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FINAL REPORT ON POTENTIAL HEALTH HAZARDS ASSOCIATED WITH THE USE OF PLASTIC PIPE IN POTABLE WATER SYSTEMS

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and
Department of Industrial Relations
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October 17, 1980

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Executive Summary

This study was commissioned by the Assembly of the State of California (ACR 98, Pappan) to determine the extent of health risks, if any, posed by the use of plastic pipe systems in homes. The Hazard Evaluation System (HES) of the Department of Health Services has analyzed the available literature and collected data on three related health aspects of the use of plastic pipe:

1) the general toxicity of the components of plastic pipe and its solvent cements and primers;

2) the extent and nature of worker exposure to solvents or pipe components and any documentable health effects reasonably related to that exposure; and

3) the likelihood of significant health risks posed to consumers from water carried by plastic pipe.

These studies were not designed to provide controlled comparisons of metal and plastic pipe, in part because the Department has completed a previous study of the health risks posed by metal pipes to consumers and concluded that a health hazard does not exist under normal usage conditions. Based on the present study, when properly installed and flushed, plastic pipe systems also do not appear to pose a health hazard under normal usage conditions. The principal findings and recommendations include the following:

A. Worker Health:

1) Adverse worker health effects from the major solvents found in in cements and primers are unlikely based on their relatively low toxicity and field measurements of exposures under a range of working conditions;

2) Certain other potential health effects cannot be evaluated at this time. These include, but are not limited to, effects stemming from combinations of exposure to plastic pipe solvents, PVC dusts, other pipefitting activities and contaminants detected in some samples of solvent cements.

3) Surveys of worker complaints are presently inadequate to draw conclusions about the overall safety of plastic pipe work; more

data, particularly pertaining to cancer of the lymphatic system, esophagus and larynx are needed to determine the nature of any cancer risk, and its possible association with one phase or another of plumbing activities.

4) Job-site water is likely to be contaminated with high levels of solvents and some volatile organic compounds and should be considered non-potable.

B. Consumer Health:

1) Under controlled conditions, levels of solvents found to leach into water held for up to two weeks in newly installed solvent-cemented plastic pipe can exceed the "safe" levels calculated by HES. The degree of health risk posed by solvents ingested from water carried by plastic pipe cannot be fully evaluated, since the toxicity of most ingredients has been established from inhalation studies.

2) Excessive levels of two volatile organic compounds normally present in low or trace levels in most California water supplies can accumulate in chlorinated water held for two weeks in CPVC plastic pipe, but not in glass controls. One of these compounds, carbon tetrachloride, is present under "worse case" conditions at ten times the presently accepted EPA action level.

3) A plasticizer has been found sporadically at low levels in water samples carried by PVC plastic pipe even though manufacturing information indicates no phthalates should be present. One phthalate found has been shown by the National Cancer Institute to cause cancer in rats and mice fed large amounts. The maximum levels in water detected pose a very low risk (on the order of one in a million) of cancer in consumers based on extrapolations from animal studies.

4) These three observations establish a substantive potential health risk from water carried in newly installed PVC and CPVC pipes. The risk is small but sufficient to require specific initial safeguards to protect consumer health.

5) Flushing of pipe reduces solvent and volatile organic compounds concentrations to low levels, a finding similar to previous results obtained in the Department's metal studies for lead in copper plumbing systems. While pipes are flushed during the course of construction safety testing and inspection, HES remains unconvinced that such uncontrolled activities are sufficient to ensure that solvent or volatile organic concentrations are at acceptable levels prior to occupancy.

C. Recommendations:

1) Require that only the four evaluated ingredients be permitted in cements and primers (dimethylformamide, methyl ethyl ketone, cyclohexanone and tetrahydrofuran), to ensure that neurotoxic or other undesirable solvents like n-hexane are excluded from pipe systems.

2) Ban any solvent cement or primer found to be improperly labelled.

3) Require that all pipe outlets in new construction that uses solvent-cemented plastic pipe in the water system be labelled "Non-potable Water: Do Not Drink" until flushing has occurred.

4) Require that a specific protocol be used by contractors for flushing newly installed pipe systems.

These procedures, if followed, will substantially reduce any health hazard from potable water carried in plastic pipe systems. A similarly beneficial effect would probably also be obtained if the flushing requirement were extended to all pipe systems.

A proposed protocol follows.

PROTOCOL

DEPARTMENT OF HEALTH SERVICES

SUGGESTED PLASTIC PIPE FLUSHING PROCEDURE

1. When plumbing is completed and ready for pressure testing, the system shall be filled and permitted to sit for at least one day. Then each cold water and hot water tap shall be flushed starting with the fixture (basin, sink, tub or shower) closest to the water meter and then each successive fixtures toward the end of the system. Flushing should be continued for at least one minute or longer until water appears clear at each fixture. *

2. The system shall be kept filled with water for at least one week and then flushed in accordance with the above procedures. The system shall be kept filled with water and not drained.

3. Before the premises are occupied, the hot water heater shall be turned on and the system shall be flushed once more. Commencing with the fixture closest to the hot water heater, the hot water tap shall be permitted to run until hot water is obtained. The time required to get hot water in a specific tap should be determined and then the cold water tap at the same location should be turned on for the same period of time. This procedure shall be repeated for each fixture in succession toward the end of the system.

* Step one may be omitted if a jurisdiction requires the Building Inspector to test each water system.

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FINAL REPORT ON POTENTIAL HEALTH HAZARDS ASSOCIATED WITH THE USE OF PLASTIC PIPE IN POTABLE WATER SYSTEMS

I. INTRODUCTION

This is the third and final report by the Hazard Evaluation System (HES, formerly the Hazard Alert System) to the Commission on Housing and Community Development on the potential health hazards associated with the use of polyvinyl chloride plastic pipe systems (CPVC and PVC pipe). The first interim report (dated February 14, 1980) documented in summary form what is known about the toxicity of the major ingredients used in these solvent cements and primers. The second interim report (dated April 29, 1980) reviewed potential worker health hazards during the installation and handling of plastic pipes or their solvent cements and primers. This final report updates our interim reports and provides a detailed analysis of the research on whether or not the use of plastic pipe for conveying potable water poses public health hazards.

This report summarizes the major conclusions of the Department of Health Services regarding the most probable nature and extent of any hazards. However, we wish to emphasize that our findings are based on laboratory studies and therefore only approximate the conditions likely to be encountered in real-life situations. As with previous reports, the present material is presented in a relatively non-technical fashion. Except where there is potential for controversy, the report presents the relevant data and discussion in summary fashion. Detailed tables, references and documentation of methods and materials in the experimental studies are presented in appendices.

II. UPDATE ON THE TOXICITY OF PLASTIC PIPE ADHESIVE SOLVENTS

HES has reviewed the information available since our prior toxicity evaluation. There are no substantial changes to that evaluation, which is attached as Appendix I. Below are comments that amplify the prior report.

A. Methyl ethyl ketone (MEK)

We are aware of no significant recently published literature on MEK. We received a report from the Chemical Industry Institute of Toxicology (CIIT) which includes a thorough review of the literature and a description of MEK studies CIIT will be conducting. Their literature review did not differ significantly from ours, and concluded that "the effects of MEK exposure, other than its neurotoxic effects, have not been adequately investigated" (Risk Assessment Study for Methyl ethyl ketone, CIIT, in- house publication). CIIT studies planned in rats include pharmacokinetic and metabolic investigations and a three-month study of concentration-response relationships for a variety of toxicological endpoints, which will be used to establish doses for a 24-30 month chronic inhalation study of the chronic toxicity and carcinogenicity of MEK.

B. Dimethylformamide (DMF)

Recent literature on DMF not previously included in our report is primarily concerned with biological monitoring of exposure. Published reports and conference papers (Krivanek et al., 1978 and Paper No 17, DuPont de Nemours Laboratory) discuss the use of blood and urine concentrations of monomethylformamide (MMF), the metabolite of DMF, as evidence of DMF exposure. This testing may prove useful in determining actual exposure to DMF since it encompasses DMF absorption through both skin and lung, whereas air sampling covers only to pulmonary exposure. However, this information is not now directly relevant to determination of DMF toxicity.

We have also reviewed the medical records of the index case of suspected DMF toxicity investigated by OSHA, referred to in our initial report. The case was complicated by the presence of a number of drugs that might have accounted for the toxicity, the presence of pre-existing disease, and uncertain exposure to DMF. However, other workers in the plant have had documented exposure to DMF, with eight-hour TWA's of up to 32 ppm, or 3.2 times the OSHA TLV of

10 ppm. While it is possible that DMF accounted for the workers' liver and pancreatic toxicity, whether or not this exposure actually caused the damage cannot be determined.

HES understands that NCI plans a three-year carcinogenicity test to assess DMF's potential for producing cancer (Kommenini, Pers. Comm.).

C. Cyclohexanone and tetrahydrofuran

We are aware of no recent information on these substances not included in our previous two reports. Specifically, we have uncovered no additional evidence to corroborate the study referred to in the interim report that suggests an association in animals between exposure to cyclohexanone and cataract formation.

No further evidence suggesting genetic toxicity of any of the four solvents has come to our attention since the interim report was filed, with the exception of a Czechoslovakian study on chromosome damage caused by DMF that we cannot evaluate (Csek. Hyg. 24: 432-6, 1979; abstract available).

D. Summary of toxicity of solvents

The toxicities of three of the solvents, MEK, cyclohexanone and THF, are relatively low and confined primarily to central nervous system depression (headache, drowsiness, and impairment of function). The effects are generally thought to occur only at high levels of exposure (ACGIH, 1977). For example, concentrations of 25,000 ppm of THF are required to produce anesthesia in dogs and mice. However, few studies with these compounds have been conducted to determine the precise levels at which CNS depression occurs, and impairment of function (such as performance of complex mental or physical tasks) tends to occur at much lower levels than obvious narcosis.

The three solvents are also sensory irritants. When present in the air they cause irritation of the mucosal membranes of the eyes, nose and throat. Individuals exposed for the first time may also become nauseated. These effects occur at much lower air concentrations than does CNS depression, which results from

absorption of the solvents from the lungs into the blood and then the brain. The current OSHA TLVs are based on the irritant effects, which are presumed to provide a good safety margin against systemic effects from air exposure.

DMF is more toxic and has toxicities distinct from those of the other solvents. The signs of toxicity are primarily gastrointestinal and include nausea, vomiting, abdominal pain and liver damage. Workers with these symptoms have all been exposed to levels of DMF in air above the current OSHA TLV of 10 ppm; but DMF is also absorbed through the skin, a factor that must be considered in the work environment. Workers exposed to DMF may also experience a potentially serious reaction to drinking alcohol, characterized by flushing and nausea.

It is reasonable to assume that those solvents (MEK, cyclohexanone and THF) with the same effect are additive in these effects. There is no evidence that DMF causes CNS depression, so its effects should be considered separately.

III. UPDATE ON THE PIPE TRADES COUNCIL STUDY OF THE HEALTH OF PIPE-FITTERS, AND ON CAL/OSHA FIELD MEASUREMENTS OF EXPOSURES TO PERSONS WHO WORK WITH PLASTIC PIPE

A. Pipe Trades Council survey

Our interim report focused on potential health hazards to workers who might be exposed to plastic pipe solvents or pipe constituents (vinyl chloride monomer or acrylonitrile) during fabrication or finishing work with PVC or CPVC pipe. In the course of that report, HES drew conclusions regarding potential health effects from the Council's raw data without benefit of a full description of the methods used to prepare that data.

We have now seen the full report and while we continue to be concerned that real health problems may in fact underlie the reported symptomatology and diseases, we have insufficient evidence to reach any conclusions regarding the possible association of adverse health effects and job experience related to work

with plastic pipe.

We have subjected the Council's study to independent Departmental review and find it methodologically unsound and unsuited for our purposes. Our full critique and the authors' response, are attached as Appendix II; the reasons for these conclusions are summarized below.

1. Absence of controls
2. Poor response rate
3. Subjectivity of responses
4. Inappropriately worded questions
5. Lack of comparability between length of exposure to plastic pipe and the period covered by health questions
6. Absence of accurate denominator data needed to calculate the true prevalence of disease or symptomatology
7. Inadequate distinction between plastic pipe and metal pipe exposures
8. Absence of "blind" or "double-blind" design to insure objectivity of measurements
9. Inappropriate statistical tests

These inadequacies, coupled with an insufficient response of the authors to a Department of Health Services critique (see Appendix II), make it impossible for us to interpret the study. We have also been unsuccessful in getting clinical confirmation of any of the reported disease states* or of the possible relation between acute symptoms of great concern to us (e.g., "red urine") and prior exposure to plastic pipe solvents. Though such temporal relationships would not prove a causal link, they would help us evaluate the data.

B. CAL/OSHA survey

The interim report showed that short-term over-exposures to solvent vapors can occur under warm weather conditions. Cal/OSHA and HES conducted follow-up

* Subsequent to this writing, confirmation of 14 cases of lymphoma among pipefitters was received from Alexandra Levine, M.D. (pers. comm. 10-29-80).