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PROBLEMS OF OCCUPATIONAL HYGIENE AND THE STATE OF HEALTH OF WORKERS
EMPLOYED IN MANUFACTURING LATEX POLYVINYL CHLORIDE

[Voprosy gigiyeny truda i sostoyaniye zdorov'ya rabochikh, zanyatykh na
proizvedstve lateksnoy nolitvinilkhlorida]

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PROBLEMS OF OCCUPATIONAL HYGIENE AND THE STATE OF HEALTH OF WORKERS
EMPLOYED IN MANUFACTURING LATEX POLYVINYL CHLORIDE

V.S. Filatova, Ye.Sh. Gronsberg, N.A. Smirnova, Ye.A. Stulova,
I.V. Oresnikovich*

The production of polyvinyl chloride is developing at a rapid tempo in the Soviet Union because of the particularly valuable qualities of polyvinyl chloride, which makes it possible to replace lead coatings in goods for the electrotechnical industry with this material. Moreover, polyvinyl chloride is employed in the manufacture of plastic, anti-corrosive coatings, special purpose fabrics, etc. We showed earlier that the primary harmful agent in the manufacture of suspension polyvinyl chloride is vinyl chloride (V.S. Filatova and Ye.Sh. Gronsberg; V.S. Filatova et al.).

The results of the long-term clinical observations of N.A. Smirnova (1956, 1962), and V.A. Antonyuzhenko et al. showed that prolonged inspiration of vinyl chloride leads to the appearance of chronic occupational intoxication in workers, whose basic symptoms are lesions of the central nervous system, particularly its higher vegetative centers (general vegetative dysfunction with an accent on disorders of vascular regulation).

The goal of this work was to study problems of occupational hygiene and the state of health of people working at the first heavy tonnage enterprise in the Soviet Union for producing latex polyvinyl chloride, whose advantage consists in continuousness of the technological process and the use of new equipment. Polyvinyl chloride is obtained by the method of water emulsion

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polymerization of vinyl chloride in the presence of an initiator. Polymerization occurs with continuous feeding of vinyl chloride to the reactor and a so-called aqueous phase at a low temperature and pressure.

The latex continuously emerging from the reactor proceeds to degassing, e.g., removal of the unpolymerized vinyl chloride by the aid of a vacuum. Vapors of the vinyl chloride are sent to the condensor after drying with caustic potash and the condensed vinyl chloride is sent to a container. The latex separated from the vinyl chloride is stabilized by a solution of calcined soda and is sent for drying, which occurs in an atomizer dryer by means of heated air. The mixture of air and polyvinyl chloride powder is sent to a cyclone from the dryer. Thence the air is purified in sleeve filters and is discharged into the atmosphere. The resin separated in the cyclone runs in streams into reinforced concrete silos, from which it is manually packaged in paper bags. In all apparatus (atomizer dryer, cyclones, filters, etc.), a rarefaction is maintained to prevent entry of the resin powder into the air of the rooms.

The enterprise we examined is divided into two buildings; the first contains the vinyl chloride polymerization section and the latex stabilization section, the second - the latex drying section. The percentage of saturation of equipment areas (relationship of the volume of equipment to the volume of the room) is low in the polymerization section - from 2.8 to 3, and significant in the dryer section (21-22) as the result of using large equipment. Planning of the rooms with various degrees of isolation of polluted air of the rooms from each other is hygienically correct.

The flow-exhaust system of ventilation with pumps significantly remote in a number of regions from the source of separating the vinyl chloride in the vinyl chloride polymerization building is poorly effective at inadequate speeds and volumes of removed air. The latex drying section is ventilated by means of a mechanical supply of flowing air in combination with natural draught through an aeration head. In the process of obtaining the latex polyvinyl chloride, the air of working areas is polluted with vinyl chloride.

gasket; 10- Local exhaust from reactor hatch with hinged screens; 11- Bearing ring of tube joint.

CONCLUSIONS

1. Pollution of the air with vinyl chloride and resin dust is possible during the manufacture of latex polyvinyl chloride. Such pollution is caused by disruption of the seal of equipment and by carrying out certain operations manually.
2. During the study of the state of health of the workers, some of them were found to have changes characteristic for the initial forms of chronic vinyl chloride intoxication: slightly pronounced disorders of the vegetative-vascular regulation, symptoms of vegetative polyneuritis and thermoregulatory disorders.
3. An improvement in the conditions of labor of workers employed in manufacturing latex polyvinyl chloride can be attained by means of sealing the equipment, improving technological operations and improving the function of ventilation.

REFERENCES

Антоноженко В. А. и др. Тезисы докладов научной конференции, посвященной основным вопросам гигиены труда, предостережения, промышленной токсикологии и профилактики профессиональных заболеваний. Горький, 1961, стр. 4, 6—См. также Н. А. Вил: Материалы по вопросам гигиены труда и клиники профессиональных болезней. Горький, 1962, сб. 3, стр. 41—Филатова В. С., Грошеберг Е. Ш. Гиг. и сан., 1957, № 1, стр. 38—Филатова В. С., Благородный В. М., Гофман Ф. Е. Гиг. труда, 1964, № 10, стр. 3.—Хрулев М. В. Поливинилхлорид. М.—Л., 1964, стр. 149.

Summary

Specific feature of the latex polyvinyl chloride production is the pollution of the atmosphere in work premises with vinyl chloride. In individual sections of the technological line polyvinyl chloride dust pervades the ambient atmosphere.

Some operators handling vinyl chloride exhibit changes in their health condition which are characteristic of initial forms of chronic occupational poisoning with this substance.

A set of health measures is recommended to improve work conditions.

Polyvinyl chloride dust is noted to enter the air in certain industrial areas.

During the study of the degree of air pollution, more than 300 air samples were taken.

The content of vinyl chloride was determined according to a method developed by Senior Scientific Associate Ye.Sh. Gronsberg. The method is based on oxidation of vinyl chloride by a mixture of permanganate and iodic acid to formaldehyde with subsequent colorimetric determination according to the reaction with chromotropic acid. Sensitivity of measurement is 10 μg in the colorimetric volume. Dustiness of the air was determined by the gravimetric method. The FPP-15 filter was used as the filtering material.

The materials of the investigations showed that the vinyl chloride polymerization and latex stabilization sections are the places where concentrations of vinyl chloride in the air are most often encountered in excess of the maximum permissible value (30 mg/m^3), exceeding it by 2 times or more. In 25% of the samples the vinyl chloride content was found to be within limits of the permissible level.

Sources of escape of vinyl chloride are leaks in the gaskets of the reactor and pump agitators, the lower hatch of the reactor when cleaning the latter, the open hatch of the vinyl chloride dryer in the period of loading the caustic potash, the degassed latex collectors, etc. In the presence of leaks in gaskets of the agitators, air pollution near the reactors increases 10 times or more. Our suggestion that supplying water to the agitator gaskets under a pressure in excess of pressure in the apparatus would have positive hygienic significance proved to be unjustified - this measure does not prevent the escape of vinyl chloride from the reactors.

Deserving of the attention of the hygienists is the escape of unreacted vinyl chloride from the latex with its return in the production cycle. Degassing of latex makes it possible to reduce air pollution at the stages of stabilization and drying of the latex. However, as the results of the in-

vestigations showed, the effectiveness of latex degassing is inadequate. Approximate analyses established that the content of vinyl chloride in latex after degassing drops 10 times. But at the same time, the absolute amount of vinyl chloride in the latex remains significant - 3.6 mg/cm^3 , and therefore its concentration in the air near the degassed latex collectors is higher than the maximum permissible amount, in a number of cases.

For the same reason, the air in the latex drying building is also polluted with vinyl chloride with the existing leaks in equipment. The concentrations of vinyl chloride at the pumps feeding the latex to the atomizer dryer channel comprised $4-48 \text{ mg/m}^3$, and near the dryers and in the control panel room - from 7 to 15 mg/m^3 . No vinyl chloride was detected in the air in the center of the top floor, between filters, and on the first floor of the dryer building. Concentrations of polyvinyl chloride dust in most working areas fluctuated from 1 to 6.5 mg/m^3 , e.g., did not exceed the maximum permissible concentration (10 mg/m^3). High dustiness of the air was measured in the area of manual packaging polyvinyl chloride - 78 mg/m^3 or more. The automatic scales and packaging machine provided for by the design were not operating.

Meteorological conditions in the industrial areas, as a rule, corresponded to the sanitary norms.

Hence, the materials of our investigations enable one to state that the continuous method of obtaining latex polyvinyl chloride with remote control of the basic stages of the technological process deserves encouragement from the viewpoint of occupational hygiene. At the same time, the existing deficiencies in the technology of production, apparatus arrangement and equipment operation have an unfavorable effect on the sanitary-hygienic conditions of labor.

Besides the hygienic investigation, a medical examination of 163 people working in the production of latex polyvinyl chloride was made (84 men and 79 women). Of these, 107 people were examined twice at an interval of 1 year

and 8 months. Most of the workers ranged in age from 21 years to 40 years, and had a working experience in the shop of 2-2 1/2 years. Many of those examined had not worked in the chemical industry before. During the study of the state of health of the workers, besides the conventional clinical methods of investigation, oscillography, skin thermometry, capillaroscopy were employed, which make it possible to characterize the condition of the vascular system in more detail.

In the process of the dynamic observations, complaints of headaches and pains in the extremities were obtained in some of the workers and certain workers combined these complaints with various paresthesias and chills. The results of the objective investigation indicated certain changes in the state of health of some workers. These were characterized by disorders of the vegetative-vascular regulation (arterial hypotony - temporal and brachial, significant fluctuations in the tempero-brachial coefficient, capillary spasms of the instep, asymmetry of the arterial pressure and oscillatory index, changes in the cutaneous-vascular reactions in the form of clearly differentiated dermographism, extension of the time of the white spot symptom beyond 5 seconds, acrocyanosis, increased sweating, disruption of temperature regulation - subfebrility, acrohypohermy, temperature asymmetry), and by certain symptoms of organic lesions of the nervous system combined with symptoms of vegetative polyneuritis (disorders of pain sensitivity, corneal reflexes, nystagmus).

The identified changes in the stage of health of workers were posed in connection with the effect of the occupational factor and in some people were qualified as initial symptoms of chronic occupational intoxication. The following data confirmed this.

1. Certain pathological signs were frequently combined in several people.
2. The greatest frequency of pathological changes was noted in equipment operators of the vinyl chloride polymerization section and welders with a working experience of 2-2 1/2 years. It is namely in the polymerization section that the greatest degree of air pollution with vinyl chloride was found.

3. The principal nature of the changes in the state of health that were found were confirmed by the data of the dynamic observation of workers. The number of complaints had increased by the second examination (headache increased and recurred in a number of people, pains in the extremities began to be noted more frequently), there was an increase in the frequency and degree of expression of separate symptoms (reduced arterial pressure, asymmetry of the skin and submuscular temperature (more than 0.5°), asymmetry of arterial pressure, etc.). The cited data confirm the relationship of the noted pathological deviations in the state of health of workers with the conditions of work, and primarily with pollution of the air with vinyl chloride.

On the basis of the hygienic investigations, the administration of the enterprise took certain measures to seal the apparatus and reduce pollution of the ventilation air (by removing discharges of abgasses from the point of air intake). This facilitated a reduction in concentrations of vinyl chloride of 2-10 times in the air. In order to improve further the sanitary-hygienic conditions of vapor, we suggested recuperative measures.

A leading role in reducing air pollution in manufacturing latex polyvinyl chloride belongs to sealing the equipment (reactors, pumps, degassed latex collectors, vinyl chloride dryer, etc.). Replacing the existing pumps for pumping the vinyl chloride with gasket-free pumps is extremely desirable.

An important measure in improving the sanitary-hygienic conditions of labor is also improving the method of sampling for technical analysis from the degassed latex collectors, packaging polyvinyl chloride, loading caustic potash into the vinyl chloride dryer, etc. Reducing the emission of vinyl chloride into the air can be achieved by improving degassing of latex.

Important significance in the studied industry belongs to an efficient system of ventilation, particularly local exhaust mechanical ventilation. The local exhausts from the reactor agitator gaskets should be in the form of removable tubes connected at one end (lower) with the main air duct, and at the other end with screens completely closing off one opening in the

gasket housing (see the drawing). The diameter of the intake pipe should be no less than 300 millimeters. The intake apertures in the screens should have an area of 0.18 m^2 in the lower half. The upper half of each screen should be openable, mounted on horizontal bearings. The volume of removed air is determined according to the velocity of intake in the opening of the housing, which should be no less than 3 m/sec, and the volume of intake air - no less than $300 \text{ m}^3/\text{hr}$.

Local exhausts from the lower hatches of the reactors should be built in the form of tubes with screens attached at a distance of no more than 400 mm. If the rate of intake near the hatch is accepted to be no less than 0.5 m/sec and the rate of intake in the tube is no less than 7 m/sec, then with an area of the intake aperture 0.18 m^2 , $4,500 \text{ m}^3/\text{hr}$ air should be removed.

The recuperative measures we recommended have been accepted by the administration of the enterprise for execution.

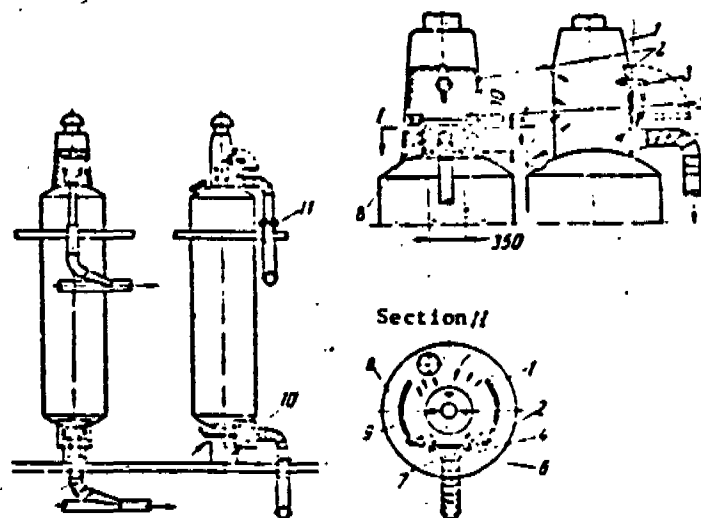


Figure. Local exhausts from the agitator gasket and reactor hatch. 1- Housing of reactor agitator; 2- Screen covering opening in housing; 3- Handle with fastener for attaching the upper half of the screen to the housing; 4- Handle with mount for attaching lower half of screen to housing; 5- Hinge between upper and lower halves of screen; 6- Diffuser with exhaust tube; 7- Brackets for attaching exhaust tube; 8- Bracket for attaching lower half of screen to housing; 9- Agitator

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<179>
Fed. Register; Stander, J. Standard for exposure to vinyl chloride. Fed. Register 39 (1974): 35890-35898 (1974).

Effective January 1, 1975, the Department of Labor Standard of Exposure for vinyl chloride will provide that no employee may be exposed to concentrations greater than 1 ppm over any 8-hr period, or to more than 5 ppm averaged over any 15 min period, or to any direct contact with liquid vinyl chloride. "Action level" is defined as 0.5 ppm VC over an 8-hr day. Initial monitoring shall determine exposures in excess of the action level; shall then be repeated monthly if in excess of the permissible exposure limit, or quarterly if in excess of the action level, or at any change which may cause excess of the action level. Regulated areas, limited to authorized personnel recorded on a daily roster, shall be established where VC or PVC is manufactured, reacted, repackaged, stored, handled or used, or where VC concentrations are in excess of the permissible exposure limit. Engineering work practice controls, supplemented where necessary by respiratory protection, and written in plans to be updated every 6 months, shall be used to reduce exposures to the permissible limit. Respiratory protection suitable to the atmospheric concentration of VC shall be supplied by the employer from those jointly approved by the Mining Enforcement and Safety Administration, and the National Institute for Occupational Safety and Health (NIOSH). Entry into unknown concentrations, or concentrations greater than 36,000 ppm, may be made only for life rescue. Employees engaged in hazardous operations shall be provided with proper respiratory protection and clean, dry protective garments. Written operational plans for emergency situations shall be developed for each facility storing, handling, or otherwise using VC as liquid or compressed gas, and each employee shall undergo training relating to hazards and precautions of its use. A program of medical surveillance shall be provided without cost to each employee. Entrances and containers shall be informatively labeled as to the hazard within. Monitoring, personnel, and medical records shall be maintained for a period of 30 yrs. Background, findings, discussion, and the detailed rules and regulations are to be found in the Standard.

STANDARDS; OCCUPATIONAL EXPOSURE

<180>
Fed. Register; Strelow, E. National emission standards for hazardous air pollutants. Notice of public hearing. Fed. Register 40(25): 60079-60080 (1975).

Notice is given of a public hearing to provide opportunity for interested persons to provide information 1) on health effects of vinyl chloride (VC) in ambient air and 2) standards to be adopted to regulate emissions of VC.

REGULATION; STANDARDS

<181>
Fed. Register; Train, R.E. Vinyl chloride. Emergency suspension order concerning registrations for certain products and intent to cancel registrations. Fed. Register 39(82): 16753-16756 (1974).

Evidence presented relative to the health effects of vinyl chloride (VC) indicates a clear risk to

humans in the use of indoor aerosol insecticide products. Therefore registrations for all such products containing VC either as an active or inert ingredient is suspended for all uses in homes, hospitals, food-handling establishments, or enclosed areas. All existent stock of these products are to be recalled by the manufacturers, and interstate shipment is banned.

ANECOLS; PESTICIDE; REGULATION

<182>
Feron, V.J.; Speck, A.J.; Willess, H.L.; Van Batten, D.; De Groot, A.V. Observations on the oral administration and toxicity of vinyl chloride in rats. Fed. Cosmet. Toxicol. 13(6): 633-638 (1975).

Administration of vinyl chloride monomer (VC) orally to rats was investigated by means of gastric intubation of a solution in edible oil; by incorporation of a solution in edible oil into the diet; and by addition of a PVC powder with a high concentration of VC to the diet. Solutions of VC in soya-bean oil appeared stable in VC content and fatty acid composition and no reaction products of VC with the components of the oil were detected. Gastric intubation was chosen because the diet constituents lose VC very rapidly; levels of 0, 30, 100, and 300 mg/kg body weight were administered once daily 6 day/wk/13 wk. Vinyl chloride was detected in the tail blood within 2 min, reached a maximum within 10 min, and decreased to an undetectable level within 40 min. Mesothelial, biochemical, and organ weight differences occurring during the 90-day tests were not considered toxicologically significant. No histopathological changes could be detected in thyroid gland tissue; no evidence of liver damage was observed at the highest dose level. This may have been due to the short duration of the experiment and the short daily exposure of the rats to VC. A no-effect level was conservatively placed at 30 mg VC/kg body weight.

FOOD; RAT; INGESTION

<183>
Filatova, V.E. (Sanitary-hygienic conditions of work in the production of polyvinyl resins and measures of improvement.) Gig. Sanit. 22(11): 38-42 (1957).

Analysis of vinyl chloride (VC) in the air of a polyvinyl chloride (PVC) manufacturing plant was carried out by the method of Grossberg, that is, photobromination of a solution of VC in chloroform with a solution of bromine in a mixture of chloroform and glacial acetic acid. VC concentrations fluctuated considerably but averaged 0.05 to 0.8 mg/l. Incidences of toxic angioneuroses among the workmen necessitated lowering the maximum allowable concentration of VC below the current legal limit of 1 mg/l.

Russ.; Eng. Summ.

STANDARDS; OCCUPATIONAL EXPOSURE; ANGIONEUROSES

<184>
Filatova, V.E.; Antonovskhenko, V.A. (Changes in hygienic conditions of work and occupational disease-incidence among workers engaged in the production of polyvinyl chloride over a period of