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651 Gateway Boulevard, Suite 900
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Dear Mr. Cardozo:

Attached are my comments on the "Draft Environmental Impact Report for CPVC Pipe Use for Potable Water Piping in Residential Buildings" (DEIR) recently produced by the California Department of Housing and Community Development. At your request I have reviewed the worker health and safety elements of the DEIR, and my comments address their technical accuracy and validity.

I appreciate the opportunity to participate in reviewing the DEIR. As the lead investigator for a 1989 Department of Health Services study of health hazards associated with CPVC pipe installation, I focused particular attention on whether that study's findings were interpreted appropriately and whether the data from that study were used in the DEIR to fully and accurately inform the policy making process. In some cases the DEIR's interpretations and applications of our 1989 data were inappropriate; my comments outline these areas and indicate the appropriate interpretations.

In addition to reviewing the DEIR itself, I have also reviewed numerous source documents on which the DEIR is based and I have reviewed other materials relevant to the issues presented. Among these were the earlier DEIR and Administrative Final EIR prepared by the Lead Agency during 1989-1990. In some cases, I drew upon my exposure data files from the 1989 DHS study to perform additional analyses.

In my professional opinion, the findings of the current DEIR are not consistent with available data and with established practices of industrial hygiene and health risk assessment. The "significance thresholds" on which the findings are based are fundamentally flawed. The DEIR in many instances bases its findings on misrepresentations, incorrect assertions, and invalid interpretations.

Workers installing CPVC potable water pipe can be expected to regularly experience exposures in excess of established exposure limits. Such exposures can

be expected under conditions of normal use. Exposures will not uncommonly be in the range previously associated with adverse health effects in humans and with cancer in laboratory animals. These exposures, and their potential health effects, must be considered significant.

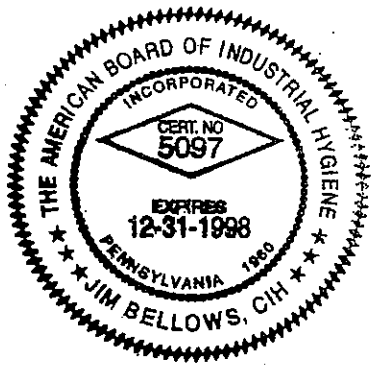
Safety recommendations on material labels cannot be expected to prevent overexposures. A combination of specific, focused hazard reduction measures should be developed and implemented to prevent overexposures and adverse health effects.

The DEIR must be revised to correct the numerous errors and misleading interpretations, to fully account for the significant impacts that can be expected, and to incorporate appropriate mitigation measures. Any revisions should be carefully scrutinized to assure that the critical errors have been corrected.

My detailed comments, analyses, and conclusions follow. My *curriculum vitae* is also attached.

Sincerely,

Jim Bellows, CIH, CSP



Comments on the Draft Environmental Impact Report for Chlorinated Polyvinyl Chloride (CPVC) Pipe Use for Potable Water Piping in Residential Buildings

Based on a thorough review of the "Draft Environmental Impact Report for Chlorinated Polyvinyl Chloride (CPVC) Pipe Use for Potable Water Piping in Residential Buildings" (DEIR), along with supporting documents and other relevant materials, my analysis, comments, and conclusions are as follows.

1. The DEIR's significance thresholds are fundamentally flawed and do not provide meaningful criteria for the existence of significant impacts.

Establishing meaningful significance thresholds is critically important in the process of evaluating the project's potential to cause serious adverse impacts. In this context, a significance threshold could be considered "meaningful" only if an impact that is expected to cause significant adverse health effects is also one that exceeds one or more established "thresholds of significance." Available data and scientific analyses are used to characterize the impacts that can be expected if the project is approved, and the significance thresholds provide a test of whether those expected impacts are significant. Without significance thresholds that establish meaningful criteria, no amount of data or analysis will produce a valid conclusion.

Future risks to human health are assessed by collecting data on the extent of exposure to a particular hazard (or hazards) and studying the relationship between exposure and health effects in exposed populations or in laboratory animals. Then expected future exposure levels are compared with those found to adversely affect health.

The "exposure" means, in the case of a toxic chemical, the concentration in the environment. The exposure determines the "dose" (the amount absorbed from the environment) and is itself determined by the conditions under which the chemical is used. Assessment of exposure (or dose) is of fundamental importance in the overall risk assessment process because virtually all chemicals – including water and oxygen – are toxic in sufficiently high concentrations, while virtually all have negligible toxicity at sufficiently low concentrations. The principle that the dose determines the frequency and severity of health effects is captured

in the phrase "the dose makes the poison," and is elaborated in some detail in the DEIR's Appendix.

In the area of worker health and safety, the DEIR establishes the following significance thresholds:

- Regularly exceeding established workplace standards by persons following material labels and Material Safety Data Sheets, documented in worker health and safety studies, for example the 1980 and 1989 California Department of Health Services reports.

- Workplace hazards, for which substantially more severe adverse health and safety impacts and substantially greater safety precautions are identified on the Material Safety Data Sheets for CPVC related materials, or published data compared to materials used for existing pipe materials.

- Other information conclusively demonstrating that the use of CPVC pipe for potable water piping would result in adverse health or safety consequences to workers which would not be avoided or mitigated to insignificance by following the safety recommendations on the material labels or Material Safety Data Sheets.

The DEIR's significance thresholds depart from established principles and techniques for incorporating industrial hygiene into the overall risk assessment process. They neglect the fundamental importance of exposure levels; they are not based on expected conditions of use; they base risk comparisons on inappropriate indicators of health risk; and they set unrealistic standards of evidence. The significance thresholds do not provide meaningful criteria, in the sense that the thresholds would not be exceeded *even if the project were expected to result in significant adverse health effects among affected workers.*

Note that the second significance threshold is based entirely on a comparison between the risks presented by CPVC pipe installation and the risk associated with installing conventional materials such as copper pipe. The appropriateness of this comparison in the CEQA context is a legal matter, which is beyond the scope of these comments. My conclusion that the second significance threshold is fundamentally flawed is based other factors. To the extent that the comparison between CPVC and existing materials is inappropriate, the second significance threshold fails even more completely to provide a meaningful standard for the significance of expected impacts.

a. *The second significance threshold disregards the critical importance of exposure levels in assessing the potential for adverse health effects.*

Exposure levels were the primary focus of the 1989 DHS study,[1] and the importance of considering exposure levels when evaluating expected health impacts is the primary focus of these comments. The DEIR fails to adequately consider exposure levels throughout the worker health section, and in fact does not present any worker exposure data anywhere in the body of the DEIR. This failure to consider exposure levels is reflected even in the central reasoning of the DEIR, including the second "significance threshold".

The second significance threshold is based on a comparison of the health effects data for CPVC primers and cements with the health effects data for copper solders and fluxes. The health effects data to be compared are from the Material Safety Data Sheets (MSDSs) or "other published data."

Every MSDS is required to include a summary of health effects associated with overexposure,[2] and many offer a good (if brief) summary of published health effects information. However, the health effects data on MSDSs are without regard to specific exposure levels.[3] This is perhaps sensible, given the intended uses of MSDSs. The author of an MSDS has no knowledge of the conditions under which a material may be used, nor of the resulting exposure levels, and must therefore warn the user of any possible health effects. However, limits the value of MSDSs for determining the health effects that can be expected under specific conditions of use, and renders them useless for comparing the health effects that can be expected under alternative exposure scenarios.

Comparing the expected health impacts of two alternative exposure scenarios by comparing the MSDS health effects summaries can result – at best – in an unsubstantiated conclusion. At worst, it can result in a completely incorrect conclusion. Consider as an example a hypothetical project that would increase by ten-fold the exposures to some toxic agent and would increase ten-fold the incidence of a serious illness. Such health impacts would be judged significant by any reasonable measure, but the DEIR's second significance threshold would not be exceeded because the MSDS health effects summary would be unchanged.

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[1] Bellows, et al., 1989; California Department of Health Services.

[2] In California, this requirement is in 8 CCR §5133.

[3] MSDSs also indicate legal and recommended exposure limits, but do not relate health effects to these or other exposure levels.

Consider another comparison between two hypothetical exposure scenarios: in one alternative, exposures to some toxic substance are virtually certain to cause numerous serious illnesses, while in the other alternative people would be exposed to a different substance that is fatal at high concentrations but harmless under the conditions of expected use. A comparison of MSDSs would indicate that the second alternative had more serious health impacts, while in reality the opposite were true. Whether or not this hypothetical example is relevant to the comparison between CPVC and copper piping depends critically upon the exposure levels as well as the toxicity of the materials used. Relevant exposure data are presented later in these comments but were omitted from the DEIR.

b. *The second significance threshold incorporates an unreasonable assumption that the recommended safety measures are a meaningful indication of the degree of hazard presented.*

The second significance threshold also involves comparison of the recommended safety precautions for CPVC- and copper-related materials. This comparison reflects an assumption that materials expected to cause more frequent or more severe health effects would be labeled with "substantially greater"[4] safety precautions.

In fact, there exist only a small number of feasible hazard control recommendations to control an enormous variety of hazardous exposures. "Use only with adequate ventilation"[5] is the boilerplate recommendation for an enormous variety of inhalation hazards, from mild to severe. Such a general precaution gives no indication whether "adequate ventilation" means an open window or a sophisticated, engineered exhaust ventilation system. Similarly, "use rubber gloves" can be used as a boilerplate recommendation for either mild or severe dermal hazards.

Similarly-worded safe use precautions do not provide a reliable indication that two hazards are similar in severity, nor that the two hazards have a similar probability of producing adverse health effects.

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[4] DEIR, p. 44.

[5] DEIR, p. 45.

c. *The first and third significance thresholds disregard the working conditions, exposures, and health effects that can be expected if the project is approved.*

The first and third significance thresholds address exposure levels and conditions of use, but they exclude consideration of significant exposures that were documented in the DHS 1989 study and can be expected to occur in the future.

Meaningful assessment of future health impacts must be based on exposures that are expected to occur. Several approaches are accepted practice in public health risk assessment. In the simplest approach, average or most-likely exposure levels are determined, and the health risks associated with those exposures are assessed.[6] In a rather different approach, various categories or types of exposures are defined. The number of people in each category is estimated, the health risks associated with each exposure category are assessed, and the overall impact on the affected population is calculated by adding together the expected health effects in each category.

The DEIR does not adopt either of these accepted approaches. Instead it essentially creates a variant on the second approach. The DEIR explicitly establishes one exposure category (exposures to "persons following material labels and Material Safety Data Sheets"[7]) and implicitly establishes a second category (exposures to persons not following material labels). The first and third significance thresholds then exclude from consideration exposures and resulting health effects to persons not following material labels.

This approach is essentially the one taken by Robert Tardiff, cited by the DEIR, in his comments in defense of CPVC. Tardiff categorizes work practices as "proper" vs. "improper", then downplays the significance of health effects attributable to "improper" work practices.[8]

The DEIR's exclusion of exposures and health effects to persons not following material labels is central to its conclusions, and must be explored in some detail. Logical analysis indicates that exposures to persons not following material labels will be insignificant if the number of such people is insignificant, or

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[6] Alternatively, data can be used to calculate both the average and the variance of exposure levels, or other distribution parameters, and these in turn used to estimate the percentage of exposures that exceed a particular level.

[7] DEIR p. 43, first significance threshold.

[8] Comments of Robert Tardiff, 1997.

if the exposures and resulting health effects among such people are insignificant. Excluding these exposures from consideration implies a belief by the Lead Agency that at least one of these conditions is true. In other words, the first and third significance thresholds imply either that all workers will follow the material labels, or that "significant" heath impacts are not expected even among workers who do not follow material labels, or both. Each proposition will be examined.

i. Safety recommendations on material labels and Material Safety Data Sheets are too vague to reliably affect work practices.

Many workers observed during the 1989 DHS study were engaged in high-exposure practices such as installing CPVC pipe in enclosed areas without mechanical ventilation, having extensive skin contact with CPVC primers and cements, or working near spilled CPVC primers and cements. These activities were contrary to recommendations on the material labels at the time, yet they were relatively common. The reasons these particular safety recommendations were not implemented have not been studied.

Health educators in a wide variety of comparable situations have documented many factors that contribute to the ineffectiveness of health recommendations, including: vague recommendations that do not point to specific action, boring and repetitive messages, lack of definitive consequences to ignoring the recommendations, lack of positive incentives to follow recommendations, and lack of supplemental or follow-up activities. Each of these applies to the recommendations on CPVC primer and cement labels, and to my knowledge none have changed significantly since 1989.

Absent any documented changes in installation practices, and absent any changes in material labeling, worker safety training, OSHA regulations and enforcement, or other factors that could change installation practices, plumbers' work practices must be expected to be unchanged. Based on the findings of the 1989 DHS study relied upon by the DEIR, it must be anticipated that a significant percentage of plumbers will install CPVC pipe in enclosed areas without mechanical ventilation, will have extensive skin contact with CPVC primers and cements, or will work near spilled CPVC primers and cements. If expanded use of CPVC pipe is approved, the number of people engaged in these activities can be expected to expand similarly.

This observation was the subject of strong comments from the State's own health experts in response to an earlier Draft Environmental Impact Report. In 1990, Richard Jackson, MD, Chief of the Office of Environmental Health Hazard Assessment, commented: "Unless HCD devises specific, effective implementation proposals, the hazard control recommendations included in the

[1989] DEIR should not be expected to have much real impact on working conditions or exposure levels."[9]

The Lead Agency apparently understood and acknowledged this point years ago. The 1990 Administrative Final EIR addressed the recommendations of Dr. Jackson and others by proposing specific mitigation measures designed to reduce worker exposures. Specifically, the earlier Administrative Final EIR included statements such as,

> "HCD will work with Cal/OSHA to define a means to ensure that employer education and training programs are in place,"
>
> "issuance of building permits could be made contingent on evidence that the contractor has an approved health and safety plan in place,"
>
> HCD "will work with Cal/OSHA to increase enforcement of ventilation requirements" and to produce a "comprehensive alert," and
>
> HCD will "[r]equire the use of protective gloves on the work site when significant chemical exposure may occur... HCD will request that Cal/OSHA remind employers of their responsibility and increase attention to enforcement of the protective requirement, including the provision of eyewash facilities. It will also require that instruction in their use be part of all education and training. Finally, HCD will work with Cal/OSHA and DHS to verify that suitable protective gloves are available."[10]

In the 1989-1990 environmental review process, the Lead Agency found that such measures were "essential if plastic pipe is to be used safetly."[11] Absent specific measures such as these, work practices cannot be expected to be safer than those documented in 1989, and exposures cannot be expected to be lower.

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[9] Comments of Richard Jackson, MD, then Chief of the Office of Environmental Health Hazard Assessment.; p. 3.

[10] 1990 Administrative Final EIR, pp. 79-81.

[11] 1990 Administrative Final EIR, p. 79.

ii. Vaguely-worded safe use recommendations may actually result in exposures being increased rather than controlled.

Vague safety recommendations can, at worst, be counterproductive. A classic example is that use of ineffective gloves – permeable to a toxic substance of concern – may inadvertently lead to increased dermal absorption. Workers wearing ineffective gloves may acquire a false sense of security, and adopt practices that produce heavy contamination of their gloves. Dermal exposure would occur when material permeated or penetrated through the gloves, and could be greater than if the material had been handled carefully without gloves. In some cases, ineffective gloves that allow permeation or penetration of toxic materials may function to hold these materials in intimate contact with the skin, increasing the quantity absorbed.

iii. Overexposure of some workers may result from others' inability to follow safe use recommendations.

Plumbers and other construction workers typically work in small crews, in close proximity to others. The 1989 DHS study found that "exposures were significantly higher when workers had secondary exposure from other workers cementing nearby."[12] This finding indicates that workers could experience significant health effects attributable to spills or excessive primer and cement usage by others.

More importantly, many of the key safe use recommendations are under the control of employers, not individual workers. For example, individual workers typically have little control over whether the plumbing is installed early in a construction project or after the spaces have been enclosed. Individual workers similarly have little control over the primers and cements used, the availability and use of mechanical ventilation, the presence of other workers installing other plastic piping systems nearby, or the availability of facilities for safely decontaminating skin and eyes. Thus, workers' exposures – and overexposures – depend critically on the actions of their employers.

Thus, even assuming health effects could "be avoided or mitigated to insignificance by following the safety recommendations,"[13] the problematic work practices will often be beyond the control of those affected. High exposures can be expected – even among workers implementing the safety recommendations

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[12] Bellows, et a., 1989; p. 19.

[13] DEIR, p. 43.

over which they have personal control – because of the actions of others. Based on the findings of the 1989 DHS study, these exposures could result in potentially significant health effects.

iv. Exposures capable of significantly affecting human heath must be considered "significant" impacts, even if they are associated with failure to follow material labels.

These comments elsewhere review in detail the evidence that CPVC pipe installers will periodically experience high solvent exposures, and that these exposures can be expected to produce health effects. Data from the 1989 DHS study indicate the highest exposures are produced by work practices contrary to manufacturers' recommendations.

In analyzing the DEIR's significance thresholds, it is most relevant to note that both the DEIR and the State's own health experts acknowledge that adverse health effects can be expected among workers not following material labels. In advising the Lead Agency on preparation of the current DEIR, DHS wrote: "Case reports point to the likelihood that overexposure related to poor ventilation has already led to illness in pipe workers."[14] The DEIR itself states: "Workers not following safe use recommendations or using improper materials can be injured, and the Lead Agency considers this to be the worst case situation."[15]

In acknowledging that exposures to persons not following safe use recommendations can cause injury or illness, but establishing a significance threshold that excludes these exposures from consideration, the DEIR implies that injury to such persons is somehow not "significant" in this policy making context. Apart from any legal issues created by this approach, this exclusion is completely contrary to accepted public health practices and to established policy making in other contexts. Indeed, most major public health programs – from AIDS prevention through tobacco control to traffic safety – are explicitly directed toward limiting the health consequences of people's inability to consistently follow safety recommendations. Policy makers in these contexts accept the reality that people cannot be expected to follow all safety recommendations, and that warnings alone cannot be expected to provide sufficient protection.

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[14] Comments of Elizabeth Katz, MPH, Acting Chief, Hazard Identification System and Information Service, Department of Health Services; June 11, 1998.

[15] DEIR, p. 69

v. Excluding consideration of exposures and adverse health effects resulting from inability to follow safe use recommendations departs from the Lead Agency's past practices and from the advice of State health experts.

The Lead Agency recognized as early as 1988 the importance of identifying health impacts under the conditions most likely to occur if expanded use of CPVC were approved. This recognition was the basis of the Lead Agency's request that DHS study exposures under real-world conditions. The approach of studying real-world conditions was supported by DHS and by representatives of workers and CPVC manufacturers. There would have been no need for such a study if policy making could be based on arbitrarily categorizing work practices as "proper" vs. "improper", then discounting any impacts attributable to "improper" work practices.

DHS reminded the Lead Agency to consider all expected conditions and exposures in its 1990 comment, "In the absence of specific, effective implementation strategies, HCD must give much more serious consideration to the worker exposures, and possible health risks, likely to occur with increased use of plastic pipe."[16]

The Lead Agency acknowledged this advice in its 1990 Administrative Final EIR, which included several specific mitigation measures intended to decrease the prevalence of unsafe work practices. During preparation of the current DEIR, DHS once again reminded the Lead Agency to base its analysis on expected conditions, commenting that expanded use of CPVC "is a question involving substitution of chemicals and work methods. Such substitutions occur in a context of real-world alternatives."[17]

vi. To provide a meaningful standard for the project's potential to cause significant adverse health impacts, the significance thresholds must be revised to reflect the real-world conditions that can be expected, and their potential health impacts.

The DEIR's first and third significance thresholds imply either an expectation that safe use recommendations will be implemented in the future, or a belief that adverse health effects attributable to unsafe practices are not

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[16] Comments of Richard Jackson, MD, then Chief of the Office of Environmental Health Hazard Assessment. December, 1989; p. 3.

[17] Comments of Elizabeth Katz, MPH, Acting Chief, Hazard Identification System and Information Service, Department of Health Services; June 11, 1998.

"significant" in policy making. Both are contrary to available data and established practices. The significance thresholds therefore do not provide meaningful criteria, in the sense that the thresholds would not be exceeded even if the project were expected to result in significant adverse health effects among affected workers. The significance thresholds should be modified to reflect the expected conditions of use and the associated exposures and health effects.

d. The third significance threshold sets an unreasonable standard ("conclusively demonstrating") for the finding of a significant impact.

The DEIR's third significance threshold sets a high standard for evidence of significant impacts: "Other information conclusively demonstrating that the use of CPVC pipe for potable water piping would result in adverse health or safety consequences to workers, which would not be avoided or mitigated to insignificance... " In other words, exceeding this significance threshold would require a conclusive demonstration that some particular levels of exposure would be experienced by plumbers installing CPVC pipe, and a conclusive demonstration that these exposure levels would not be mitigated by non-specific safe use recommendations, and a conclusive demonstration that the exposures could result in adverse health effects.

The first element (conclusive demonstration that high exposures would occur) requires a level of certainty about future events that seems unachievable on its face, but this is perhaps a legal issue and is not considered further in these comments. The second element (conclusive demonstration that exposures could not be mitigated by safe use) is tautological: the boilerplate recommendation "use only with adequate ventilation" is worded so broadly as to guarantee that any exposure causing adverse health effects was the result of failure to the recommendation. Again, this is perhaps a legal issue and is not considered further in these comments.

The possibility of meeting the third test – "conclusively demonstrating" any causal relationship between exposure and health effects – is a scientific matter that merits further consideration. In general, a causal relationship may be conclusively demonstrated only if all the following prevail: the health effects of interest are readily identifiable, the health effects are manifest at a predictable (and usually short) period after exposure, a high percentage of exposed individuals experience the effects of interest, and a low percentage of unexposed individuals experience the effects. Many exposure-response relationships meet all these conditions, and the causal relationships can be demonstrated quite conclusively using the analytic techniques of medical toxicology and epidemiology. For example, there is no apparent disagreement with the findings that (if the concentrations are sufficient) acetone exposure causes central

nervous system depression, exposure to copper fumes causes "metal fume fever," and tetrahydrofuran causes severe corneal irritation; these exposure-response relationships can be said to have been "conclusively demonstrated."

For other types of health effects – those that do not meet the conditions listed previously – the prospects for "conclusive demonstration" of a causal relationship are remote, simply because the available analytic techniques are not sufficient to provide this level of evidence. Cancers are the best-known example; their causes are notoriously difficult to pinpoint because a long and variable latency period separates exposure from the appearance of disease. Even in the case of cigarette smoke – with hundreds of millions of people exposed and tens of millions of cancer deaths – dozens of studies over several decades were required before the relationship between smoking and lung cancer was conclusively demonstrated.[18]

Cancers are only the best-known example of health effects whose causes are difficult to conclusively demonstrate. Similar difficulties are presented by many other types of exposure-effect relationships, such as: chronic neurologic impairment caused by solvent exposure (because characterizing the health effects is difficult), hypertension caused by lead exposure (because the condition is often not identified until after exposure has ceased), occupational asthma (because many exposed individuals are unaffected), spontaneous abortions caused by glycol ethers (because many unexposed individuals are affected), and chemically-induced birth defects (because the timing of exposure is critical).

Epidemiology is the only scientific discipline capable of demonstrating causation for conditions such as those listed in the previous paragraph. However, epidemiology can provide evidence that approaches the level of "conclusively demonstrating" exposure-response relationships only if the presence or absence of the illness can be clearly established, exposures are determined accurately, a large number of people have been affected, and multiple systematic studies have been conducted. These conditions are extremely restrictive, and they account for the very small number of cases in which epidemiology can be said to have "conclusively demonstrated" an exposure-response relationship. Of the exposure-response relationships listed in the previous paragraph, many are widely accepted but could not be described as "conclusively demonstrated."

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[18] Some people still do not accept that the role of cigarette smoke in causing lung cancer has been conclusively demonstrated, and cigarette smoke's role in causing cancer at several other sites is still uncertain.

Because the third significance threshold relies on the standard of "conclusively demonstrating" an exposure-response relationship, and because this level of evidence is essentially unachievable for many adverse health effects, there is effectively no possibility that exposures causing these health effects could trigger a finding of significance. In incorporating such a strict level of evidence in the significance threshold, the Lead Agency has either disregarded the inherent limitations of epidemiology or has intentionally excluded consideration of a wide class of adverse health effects.

The standard of "conclusively demonstrating" adverse health effects is inconsistent with public health practice and with the limitations of epidemiology and risk assessment, and the third significance threshold must be revised if it is to provide a meaningful test for the significance of expected impacts.[19] A more realistic standard of evidence is incorporated in the first significance threshold: "documented in ... studies." A comparable standard should be used in the third significance threshold.

e. Conclusion regarding significance thresholds

The significance thresholds are inconsistent with established risk assessment and public health practice, incorporate assumptions that cannot be supported by facts or analysis, and disregard the earlier recommendations of the State's health experts. The significance thresholds must be revised if they are to provide a meaningful standard for the significance of expected impacts. Findings based on the significance thresholds must be considered invalid unless the significance thresholds are modified substantially.

2. The DEIR's finding of no significant impacts on worker safety is not supported by any data or scientific analysis, and is based on several misrepresentations, incorrect assertions, and invalid assumptions.

The DEIR – after presenting fundamentally flawed significance thresholds – summarizes some information on the potential impacts of CPVC installation, adds its own assumptions, assertions, and interpretations, and combines these to reach the conclusion that expanded use of CPVC would not result in significant impacts to worker health and safety. Many of the assumptions, assertions, and interpretations are misleading, unsupported, invalid, or factually incorrect.

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[19] The DEIR in other sections also applies similarly unrealistic standards of evidence. See for example, on page 47: "There is still no information *proving* adverse health effects from long-term exposures... " (emphasis added).

a. *The DEIR's use of conclusions from a 1980 report is misleading because that report was written nine years before key data were available.*

The DEIR quotes directly from the conclusion of a 1980 DHS report on health effects related to plastic pipe.[20] Perhaps the Lead Agency found it preferable to quote this report rather than the later and much more comprehensive 1989 DHS report because its conclusions are more favorable to the proposed project. However, this use of the 1980 conclusion is misleading and inappropriate. The 1980 DHS report was not able to draw on any extensive exposure data, because none had yet been produced.

The passage quoted refers to "field measurements of exposure under a wide range of working conditions," but in fact the exposure data available in 1980 was rather limited. The experience of the 1989 study team was that monitoring exposure under a wide range of conditions required extraordinary effort and expense, especially because the activity of greatest interest (installation of CPVC potable water pipe for residential use) was generally not permitted in the state. Studies prior to the 1989 DHS study did not identify, locate, or monitor the wide range of working conditions monitored in 1989.

Conclusions drawn from earlier studies, which drew on only a small portion of the exposure data now available, are irrelevant given current information. Quoting these conclusions is misleading, unless the quote is to provide historical context.

Curiously, the body of the DEIR does not quote directly the conclusions of the more extensive and more relevant 1989 DHS study. The most relevant conclusions of that study describe the full range of exposures documented, including:

"1. Short-term exposure limits for THF, and for the additive effects of THF, MEK, CHX, and ACE [tetrahydrofuran, methylethylketone, cyclohexanone, and acetone], are sometimes exceeded during routine residential plastic pipe installation. The probability of exceeding the short-term exposure limits at least once in a work day is dependent on working conditions and is highest for workers installing CPVC potable water pipe; for these workers, this probability is estimated to be 68%.

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[20] DEIR, p. 44.

"2. ... full shift overexposures occur on some work days. Full-shift overexposures are most likely to occur during CPVC-pw [potable water] installation, in which the probability of overexposure is estimated to be 10%."

and

"5. Dermal absorption of THF probably contributes significantly to the total (airborne plus dermal) exposure of workers who have heavy skin contact with primers and cements. Based on their urine THF concentrations, four of these workers had estimated equivalent airborne exposures ranging from 150 to 740 ppm. Despite the uncertainty of these estimated values and the lack of chronic toxicity information, these data are of concern because they suggest that for some workers, total exposure may far exceed the airborne exposure limit."[21,22]

These conclusions must be cited directly if the DEIR is to provide an accurate indication of DHS findings in its extensive 1989 study.

b. The DEIR's interpretation of the 1989 DHS study misrepresents the study's stated conclusions, and misrepresents the importance of the study in understanding the exposures that can be expected if expanded use of CPVC is approved.

The DEIR describes briefly the 1989 DHS study, and paraphrases key findings of the study as follows: "Some potential for short-term and long-term overexposure to solvents was found."[23] That paraphrase badly misrepresents the actual conclusions quoted previously.

The 1989 DHS study did not find "potential" for overexposures; it documented *actual* overexposures during conditions of normal use. Short-term exposures to THF were up to 529 ppm, more than twice the exposure limit. The study found that short-term overexposures were not uncommon, and estimated that they were likely to occur in over two-thirds of work days when CPVC is being installed.

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[21] Bellows, et al., 1989; p. 33.

[22] Note that significant new data on chronic toxicity of THF have become available since the 1989 DHS report. The conclusions of the 1989 report are quoted because they are still the best available summary of exposures expected during installation of CPVC piping. The 1989 report's conclusions regarding the potential for adverse health effects are no longer accurate because they do not reflect current toxicity information.

[23] DEIR, p. 45. The DEIR does provide on p. 47 a somewhat more accurate paraphrase of DHS' 1989 findings.

The DEIR also misrepresents the conclusions of the 1989 DHS report by failing to mention a key conclusion: that dermal absorption contributes significantly to total exposure for some workers, and that for these workers the total exposure may "far exceed" the airborne exposure limits. Selective omission of key results does not meet recognized standards for fair and honest presentation of scientific data.

The DEIR largely dismisses the 1989 DHS conclusions, by pointing out that many workers studied did not follow safe use recommendations. The fact remains that the 1989 DHS study is the best available determination of exposures under a wide range of real-world working conditions, and is therefore the best available indication of exposures that can be expected if expanded use of CPVC is approved. Note again the DHS comments on the 1989 DEIR, that absent effective mitigation measures "the hazard control recommendations included in the DEIR should not be expected to have much real impact on working conditions or exposure levels." The 1990 Administrative Final EIR found that such measures were "essential."[24]

Regular overexposures were documented in the 1989 DHS study, and absent evidence of changes since that study was conducted, regular overexposures must be expected if expanded use of CPVC is approved.

c. *The DEIR's statement that technological advances since the DHS study have reduced exposure levels is not based on data or analysis; and assertions and inferences offered in support of this statement are incorrect.*

The DEIR focuses substantial attention on changes since the 1989 DHS study. Any significant changes are indeed a legitimate subject of consideration. Changes in materials or working conditions could certainly change exposure levels, and could decrease (or increase) the potential for significant adverse health effects. The changes produced by new materials or working conditions could be documented by collection of new data, or could be estimated using scientific models or evidence-based analysis. However, the DEIR cites neither data nor rigorous analyses in claiming, "Measures which would greatly reduce the likelihood of exceeding the standards were implemented prior to the beginning of preparation of this EIR."[25]

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[24] 1990 Administrative Final EIR, p. 79.

[25] DEIR, p. 47.

The DEIR does cite several "changes" since the 1989 DHS study. Each of these merits consideration.

i. The DEIR's statement that dyes have been added to solvent primers, with the intent of discouraging dermal exposure, is factually incorrect.

The DEIR asserts that "consistent with the recommendations of the DHS report, dyes have been added to the formulae for solvent primers."[26] No substantiation is offered for this assertion. More importantly, the assertion is factually incorrect. I reviewed the CPVC primer and cement product descriptions and MSDSs of two major manufactures.[27] Both manufacturers offered CPVC primer in either dyed or clear formulations. In other words, the situation is unchanged from 1989: some primers are dyed and others aren't. No changes in working conditions or exposures can be expected.

ii. The DEIR's assertion that one-step cements would eliminate the need for adding dyes to CPVC primers is unsubstantiated and is not consistent with observations of the 1989 DHS study.

The DEIR claims that "while dyes are desirable, the one-step cements would obviate the need for this measure."[28] This claim is not supported by any substantiation or any analysis. During the 1989 study, several workers used primers to remove cement residue from their skin. This practice was contrary to safe use recommendations on the material labels.

Based on my conversations with workers, my understanding is that they used primers for this purpose because they were unskilled in keeping cement off their skin, they disliked the process of peeling cement residue from their skin, the primer is formulated to be an ideal solvent for the residue, and the primer is readily available. Of these, introduction of one-step cements would have no impact on the first three, and would have minimal effect on the availability of primers unless all primers were removed from the market. So long as undyed primers are available for drain, waste, and vent lines (DWV), irrigation, fire sprinkler systems, and the like, plumbers who like to use them as a hand cleaner must be expected to continue this practice.

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[26] DEIR, p. 46.

[27] The manufacturers were Oatey and IPS. The product descriptions and MSDSs were readily available to the Lead Agency.

[28] DEIR, p. 46.

iii. The DEIR implies incorrectly that safety recommendations on material labels have changed.

The DEIR includes in a list of technological changes a statement that "instructions consistent with DHS recommendations to reduce exposures are now on the material labels."[29] This statement, and its placement in a list of recent changes, imply that safety recommendations on material labels have changed since the 1989 DHS study. The DEIR offers no substantiation. To my knowledge, the material labels typical of these products have remained essentially unchanged since the 1989 study (and before).[30] No changes in work practices or exposure levels can be expected.[31]

d. The DEIR's assertion that use of low-VOC primers and cements will reduce worker exposures is not substantiated by any data or analysis; an evidence-based analysis indicates it is incorrect.

The DEIR asserts that introduction of low-VOC primers and cements will reduce the exposures associated with CPVC pipe installation.[32] This point receives the greatest emphasis in the Lead Agency's assertion that technological changes since 1989 would reduce exposure levels. The claim is not substantiated by any data or any scientific analysis.

The 1989 DHS study was specifically designed to help policy makers evaluate exposure scenarios other than those actually monitored. The study report presents data and an exposure model ideally suited to estimating the exposures that can be expected under modified conditions, such as with alternative primers and cements. The analysis is as follows.

The 1989 study proposed and tested the exposure model:

$$C_i = \frac{k_N N^{b_N} \times k_B B_i^{b_B} \times k_T T^{b_T}}{k_V V^{b_V}}$$

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[29] DEIR, p. 46.

[30] Comparison based on current labels and the label language quoted in Bellows, et al., 1989, p. 14.

[31] Safe use recommendations on material labels were not implemented in 1989, so no substantial changes in work practices would be expected even if modest changes were made in material labels.

[32] DEIR, p. 48, and implied on pp. 45, 112.

where c_i is the airborne concentration (or exposure) of some substance i, B_i is the bulk concentration of substance i, and the other symbols are as identified in the 1989 DHS report.[33] The data confirmed the hypothesized effects of bulk concentration and air flow rates on worker exposures, namely that the exposure to a particular substance is directly proportional to the bulk concentration and inversely proportional to the air flow rate.[34] Exposures are highest when bulk concentrations are high and air flow is low.

The exposure levels that would be expected to occur if alternative primers and cements were used, but all other working conditions were unchanged, can be estimated from:

$$c_{i,est} = c_{i,obs} \cdot \frac{B_{i,est}}{B_{i,obs}}$$

where $c_{i,est}$ is the estimated exposure to i under the modified conditions, $c_{i,obs}$ is the observed exposure, $B_{i,obs}$ is the bulk concentration in the conditions observed, and $B_{i,est}$ is the bulk concentration for the modified working conditions.[35] Full-shift exposure to multiple substances that can cause additive effects is reflected in the combined exposure index:

$$\%FSEL_{est} = \sum_i \left(\frac{c_{i,obs}}{FSEL_i} \cdot \frac{B_{i,est}}{B_{i,obs}} \right) \cdot 100\%$$

where $\%FSEL_{est}$ is the estimated combined exposure index under the modified conditions and $FSEL_i$ is the full-shift exposure limit for i.

Estimates of the combined exposure index were produced for the hypothetical scenario that a typical low-VOC primer and cement were used at all the CPVC potable water sites monitored for the 1989 DHS study.[36] The

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[33] Bellows, et al., 1989; p. 11.

[34] Bellows, et al., 1989; p.21 for short-term exposures, p. 23 for full-shift exposures.

[35] This incorporates a simplification from the original model that is valid only if the model parameter b_B is equal to unity, as hypothesized. The study data were entirely consistent with the hypothesis and support the simplified form of this estimate.

[36] The bulk concentrations used to produce these estimates were based on the manufacturers MSDSs for a leading brand (Oatey), as follows – primer: 12% THF, 72% MEK, 13% CHX, and 3% ACE; cement: 45% THF, 2.5% MEK, 7.5% CHX, and 30% ACE. As in the original study, the bulk concentration entered into the model was the average of the primer concentration and the cement concentration.

estimated combined exposures were *higher* than the observed exposures for all six CPVC-pw sites, by 11% to 155%. The highest estimated combined exposure ($\%FSEL_{est}$) was 229%, more than double the highest observed value for *%FSEL*. The average $\%FSEL_{est}$ for all sites would be 67.7%, nearly double the average observed *%FSEL* of 36%.[37]

These estimates, derived from study data collected under conditions of actual use and applied to the exposure model presented in the 1989 DHS study, directly contradict the assertions in the DEIR. The estimates indicate that widespread use of typical low-VOC primers and cements would actually *increase* the expected combined exposures.

This result is worth considering in some detail because it may at first seem counterintuitive. Consider as an example the site at which the combined full-shift exposure was 107%, the highest observed. One component of that exposure was 23 ppm MEK. The average bulk composition of the primer and cement used at the site was just 3.5% MEK (primer, 7%; cement, 0%). However, the average bulk composition of a typical low-VOC primer and cement is 37% (primer, 72%; cement, 2.5%), more than ten-fold higher.

Ten-fold higher bulk concentrations would be expected to result in ten-fold higher airborne concentrations as the primer and cement evaporate. The estimated MEK exposure for this example would be 243 ppm, exceeding the full-shift exposure limit of 200 ppm. Similar adjustments for the other constituents produce an estimated combined exposure of 189%.

e. The DEIR draws invalid inferences from the absence of documented, serious health effects in previous worker safety studies.

The DEIR notes correctly that previous systematic studies have not "found significant adverse effects on workers" installing CPVC pipe.[38] The DEIR then implies that this provides evidence for the safety of CPVC pipe installation. The inference is spelled out most clearly in the following passage: "The Lead Agency is not aware of any other data which demonstrates that the use of CPVC pipe has resulted in a pattern of workplace injury, despite the fact that there is a long history of it use in this State, other states, and other nations. The absence of this

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[37] Similar exposure estimates could be produced for short-term exposures, but are not presented.

[38] DEIR, p. 47.

information in the face of over a generation of use suggests a reasonable assurance that there is not a significant risk associated with CPVC."[39]

This inference is completely invalid and is unsupported by any analysis. Previous studies have not found much evidence of adverse health effects precisely because the studies were not intended or designed to examine adverse health effects. The 1989 DHS study, for example, included a survey in which participating workers were asked whether or not they had experience symptoms of ill health on the day(s) their exposures were monitored. The results of this symptom survey were not highlighted in the study's conclusions, because the study was explicitly "not designed for analysis of differences in self-reported symptoms among various exposure groups."

No rigorous comparison was possible between the self-reported symptoms of workers installing CPVC pipe and the symptoms of workers installing copper pipe. The study design, the data collection methods, and the statistical power were all inadequate to support any strong statement about health effects, so none was made. Any further interpretation in the DEIR is contrary to fundamental principles of epidemiology and biostatistics.

The 1989 DHS report did make the following observation: "The most commonly reported symptoms are noteworthy in that they are consistent with the known (or suspected) acute effects of overexposure to THF, MEK, CHX, and ACE: irritation of mucous membranes and skin, and depression of central nervous system function."[40] While the study was not designed to be able to formally test the hypothesis that exposure to plastic pipe primers and cements caused the reported symptoms, the data were certainly consistent with such a hypothesis.

Perhaps the Lead Agency did not realize that symptoms consistent with the health effects of toxic exposure were documented during the 1989 DHS study. Alternatively, perhaps the Lead Agency did not consider mucous membrane irritation and central nervous system depression to be "significant" adverse effects. However, as DHS has previously advised, "the consequence of repeated irritation... should not be lightly dismissed."[41] Further, central nervous system depression would certainly be significant for workers who drove vehicles

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[39] DEIR, p. 112-113.

[40] Bellows, et al., 1989: p. 16.

[41] Comments of Richard Jackson, MD, then Chief of the Office of Environmental Health Hazard Assessment. December, 1989; p. 3.

immediately after their work shifts, and that included virtually every worker in the study.

The 1989 DHS study made absolutely no attempt to identify signs or symptoms of other health effects the Lead Agency might consider more significant, such as liver or kidney damage. Ascertaining internal organ toxicity would have required a completely different study protocol. Thus the 1989 study offers absolutely no evidence – positive or negative – regarding liver or kidney damage associated with plastic pipe installation.

Only two other previous studies – the NIOSH Health Hazard Evaluations – offer any possibility of establishing a causal relationship between plastic pipe exposure and adverse health effects. The DEIR contains brief summaries of these studies,[42] but cites no data and offers no substantive analysis of how the study results did or did not contribute to the DEIR's findings.

A substantive analysis would have addressed the issue of whether or not the studies had adequate statistical power to find a relationship between exposures and outcomes if such a relationship truly existed. Consideration of the statistical power of a study is standard practice and is essential in properly interpreting study results. In fact, the NIOSH studies were like the 1989 DHS study in that they lacked the statistical power to support strong causal inferences about possible health effects of installing plastic pipe. Had the DEIR included any substantive analysis of these studies, it could only have concluded that they offer little support for statements such as "other data ... suggest a reasonable assurance that there is not a significant risk associated with CPVC."

Systematic studies of health effects related to toxic exposure are expensive and time-consuming. They are typically conducted only if indirect evidence suggests that an exposure has the potential to cause adverse health effects. Most often that evidence falls into two categories: case reports associating exposure with illness, or evidence of high exposures to substances found to cause adverse health effects in animal tests. Both kinds of evidence now exist indicating the potential for plastic pipe primers and cements to cause adverse health effects. This evidence indicates that systematic health effects studies could be appropriate at this time. In the absence of such studies, the health effects inferences in the DEIR are invalid and misleading.

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[42] DEIR, p. 66.

f. The DEIR misrepresents recent comments by the Department of Health Services.

Rather than providing an independent analysis of the impact of expanded CPVC use on worker health and safety, the DEIR draws heavily on recent DHS comments and on comments provided by an industry source.[43,44] Neither of these comments describe any substantive, scientific analysis of the frequency or severity of health effects that would result from the exposures expected during CPVC installation.

The DEIR summarizes the DHS comments as follows: "After review of all the information available, the DHS found that while THF may be found to be a human carcinogen in the future, it is not considered one at this time, and there is no reason to revise the conclusions of the 1989 study."

This summary is misleading. It suggests that the DHS opinion about the conclusions of the 1989 study was based on "all the information available." In fact, this statement was drawn from DHS' first comment letter, written when the Lead Agency had apparently provided DHS with incomplete and misleading information.

Specifically, the Lead Agency had chosen not to provide DHS with the National Toxicology Program (NTP) final draft report documenting evidence of THF carcinogenicity in mice and rats, the conclusions of which had already been approved by NTP's expert panel. The Lead Agency had also chosen not to forward to DHS case reports associating THF with liver and kidney toxicity and with seizures following exposure. These documents indicate that at least one conclusion from the 1989 DHS study needs to be updated. Conclusion #4 from the DHS report states in part: "for some of these substances (notably THF) the health effects of long-term exposure have not been studied."

Had the NTP bioassay report – documenting the health effects of long-term exposure – been in its possession at the time of its first comments, DHS would have been unable to responsibly assert that there is no reason to revise the 1989 conclusions. The Lead Agency apparently had also informed DHS that one-step cements are commonly used in California, while in fact such cements are not even approved for use. After these errors and omissions were brought to its attention, DHS' follow-up comments were more cautious and did not repeat

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[43] Comments of E. Katz, April 28, 1998 and June 11, 1998.

[44] Report of Robert G. Tardiff, 1997.

the opinion that there is no reason to revise the conclusions of the 1989 DHS report.

The DEIR states that the above-referenced information was "not otherwise available to the Lead Agency."[45] If true, this suggests that the Lead Agency's data gathering efforts were less than thorough, because the information is readily available and is central to any meaningful analysis of the potential impacts of expanded CPVC use.

g. The DEIR misrepresents the level of protection afforded by existing exposure limits.

The DEIR acknowledges that solvent overexposures occur during CPVC pipe installation, but discounts the possibility that these overexposures produce adverse health effects. Specifically, the DEIR asserts that "the workplace standards are set to protect the health of workers over their lifetimes with a substantial margin of safety for significant adverse health effects."[46] This assertion is integral to the DEIR's finding of no significant adverse impact on workers: "The Lead Agency does not consider the potential for solvent exposures to occasionally exceed standards based on lifetime exposure regimes, with a built-in margin of safety, to be a significant impact within the context of CEQA."[47]

The Lead Agency, however, fails to consider that the exposure limits for THF have not yet been updated to reflect the evidence of carcinogenic activity found in the NTP bioassay. NTP in its own report and based on its own findings commented, "exposure at the current occupational standard may pose a risk to human health."[48] In other words, the exposure limits for THF are out of date may provide no protection against significant adverse health effects.

The DEIR is also incorrect in implying that exposure limits in general provide a substantial margin of safety. Extensive research has shown that Threshold Limit Values (TLVs) in general do not provide any margin of safety and are in many instances not even protective of human health.[49] They are

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[45] DEIR, p. 67.

[46] DEIR, p. 47.

[47] DEIR, p. 47.

[48] National Toxicology Program, *Technical Report on the Toxicology and Carcinogenesis of Tetrahydrofuran in F344/N Rats and B6C3F$_1$ Mice*, Board Draft.

[49] Roach, S. Comments submitted to the Lead Agency in preparation 1989 DEIR.

instead most closely related to the economically-feasible exposure levels at the time the TLVs were established. The existing OSHA exposure standards for THF, MEK, CHX, and ACE were all drawn directly from early TLVs, so they cannot be considered to have any "substantial margin of safety."

The DEIR is also incorrect in stating that the referenced exposure limits are "based on lifetime exposure regimes," and implying that "occasional" overexposures are thus unlikely to produce significant health effects. For the solvents used in CPVC primers and cements, the full-shift and short-term exposure limits were established on the basis of health effects that can occur after a few hours or days of exposure. Exposures exceeding these limits thus have the potential to result in adverse health effects, even of the overexposures occur only occasionally.

Some of the solvent exposure limits were established on the basis of the solvents' ability to irritate eyes and mucous membranes. DHS has stated clearly: "Short-term irritation is a material impairment to health,"[50] and "The consequence of repeated irritation of eyes, nose, and throat should not be lightly dismissed. A growing body of evidence suggest that repeated irritation may contribute to chronic illness."[51]

Exposure limits are intended to be just that – limits on exposure. The potential for adverse health effects must also be taken into account any time exposure limits are exceeded, or when exposures are below existing limits but the limits are known not to reflect current toxicity information. In discounting the significance of regular exposures above existing exposure limits, the DEIR ignores the purpose of the exposure limits and is contrary accepted industrial hygiene practice.

h. The DEIR misrepresents the relevance of case reports of THF toxicity.

The DEIR implies that case reports of adverse health effects associated with THF exposure are not relevant, because they were associated with "massive overexposures."[52] Exposure levels were documented in only one of the case reports; short-term exposures in that case were 389–757 ppm and were

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[50] Bellows, et al., 1989: p. 73, from toxicology review by Frank Mycroft, PhD.

[51] Comments of Richard Jackson, MD, then Chief of the Office of Environmental Health Hazard Assessment.; p. 3.

[52] DEIR, p. 67.

indeed described as "massive."[53] The description may be appropriate, but the high exposure levels in no way make the case report irrelevant to the evaluation of potentially significant adverse health effects from CPVC installation. The highest short-term exposures measured in the 1989 DHS study fall in the same range. Similar exposures would indeed be expected, because the task (CPVC installation), work environment, and work practices were apparently all similar to those observed in the DHS study. Biological monitoring in the 1989 DHS study indicated that some workers' combined exposures (inhalation plus dermal) were in the same range even when averaged over an entire work day. The reported health effects following THF exposure are therefore entirely relevant to the DEIR.

High exposures are typical of case reports in occupational health. Individual cases or case series are typically documented and published precisely because they involve exposures noteworthy in their magnitude or novelty. The presence or absence of adverse health effects at lower exposure levels can be determined only by systematic epidemiologic study. High-exposure case reports typically serve as a first indication that adverse health effects are occurring in some exposed population, and often trigger systematic studies to determine the incidence and severity of adverse effects. Rather than dismissing the case reports of adverse effects associated with THF exposure, the Lead Agency should consider them an indication that systematic epidemiologic study may be warranted in preparation of the EIR.

i. The DEIR misrepresents the applicability and relevance of the NTP bioassay for THF.

The DEIR implies that the positive cancer bioassay for THF is not relevant, because tumors were found in test animals only at very high exposure levels.[54] This implication is misleading at two levels. First, the bioassay was conducted according to completely standard bioassay procedures.[55] Its results are therefore highly relevant to assessing the health risks of THF, just as are the results of any other standard cancer bioassay.

Perhaps more importantly, the exposure levels that produced tumors in male rats and female mice are not much greater than documented worker exposures. Excess tumors in male rats were produced by exposure to 600 ppm

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[53] Albrecht, WN, Boiano, JM, and Smith, RD, 1987. IgA glomerulonephritis in a plumber working with solvent-based pipe cement. *Industrial Health*; 25:157-158.

[54] DEIR, p. 67.

[55] National Toxicology Program, *Technical Report on the Toxicology and Carcinogenesis of Tetrahydrofuran in F344/N Rats and B6C3F$_1$ Mice*, Board Draft.

THF, lower than the highest estimated equivalent exposure level of 740 ppm documented in the 1989 DHS study for combined (inhalation plus dermal) exposure. Excess tumors were produced at and above 200 ppm in female mice, although the excess was not statistically significant for exposures for exposures below 1800 ppm. These data indicate that there is essentially no margin of safety between the THF exposures that cause cancer and laboratory animals and those that are experienced by workers installing CPVC pipe. The bioassay is therefore of critical importance in assessing the risks of THF exposure during CPVC installation and must be considered fully in evaluating the impact of expanded CPVC use.

j. Conclusions regarding the DEIR's finding of no significant adverse impacts to workers

The DEIR's finding of no significant adverse impact to workers is based upon unsupported assertions, misrepresentations, and misleading interpretations. Just as DHS commented on the earlier 1989 DEIR: "The DEIR's conclusion that repeated exposure would 'probably not accumulate to serious, long-term health risks' is entirely inappropriate."[56] In 1990 the Lead Agency addressed these concerns in the Administrative Final EIR by acknowledging the risks associated with CPVC pipe installation and by proposing substantive hazard reduction measures. The omission from the current DEIR of any clear acknowledgement of risk and any substantive exposure reduction proposals is cause for serious concern. Indeed, recent indications that THF has carcinogenic activity increase significantly the apparent risks associated with CPVC installation.

3. Expanded use of CPVC pipe would result in potentially significant impacts to workers.

Any meaningful assessment of potential impacts from expanded CPVC pipe use must be based on comparing worker exposures to the relevant exposure limits, to the exposure levels that have been associated with human toxicity, and to the levels that have produced adverse affects in laboratory animals. The worker exposures appropriately used in such an evaluation are those that can be expected to occur, based on the best available exposure data.

The best available exposure data for this purpose are those in the 1989 DHS study. This is hardly surprising since the 1989 study was expressly

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[56] Comments of Richard Jackson, MD, then Chief of the Office of Environmental Health Hazard Assessment. December, 1989; p. 2.

designed to produce data relevant to assessing the impact of expanded CPVC use.

The analysis in this section is based on the expectation that future exposures would be essentially the same as exposures measured in the 1989 DHS study. This is the most realistic and scientifically justified expectation. Despite the assertions in the DEIR that technological changes since 1989 have reduced worker exposures, no data or scientific analysis support these assertions. As presented in section 2.c. of these comments, no documented changes in working practices or environmental conditions have occurred since 1989. Absent specific measures to reduce exposures, future reductions cannot be expected.

The DEIR does indicate that the Lead Agency will affect future working conditions in one way: by requiring use of low-VOC primers and cements. Use of these materials would be expected to actually increase – not decrease – overall worker exposures as presented in section 2.d. of these comments. The magnitude of such an increase – and the nature of any changes in exposures to individual chemical constituents – depends upon the composition of the materials that will be used when the Lead Agency's new regulations are in effect. This information cannot be known at this time. The analysis in section 2.d. represents the most realistic and scientifically justified expectation, but is still less certain than the actual exposure data collected in the 1989 DHS study. Changed exposure levels – reflecting use of low-VOC primers and cements –are therefore not reflected in this section, except in estimating worst-case exposure levels.

a. *Full-shift and short-term solvent exposures in excess of established exposure limits must be expected on a regular basis among workers installing CPVC pipe.*

Based on air monitoring data collected during the 1989 DHS study, full-shift airborne solvent exposures in excess of exposure limits can be expected among workers installing CPVC pipe for potable water.[57] Airborne THF exposures are expected to exceed the legal exposure limit of 200 ppm on 5.5% of work days.[58] Airborne MEK exposures are expected to exceed the legal exposure limit of 200 ppm on 2.2% of work days. Additive exposure to airborne THF, MEK, CHX, and ACE – as expressed in the combined exposure index %FSEL – can be expected to exceed the 100% exposure limit on 10% of work days. These exceedances,

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[57] Bellows, et al., 1989: p. 21-23.

[58] Bellows, et al., 1989: Table 13, p. 47.

based on the most relevant available data collected during actual working conditions, indicate that regular overexposures must be expected during CPVC pipe installation.

Data from the 1989 DHS study indicate that many workers can also be expected to have substantial skin contact with primers and cements, and that for workers with heavy skin contact, dermal exposures may equal or exceed their airborne exposures.[59] For example, the worker with the highest measured urine THF concentration (6700 μg/l) had combined exposure (airborne plus dermal) equivalent to airborne exposure of 740 ppm THF, nearly four times the legal exposure limit. His actual airborne exposure was 158 ppm, suggesting that his dermal exposure contributed an additional THF dose equivalent to airborne exposure of 582 ppm, more than three-fold greater than his airborne exposure. This exposure occurred during installation of CPVC pipe for potable water supply, as did all the exposures that produced the highest urine THF concentrations.

For workers with little or no skin contact, the 1989 DHS study found that the relationship between airborne THF exposure and urine THF concentrations was best expressed as:

$$THF_{urine} = 9.0 \cdot THF_{airborne} + 84$$

where THF_{urine} is the urine THF concentration in μg/l and $THF_{airborne}$ is the airborne THF exposure in ppm.[60] This relationship suggests that full-shift airborne exposure at the legal exposure limit of 200 ppm would be associated with a urine concentration of 1884 μg/l in the absence of dermal exposure. Urine THF concentrations exceeded this level on 3 (21%) of 14 worker-days monitored for CPVC potable water installation.[61] These high urine concentrations are attributable to heavy dermal exposure, and represent combined (airborne plus dermal) exposures greater than allowed at the airborne exposure limit.

Short-term exposures must also be expected to exceed accepted exposure limits on a regular basis, based on data from the 1989 DHS study. THF exposures during 15-min intervals during CPVC potable water installation were up to 529 ppm, more than twice the exposure limit of 250 ppm.[62] THF exposures

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[59] Bellows, et al., 1989: p. 23-24.

[60] Bellows, et al., 1989: Figure 10, p. 57.

[61] Bellows, et al., 1989: Table 17, p. 48.

[62] Bellows, et al., 1989: p. 23-24.

can be expected to exceed the short-term exposure limit on 17-20% of 15-min intervals when workers are cementing joints in enclosed spaces.[63] For workers installing CPVC potable water pipe under typical conditions, short-term exposures are estimated to exceed the exposure limit at least once on 66% of work days.[64] MEK exposures are estimated to exceed the exposure limit on 5% of typical work days, and combined solvent exposures – measured by the combined exposure index %STEL – are estimated to exceed the exposure limit on 68% of typical work days.

Exposure limits do not represent an absolute threshold – below which no health effects will occur and above which effects are certain. Some workers may experience adverse health effects below the exposure limits while other workers may tolerate excursions above the limits. The exposure limits for CPVC solvents are not based on extensive dose-response data. For THF in particular, "exposure at the current occupational standard may pose a risk to human health."[65] These limitations notwithstanding, exposure limits provide a useful reference point. Exposure above the established exposure limits represents a risk of adverse health effects. The DEIR itself recognizes exposure limits as a key reference point, basing one of its three significance thresholds on "exceeding established workplace standards."[66]

b. Exposures higher than those measured in the 1989 DHS study must be expected under worst-case conditions.

The 1989 DHS study measured exposures under a wide range of working conditions, and investigated the relationship between exposure levels and various determining factors such as temperature, worksite air flow, bulk composition of primers and cements, presence of primer or cement spills, and the number of joints cemented in an exposure interval. During the course of the study, exposures exceeding established limits were documented, and were found to occur in association with several of these factors.[67]

However, no situations were observed or monitored in which all the factors that contribute to high exposures were present together. None of the monitoring

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[63] Bellows, et al., 1989: Table 8, p. 45.

[64] Bellows, et al., 1989: p. 20.

[65] National Toxicology Program, *Technical Report on the Toxicology and Carcinogenesis of Tetrahydrofuran in F344/N Rats and B6C3F$_1$ Mice*, Board Draft.

[66] DEIR, p. 42.

[67] Bellows, et al., 1989: Table 7, p. 44.

sites selected happened to have high temperatures, low air flow, extreme bulk composition, spills, and a high work pace, so exposure levels under these conditions were not measured. If widespread use of CPVC potable water pipe is approved, it must be expected that some installations will occur when all these factors are present together.

The 1989 DHS study was expressly designed to provide information that could support informed estimates of worst-case exposures. Most importantly, the impact on exposure levels of various working conditions was studied in some detail. Full-shift THF exposures were found to be significantly related to air flow rate, composition of bulk primers and cements, and ambient temperature, and MEK exposures were significantly related to air flow rate, composition of bulk products, and the number of joints cemented.[68] The DHS report warns against extrapolating beyond the conditions monitored, but can be validly used to estimate exposures that would occur if the most extreme conditions monitored were all to occur together.

For example, the highest measured full-shift exposure (107% of the full-shift exposure limit for combined exposure) was experienced by a worker installing CPVC potable water pipe. He was cementing a fairly large number of joints (35), in an enclosed space (air flow of 25 ft/min), at a moderate temperature (72° F), while other workers were also cementing joints in the same space.

Exposure levels under realistic worst-case conditions can be estimated as follows: The analysis in section 2.e. of these comments indicates that if a typical low-VOC primer and cement had been in use during the highest full-shift exposure period monitored, the expected index of combined exposure would have been 189%. If in addition the air flow rate had been 21 ft/min (the lowest observed during CPVC potable water pipe installation), the expected combined exposure index would have risen from 189% to 231% because of the reduced ventilation.[69] Similarly, if the number of joints cemented had been 90 (the highest

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[68] Bellows, et al., 1989: p. 22-23.

[69] This estimate is based on the regression coefficients shown in Bellows, et al., 1989: Table 14, p. 47. The coefficients are derived from a log-log model, so the appropriate calculation is:

$$c_{i,est} = \exp\left[\ln(c_{i,low-VOC}) + b_{v,i}(\ln v_{est} - \ln v_{obs})\right]$$

where $c_{i,est}$ is the estimated concentration of substance i under the hypothetical air flow conditions v_{est}, $c_{i,low-VOC}$ is the expected concentration of i under the observed air flow conditions v_{obs} and assuming use of low-VOC products, and $b_{v,i}$ is the regression coefficient for air flow rate. Exposures to CHX and ACE were estimated to remain unchanged in the reduced air flow conditions because the relationship between air flow and these substances was not presented in the 1989 DHS report. In fact, a similar relationship holds for these substances as for THF

observed during CPVC potable water pipe installation), the expected combined exposure would have risen further to 312%.[70] Finally, if the ambient temperature had been 102° F (the highest observed during the study), then the expected combined exposure would have been 602% (718 ppm THF, 460 ppm MEK, 2 ppm CHX, 15 ppm ACE).[71] This highest expected exposure value for THF must be interpreted with some caution, because the precise relationship between temperature and exposure levels has not been strongly established and because possible interaction between temperature and air flow has not been taken into account. (This caution does not apply to the values for MEK, CHX, and ACE, which were not adjusted for temperature.) The presence of other factors – such as additional spills or additional co-workers in the same enclosed area – could raise the exposures yet further, but the effects of such factors were not tested statistically in the 1989 DHS report and are thus not considered quantitatively here.

The same approach can be applied to estimating worst-case short-term exposure levels. The highest measured short-term exposure in the 1989 DHS study (an interval of the highest full-shift exposure analyzed above) had a combined exposure index of 181% (426 ppm THF, 33 ppm MEK, 4 ppm CHX, and 208 ppm ACE). Taking into account use of low-VOC products and reduced air flow as described above, expected combined exposures under realistic worst-case conditions would be 399% of the combined exposure limit (372 ppm THF, 642 ppm MEK, 7 ppm CHX, and 88 ppm ACE).[72] Basing a realistic worst-case estimate on a different short-term exposure interval at the same work site, expected combined exposures under realistic worst-case conditions would be 170% of the combined exposure limit (444 ppm THF, 12 ppm MEK, 13 ppm CHX, and 0.4 ppm ACE).

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and MEK. Had estimated CHX and ACE exposures been adjusted for reduced air flow, the estimated index of combined exposure would have been 233% instead of 231%.

[70] Calculation is completely analogous to that presented in the preceding footnote, adding adjustment for number of joints to the previous adjustments for bulk concentration and air flow. The relationship between exposure level and number of joints cemented was statistically significant only for MEK, so no adjustment was made for THF, CHX, or ACE exposures.

[71] The calculation is again completely analogous and the regression coefficient drawn from Table 14. The relationship between exposure level and temperature was not statistically significant for MEK, CHX, or ACE, so no adjustment was made for these substances.

[72] Calculations are analogous. Regression coefficients are from Bellows, et al., 1989: Table 9, p. 46. No adjustments were made for number of joints cemented because these data were not available. No adjustment was made for temperature because the THF regression coefficient reported in Table 9 is not plausible and would not be statistically significant under a one-tailed test.

The expected worst-case exposure values presented above are based upon several assumptions that have not been thoroughly tested, and the values thus have uncertainty associated with them. However, they are derived directly from the model and data presented in the 1989 DHS report, and are the best available scientifically-based estimates of exposure levels under realistic worst-case conditions. The estimates are conservative in the sense that they do not incorporate factors that are likely to increase exposures but that were not evaluated in detail during the 1989 DHS study. They demonstrate that exposures substantially greater than those documented in the 1989 DHS study can be expected to occur if widespread use of CPVC pipe is approved. In the case of full-shift exposures, estimated worst-case levels are more than five-fold greater than the highest measured levels. The expected worst-case exposures clearly far exceed established exposure limits, and must be considered significant in analyzing the impact of the project.

c. THF exposures comparable to those previously associated with human health effects can be expected.

Available data on the human health effects of THF are "extremely limited."[73] No systematic studies of THF health effects have been conducted. Only a few case reports have been published, and only one of these includes exposure data. In that case, glomerulonephritis was reported in a worker whose short-term exposures were 389-757 ppm THF.[74] A case report of hepatotoxicity involved workers whose exposures were qualitatively similar, but no exposure levels were reported.[75] These case reports do not definitively establish a causal relationship between exposure and subsequent illness, but in the absence of other studies they do suggest the potential for health effects to occur and provide a preliminary indication of the exposure levels that may produce adverse health effects. The State's own health experts recently concluded, "These case reports point to the likelihood that overexposure related to poor ventilation has already led to illness in pipe workers."[76]

The highest short-term THF exposure documented in the 1989 study (529 ppm) falls squarely in the 389-757 ppm range. An estimate of worst-case short-

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[73] Bellows, et al., 1989: p. 68, from toxicology review by Frank Mycroft, PhD.

[74] Albrecht, WN, Boiano, JM, and Smith, RD, 1987. IgA glomerulonephritis in a plumber working with solvent-based pipe cement. *Industrial Health*; 25:157-158.

[75] Garnier, R, Rosenberg, JM, et al., 1989. Tetrahydrofuran poisoning after occupational exposure. *British Journal of Industrial Medicine*. 46:677-78.

[76] Comments of Elizabeth Katz, MPH, Acting Chief, Hazard Identification System and Information Service, Department of Health Services; June 11, 1998.

term exposure (444 ppm) with low-VOC products also falls in the 389-757 ppm range. Full-shift airborne exposures up to 357 ppm THF can be expected under realistic worst-case conditions. Such exposures must be considered more likely to produce adverse health effects than would similar short-term exposures, because continued exposure at high levels would result in a higher internal dose. When dermal exposure is also taken into account, urine monitoring data from the 1989 DHS study suggest that combined (airborne plus dermal) exposures of workers with heavy skin contact was up to 740 ppm, also within the 389-757 ppm range. In short, many distinct analyses all indicate that exposures in the range previously associated with human health effects must be expected during installation of CPVC potable water pipe.

d. MEK exposures comparable to those previously associated with human health effects can be expected.

Several studies have reported human health effects in the range of 100-600 ppm MEK.[77] These effects include headache, nausea, and irritation of eyes, nose, and throat. As DHS noted in its response to the 1989 DEIR, "The consequences of repeated irritation of eyes, nose, and throat should not be lightly dismissed. A growing body of evidence suggests that repeated irritation may contribute to chronic illness."[78]

The highest short-term exposures documented in the 1989 DHS study (93 ppm for CPVC fire sprinkler installation and 53 ppm for CPVC potable water installation) approached but did not reach this range. However, expected short-term MEK exposures under realistic worst-case conditions (642 ppm) exceed the 100-600 ppm range. Exposures are expected to be particularly high with use of low-VOC primers and cements, since these typically contain more MEK than do the products commonly used in 1989. Expected full-shift exposures under realistic worst-case conditions (460 ppm) also fall within the 100-600 ppm range. Again, full-shift exposures of this magnitude must be considered more likely to produce adverse health effects than would similar short-term exposures, because continued exposure at high levels would result in a higher internal dose. These analyses indicate that MEK exposures in the range previously associated with human health effects must be expected during installation of CPVC potable water pipe.

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[77] Bellows, et al., 1989: p. 69, from toxicology review by Frank Mycroft, PhD.

[78] Comments of Richard Jackson, MD, then Chief of the Office of Environmental Health Hazard Assessment. December, 1989; p. 3.

e. *THF exposures during CPVC pipe installation approach the levels associated with cancer in laboratory animals, so THF-related cancers in exposed workers would not be unexpected.*

The NTP bioassay for THF found excess tumors in male rats exposed to 600 and 1800 ppm, and excess tumors in female mice exposed to 1800 ppm. Female mice exposed to 200 to 600 ppm had somewhat increased tumors in comparison with unexposed controls, but the increase was not statistically significant. In summary, THF produced excess tumors at 600-1800 ppm in laboratory animals.[79]

The highest THF exposure measured in the 1989 DHS study (529 ppm) approached this range, but was not sustained over a full workshift. The highest full-shift exposure (158 ppm) was somewhat below the 600-1800 ppm range. Expected full-shift airborne exposure under realistic worst-case conditions (357 ppm) are closer but still somewhat below the 600-1800 ppm range. With dermal exposure taken into account, data from the 1989 DHS study suggest that combined (airborne plus dermal) exposures of workers with heavy skin contact was up to 740 ppm, within the 600-1800 ppm range. Cancers produced by THF exposure would not be unexpected, given that worker exposures during CPVC installation approach or exceed the levels that produce tumors in laboratory animals, leaving essentially no margin of safety.

A fuller assessment of the cancer risk associated with THF exposures is best provided by a toxicologist. Such an assessment would be based either on accepted safety factors or on a more sophisticated model, depending on a number of considerations. The exposure data presented in these comments could be used as inputs into a more detailed cancer risk assessment.

f. *Installation practices for CPVC pipe indicate that a higher frequency of accidental injuries can be expected, in comparison with copper pipe installation.*

These comments have focused largely on the potential for the solvents in CPVC primers and cements to produce illnesses – including cancers and liver or kidney damage – in exposed workers. Such illnesses may indeed be particularly severe, and are cause for significant concern. However, acute traumatic injuries that occur during pipe installation are more immediate and perhaps more common, and also merit attention.

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[79] National Toxicology Program, *Technical Report on the Toxicology and Carcinogenesis of Tetrahydrofuran in F344/N Rats and B6C3F$_1$ Mice*, Board Draft.

The 1989 DHS report noted, as one of its key conclusions, that "Pipe installation workers face a variety of safety hazards including: chain saws and wood-boring tools used in awkward positions, unsafe ladders, and objects falling from above."[80] In preparing the 1989 DEIR, the Lead Agency asserted without substantiation that "increased use of plastic pipe may also lead to a decrease of unknown magnitude in the risk of accidental injury."[81] DHS experts then advised the Lead Agency that such a conclusion could not be supported and that it ignored two key risk factors identified during the 1989 DHS study "that could well lead to an increase in serious accidents" during CPVC installation.[82] Specifically, DHS highlighted documentation in its 1989 report that workers installing CPVC potable water pipe were less experienced than other plumbers and that they worked at a faster pace. Both factors must be expected to increase the frequency of injury.

The 1989 DHS report also provides documentation of another risk factor that could result in a greater frequency of accidental injuries during CPVC installation. The four solvents used in CPVC primers and cements – THF, MEK, CHX, and ACE – all have the ability to profoundly depress central nervous system (CNS) function at sufficiently high doses. Subtle depression of CNS function at lower exposures has been studied only for acetone, which was found to cause mild CNS depression at 250 ppm.[83] Exposures to these solvents were highest during CPVC potable water pipe installation, and are expected to exceed exposure limits on a regular basis. Together with the toxicity information, these data suggest that CPVC pipe installation workers may experience some degree of solvent-induced CNS depression. Indeed, dizziness was the second most common symptom of ill health reported by workers participating in the 1989 DHS study. Dizziness was reported by 11% of workers completing a symptom survey; headache was reported by 10%.

Workers with depressed CNS function would be at higher risk of experiencing an accidental injury, either during pipe installation or while driving a motor vehicle after exposure. The principle mechanisms would be slowed reflexes, impaired judgement, and/or reduced sensory acuity. Any solvent-induced CNS depression would be exacerbated by alcohol consumption. Based on reported occurrence of subtle CNS depression at solvent exposure levels

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[80] Bellows, et al., 1989: p. 34.

[81] 1990 DEIR.

[82] Comments of Richard Jackson, MD, then Chief of the Office of Environmental Health Hazard Assessment. December, 1989; p. 3.

[83] Bellows, et al., 1989: p. 72, from toxicology review by Frank Mycroft, PhD.

comparable to those expected to occur during CPVC pipe installation, CPVC installation presents a risk of increased accidental injuries.

The Lead Agency in the current DEIR seems to have disregarded the earlier DHS advice that CPVC installation entails risk factors that would increase – not decrease – the frequency of accidental injuries, including fatalities. While the "Lead Agency... points out that many of the workplace hazards faced by pipe fitters are unrelated to the type of pipe used,"[84] it does not mention the risk factors associated with CPVC installation and it highlights a very few injuries related uniquely to copper installation.

Specifically, the DEIR refers to seven accidental injuries associated with copper pipe during 1980-1997, and implies that reducing copper pipe use would result in fewer severe accidental injuries.[85] The seven reported injuries may have been somewhat unique in that they could be attributed to the pipe material itself, but they constitute only a tiny fraction of all injuries associated with pipe installation. For comparison, during the same period approximately 600 work-related fatalities occurred among plumbers, pipefitters, and steamfitters. Most were caused by falls, motor vehicle injuries, or by exposure to harmful substances and environments. During the same period, approximately 540,000 disabling injuries (those with at least one lost work day) occurred among plumbing, heating and air conditioning employees.[86]

Most accidental injuries to plumbers arise from the overall installation process, not from contact with the pipe itself. Any risk factors that increased the frequency of accidental injuries during pipe installation could produce a significant burden of excess injuries, and those excess injuries could far outnumber the few injuries directly attributable to pipe material. Fast work pace, little training and experience, and exposure to CNS-depressing solvents are all risk factors that place CPVC pipe installation workers at increased risk of accidental injury. These factors suggest that widespread use of CPVC pipe in place of copper is likely to result in increased accidental injuries.

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[84] DEIR, p. 113.

[85] DEIR, p. 69-70.

[86] Fatality and injury figures derived from Bureau of Labor Statistics data for 1996, conservatively estimating that injury rates and total employment had been constant from 1980-1997.

g. Conclusions regarding significant adverse health effects.

Workers installing CPVC potable water pipe can be expected to experience solvent exposures in excess of established exposure limits. This conclusion is based upon the airborne exposures documented in the 1989 DHS study, the combined (airborne plus dermal) exposures indicated by biological monitoring in the 1989 DHS study, and the exposures that can be expected under realistic worst-case conditions. The solvent exposures that can be expected are in a range that has been previously associated with human health effects. The exposures and are also comparable to the levels that produced tumors in laboratory animals. As a result, human health effects must be expected, and cancers would not be unexpected.

An industry consultant cited repeatedly in the DEIR agrees that solvent exposures during CPVC installation have the potential to produce adverse health effects: "The amount of CPVC pipe cleaner and/or cement exposures necessary to result in an absorbed dose sufficient to elicit the less serious adverse health effects in humans... has not been quantified; however the range may be from 25 to 150 ppm. Therefore, installers... may be receiving doses in this range of concentrations sufficient to cause some of these effects."[87] (The consultant qualified this conclusion with a phrase – omitted here from the quoted passage – limiting the conclusion to "installers who are improperly installing CPVC pipe." As these comments have indicated previously, a meaningful analysis must be based on exposures that can be expected under conditions of normal use.)

The consultant also concluded: "The more serious health effects, including adverse hematologic, hepatic, renal, ocular, and neurological effects occur only at much higher levels of exposure, i.e., 300 to 6,000 ppm, to which installers would rarely, if ever, be exposed." The toxicology summary in this statement is perhaps somewhat conservative, but the conclusion regarding exposure levels is clearly inconsistent with the data and with evidence-based analysis. Biological monitoring in the 1989 DHS study indicated that at least two (14%)of 14 CPVC pipe installation workers had combined (airborne plus dermal) exposures greater than 300 ppm. This prevalence can in no way be considered "rare." Expected exposures under realistic worst-case conditions are also in the 300-6,000 ppm range. CPVC pipe installation workers can indeed be expected to experience solvent exposures at levels associated with "more serious health effects" in humans.

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[87] Comments of Robert Tardiff, PhD: p. 17.

4. The DEIR fails to consider cumulative impacts on worker health and safety.

The DEIR explicitly addresses cumulative impacts in other areas, but is conspicuously silent on cumulative impacts to worker health.[88] This oversight is significant.

a. The DEIR fails to consider as a cumulative impact the high exposures that occur when CPVC potable water pipe is installed concurrently with other plastic piping.

The 1989 DHS study clearly indicated that solvent exposures during CPVC potable water pipe installation were highest when plastic DWV pipe was being installed concurrently in the same work area.[89] The solvent vapors produced by cementing CPVC potable water pipe, released into the same work space as solvent vapors produced by cementing ABS or PVC drain, waste, and vent lines constitute a significant cumulative impact.

b. The DEIR fails to consider impacts of installing CPVC pipe in non-residential occupancies.

The Lead Agency states that "it is reasonable to assume" that the current DEIR could be used (by other agencies) to extend CPVC approval to structures other than residential buildings.[90] In the area of worker health and safety, the "environment" impacted during residential construction differs in key respects from the "environment" of commercial construction, so the data and analyses supporting the current DEIR cannot be validly applied to the commercial plumbing environment.

The 1989 DHS study states explicitly: "Conclusions about the possible hazards of installing residential plumbing do not directly apply to the hazards faced by these same workers at other sites."

The interviews and walk-through surveys conducted at the outset of the 1989 DHS study revealed many differences between residential and commercial installations. Most obviously and perhaps most importantly, non-residential installations generally involve larger pipe sizes and more piping. Larger pipe

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[88] DEIR, p. 97-102.

[89] Bellows, et al., 1989: p. 19.

[90] DEIR, p. 11.

sizes require larger cemented surfaces, and thus a greater volume of cement. Applying a greater volume of cement requires more care and more time, so the cement is spread thin for a longer period before each joint is completed. All these factors indicate a greater opportunity for primer and cement constituents to volatilize into workers' breathing zones.

Other factors also differ. Much of the plumbing is typically installed later in the construction process on non-residential buildings, so the structure is more enclosed and ventilation is reduced. Work crews are often larger on larger-scale construction, providing more opportunity for concurrent exposure. Both factors would produce higher exposure levels.

Extending the widespread use of CPVC to non-residential buildings would also increase workers' long-term cumulative solvent exposures, along with increasing their risk of cancer or other chronic toxicity. Complete assessment of adverse health impacts associated with CPVC installation in non-residential buildings would need to consider both types of cumulative impacts: concurrent exposures within work groups, and increased long-term cumulative exposures for workers employed in both residential and commercial installations.

c. *The DEIR fails to consider the potential health impacts of cumulative long term exposures, among plumbers who install both CPVC potable water pipe and other plastic piping systems.*

A third type of cumulative impact must also be considered. Much of the focus of the 1989 DHS study was on short-term exposures, largely because there existed at that time little information on chronic toxicity – such as cancer – at the observed exposure levels. Exposures within a work day were characterized in some detail, but no effort was made to evaluate plumbers' exposures over a period of months or years. Such issues are relatively unimportant in assessing risks of acute toxicity.

The 1996 results of the NTP cancer bioassay for THF have changed raised significant new issues. Most significantly, cancer risk assessment depends critically upon estimates of long-term cumulative exposures. Consider as a hypothetical example a residential plumber who currently installs copper potable water pipes during 50% of work time and PVC drain, waste, and vent lines during the other 50%. Suppose as a result of the proposed project this plumber's duties are changed, and are then split evenly between installing CPVC potable water pipes and PVC drain, waste, and vent lines. Even if the peak exposure levels are unchanged, and even if the average on any given work day is unchanged, the long-term cumulative exposure would be doubled. Cancer risk would also be doubled, using the most common cancer risk assessment models.

The DEIR cannot fully assess potential health impacts to workers without explicitly considering cumulative effects. Three kind of cumulative impacts must be considered: increased exposure levels resulting from concurrent installation of CPVC potable water pipe and ABS or PVC drain, waste, and vent lines, installation of CPVC pipe in non-residential buildings, and increased long-term cumulative solvent exposures even when these installations are not concurrent.

5. Mitigation measures should be established to address the potentially significant health hazards.

As outlined in the preceding section, CPVC pipe installation under typical conditions results in exposures that regularly exceed established exposure limits and that have been associated with adverse health effects in humans and laboratory animals. The appropriate industrial hygiene response would be to design and implement measures to control the exposures, reducing them to safer levels.

DHS advised the Lead Agency in response to the 1989 DEIR: "We believe that the exposures known to occur during installation of plastic plumbing pipe are significant enough that HCD must provide some mechanism for assuring, more directly, that the recommended control measures are adopted throughout the industry."[91] The Lead Agency accepted the earlier DHS recommendation, incorporating specific, substantive mitigation measures in the 1990 Administrative Final EIR. Indeed, the Lead Agency determined that such mitigation measures were "essential" to protect worker health.[92] The need for mitigation measures has increased since that time, primarily because of the findings of the NTP cancer bioassay for THF.

The current DEIR refers repeatedly to the notion that worker exposures would be lower – and acceptable – if workers would follow the safe use recommendations on material labels and MSDSs. The principal recommendations are to "avoid contact with skin" and to "use only with adequate ventilation." This vague language gives no concrete guidance to workers or their employers. Even a careful reading of the material labels would leave unanswered questions such as: How carefully must skin contact be avoided? Are gloves an appropriate barrier to skin contact? What kind of gloves? How much ventilation is "adequate"?" As noted in the 1989 DHS study: "Many workers

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[91] Comments of Richard Jackson, MD, then Chief of the Office of Environmental Health Hazard Assessment. December, 1989; p. 1.

[92] 1990 Administrative Final EIR, p. 79.

considered the label warnings – such as 'avoid contact with skin' and 'use only in well-ventilated areas' – to be comically impractical."[93]

Reliance on vague warning labels cannot be considered an appropriate or effective prevention strategy. Hazard control measures are successful largely to the extent that they are carefully designed, specific to the particular exposure conditions, readily implemented, and integrated into existing (or modified) work practices. Warning labels alone do not meet any of these standards.

Reducing exposures below the levels observed in 1989 will require specific, focused measures. A comprehensive intervention plan would be beyond the scope of these comments, but some options are described in the following paragraphs. A comprehensive intervention could be designed by using any combination of options that would reliably and effectively reduce exposures to acceptable levels. No single option can be expected to reduce exposures sufficiently. Some of the options outlined would have overlapping effects; not all would be needed to control exposures.

Note that the options outlined are only *possible* control measures. They would need to be carefully adapted to specific working conditions, and their effectiveness must be evaluated before they can be considered effective and reliable. A fundamental aspect of any hazard control strategy is assignment of responsibility, but indicating the responsibilities of various parties is beyond the scope of these comments.

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[93] Bellows, et al., 1989: p. 14.

a. *Options for reducing airborne exposures:*

i. modify primer and cement formulations to reduce airborne emissions;

ii. develop and disseminate clear, specific guidance about the conditions under which mechanical ventilation is needed, including any tools needed to determine whether those conditions are present at a particular worksite;

iii. require mechanical ventilation whenever CPVC pipe is installed in an enclosed space, and provide a mechanism for assuring that this requirement is heeded;

iv. to prevent cumulative exposures, prohibit concurrent installation of CPVC potable water pipe and any other plastic piping system, and provide a mechanism (such as separate inspections of each piping system) to assure that installations are not concurrent;

v. require that all workers evacuate any enclosed space in which a substantial volume of primer or cement has been spilled, and that work not resume until vapors from the spill have dissipated (simply wiping a spill is likely to be counterproductive – increasing its surface area and thus increasing the rate at which vapors are released);

vi. develop a mechanism to assure that plumbing contractors bidding on CPVC pipe installation jobs are knowledgeable in methods for limiting airborne solvent exposures and that they provide all needed equipment; or

vii. develop a mechanism to assure that CPVC pipe installation workers receive regular, comprehensive, effective training in methods for limiting airborne solvent exposures.

b. *Options for reducing dermal exposures:*

i. modify primer and cement formulations to reduce dermal absorption;

ii. develop and deploy a device that could apply primer and cement to pipe and fittings within an enclosed chamber (as an illustration, imagine a device similar to an electric pencil sharpener – a pipe end would be inserted rough and withdrawn with primer and cement applied, ready to be inserted immediately into a fitting);

iii. require use of chemical protective gloves during all handling of CPVC primers and cements (providing gloves can be identified that give reliable, lasting protection against liquid THF, MEK, CHX, and ACE);

iv. add brightly colored dye to all primers and cements to discourage unnecessary skin contact;

v. develop a mechanism to assure that plumbing contractors bidding on CPVC pipe installation jobs are knowledgeable in - methods for limiting dermal solvent exposures and that they provide all needed equipment; or

vi. develop a mechanism to assure that CPVC pipe installation workers receive regular, comprehensive, effective training in methods for limiting dermal solvent exposures.

Unless a comprehensive package of reliable, effective exposure control measures are adopted, solvent exposures in the future will be similar to those observed by DHS in 1989. Those exposures can be expected to produce adverse health effects in CPVC pipe installation workers.

6. Conclusions

The DEIR's significance thresholds for worker health and safety are fundamentally flawed, and do not provide meaningful criteria for the existence of significant impacts. As a result, the DEIR's conclusion that CPVC pipe installation will not result in significant adverse impacts to workers is also fundamentally flawed.

The DEIR's finding of no significant impacts on worker safety is not supported by data or scientific analysis, and is based on several misrepresentations, incorrect assertions, and invalid inferences. A key assertion is that use of low-VOC primers and cements would reduce exposures. This assertion is not supported by facts or analysis; an evidence-based analysis indicates that combined exposures to THF, MEK, CHX, and ACE would actually be increased. In many instances, the Lead Agency has disregarded the advice of its own health experts, provided in 1990 during preparation of the earlier EIR.

Expanded use of CPVC pipe would result in potentially significant health impacts to workers. Full-shift and short-term overexposures would occur on a regular basis. Skin contact with primers and cements would result in dermal absorption, and in some cases dermal absorption could outweigh airborne exposures. Expected exposure levels under realistic worst-case conditions would be at least twice as high as the highest exposures measured in the 1989 DHS study. Exposures would be similar in magnitude to the exposure levels previously associated with THF and MEK toxicity in humans, and similar in magnitude to the levels that produced excess tumors in laboratory animals. These exposures must be considered a significant impact.

The DEIR fails to consider cumulative impacts on worker health and safety, even though the 1989 DHS report clearly indicated that exposures were highest when CPVC potable water pipe was installed concurrently with other types of plastic piping systems. The DEIR also fails to consider impacts of installing CPVC pipe in non-residential occupancies, if the approval of CPVC pipe for potable water supply was to be extended to commercial installations. The DEIR also fails to consider the impacts of cumulative long-term exposures among workers who would install CPVC potable water piping on some work days and other plastic pipe on other days. These failures are particularly significant in light of recent evidence of carcinogenicity for THF, which increases the importance of cumulative lifetime exposures. Significant cumulative impacts can be expected.

Reliance on vaguely-worded material labels cannot be considered an effective strategy to reduce exposures. A combination of reliable, effective mitigation measures should be established to reduce exposures to acceptable

levels. In the absence of such measures, significant adverse health effects among workers can be expected.

DHS reached a similar conclusion in 1990: "We believe that the exposures known to occur during installation of plastic plumbing pipe are significant enough that HCD must provide some mechanism for assuring, more directly, that the recommended control measures are adopted throughout the industry."[94] This conclusion is just as applicable now as it was eight years ago. The most significant development since 1990 is the new evidence that THF has carcinogenic activity. This strengthens considerably the importance of assuring that workers are not exposed in the future at the levels documented in 1989.

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[94] Comments of Richard Jackson, MD, then Chief of the Office of Environmental Health Hazard Assessment. December, 1989; p. 1.

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