максимальная 10
У шприцмашин в зоне 5 дыхания рабочего . . .	0,003	0,1	0,003	0,06	0,3	0,6	—	—
Над проводом, покрытым 6 горячей пластмассой . .	0,14	0,65	Не обнаружена	—	—	—	0,017	0,05
В середине помещения //	0,004	0,068	То же	—	—	0,11	—	0,02
Над сушильным шкафом 7	0,10	0,14	—	0,016	0,08	0,24	—	—

1. Place of the sample taking; 2. organochlorine compounds; 3. concentration in mg/l; 4. summarily; 5. at the extruder in the zone of the worker's respiration; 6. over the wire, coated with hot plastics; 7. over the drying chest. 8. was not detected; 9. minimum; 10. maximum 11. in the center of the place.

In the composition of the volatile substances, evolved at the heating of the vinylchloride plastics, up to 120 - 140°, there is an organochlorine content of 0,003 to 0,6 mg/l, vapors of free hydrochloric acid from 0,001 to 0,06 mg/l, hydrocarbon vapors from 0,08 to 0,6 mg/l, and carbon monoxide vapors from 0,01 to 0,05 mg/l.

The ventilation of the plant was accomplished by means of exhaust hoods, arranged on the telescopic downstroke over each extruder head. The gases, evolving at the drying of the plastic compound in the drying chest and at the cooling of the vinylchloride wire after discharging from the extruder head, arrived in the atmosphere of the working places, maintaining in them a considerable concentration of toxic substances.

Results of the medical examination of the workers:- A randomly selected group of workers in the inspected plant was subjected to medical examination. In the vinylchloride plant 48 men were examined, mainly roller workers. At the rhino-larynx examination, in a great number of the workers, in the upper respiratory tracts (in the nose, larynx, and trachea) white films of dust were observed, which were formed as a result of the mixture of dust with the mucus. These films were compact at the touch and could be removed from the surface of the mucous membrane only with difficulty. In 17 men hyperemia of the mucous membrane of the upper respiratory tract was found. Chronic bronchitis was detected in 13 men. As to the change in blood circulating organs, one must mention vascular hypotonia (90 - 100/45 - 50) in 13 men, moderate hypertonia in one, arterio-cardio-sclerosis - in 5. The condition of the gastro-intestinal tract was characterized in 10 examined workers by chronic gastritis and in 2 by chronic colitis. In 15 workers there were alterations in the liver in form of more or less pronounced hepatitis, accompanied in 2 examined workers by cholecystitis.

Regarding the blood, 29 examined workers had low hemoglobin count: or - 46%, 22 50-55%, and 6 56-60%. The blood picture and the ROE were without peculiarities.

One must pay attention to the skin diseases (acne, bleakheads), especially on the face, the neck and the chest, found in the examined group. The skin injuries were found not only on the face of those who were in contact with sovol, but also on those, who were not in direct contact with it, but were working in the same place. Evidently, the skin disease was caused by the action of sovol, when its vapor was sorbed.

In the chemical plant 25 female workers were examined, mainly those, working at the presses and welding with a long working record of 3 - 6 years in the said professions. In some of them, examined for ear - larynx different degree of hyperemia of the mucous membrane of the upper respiratory tract was observed, on its whole extent, or only on the organic parts. Chronic bronchitis was found in 5, mildly expressed emphysema of the lungs in 3 and remaining signs of pleurisy in 2.

As to the cardio-vascular system in 14 men vascular hypotonia (R/R 90 - 110/55-65) and in 4 mildly expressed hypertonia (R/R 140 - 165/90-85) was detected. Thudding sound of the heart, its enlargement and the data of the ECG: low T-wave of heart, not less than by 2 basic abduction and the roundness of the S - T interval, gave foundation, in some cases, to diagnose dystrophy of the myocardium.

In the examined group, in 6 workers hepatitis was diagnosed. At the same time, in some persons, simultaneously liver and stomach disease was detected. Not in one of the liver disease cases could we find in the anamnesis, or at the examination, signs of jaundice. Neither did we detect any bile pigment in the urine. In a considerable number of the examined workers small swelling of the liver, without characteristic pain and sensitivity at palpation was observed.

Analyzing the results of the medical examination, one must remark, that in a known part of the workers, changes in the upper and deeper respiratory tracts were detected. These findings are confirmed also by the data of the literature.

One must pay attention to the high percentage of skin injuries, which is, no doubt connected ethiologically to the action of sovol.

The presence of hepatitis in some workers, in contact with vinylchloride resin and vinylchloride plasticizers deserves serious consideration. Therefore further dynamic observations on the state of the health of the workers, who are in contact with vinylchloride resin and its plasticizers are necessary, to prevent the development of severe liver damage.

R e s u l t s .

1. - Into the composition of volatile substances, which form at the thermal finishing of vinylchloride resins and plasticizers, during the manufacturing organo-chlorine compounds, hydrocarbons, vapors of free hydrochloric acid and of carbon monoxide enter.

2. The action of these volatile substances are manifested in the irritation of the mucous membrane, mainly of the upper respiratory tracts; lengthy influence of finely dispersed dusts and vinylchloride resin vapor cause, besides, dryness and atrophy of the mucous membrane of the upper respiratory tracts, and is also responsible for the development of chronic bronchitis.

3. A considerable number of hepatitis among the examined workers, and also the change in the upper respiratory tracts, raise the question of the necessity for further dynamic research on the state of the health of the workers and to take a series of therapeutic-prophylactic measures, in particular by organizing heat and moisture^{*} inhalation of drugs for the workers.

4. At the use of vinylchloride solvent, as plasticizer, on most workers acne type skin injuries, with preferable location on the face and neck, were observed.

5. For the prophylaxis of skin diseases at the work with solvent, the following complex sanitary measures have to be taken: 1) securing for the workers work underwear and outfit; 2) construction of sanitary showers

^{*}) (alkaline)

with separate undressing for home and work cloths. At the sanitary passage, there must be a vapor chamber for the low temperature steaming of underwear and work outfit, at a temperature of 110-120°, for one hour. The plant should be equipped with wash basins with hot and cold running water.

6. For the sanitation of the atmosphere, it is necessary to decrease as much as possible, the degree of vinylchloride resin decomposition at thermal finishing. This must be attained by standardizing its heat resistance, and also by controlling the temperature when the rollers, the presses and other equipment are heated, not to exceed 120-130°.

Of extremely great importance is the rationally equipped ventilation system, calculated on maximum screening-off the source of gas-, vapor- and dust separation.

In connection with the fact, that in some factories the inflammation of the condensate was observed, which occurred in the exhaust ventilation tubes in contact with open flame, the exhaust apparatus must be projected by observing the conditions, adopted by the construction legislation for construction, designated for the mixing of inflammable gaseous mixtures.