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July 15, 2005
TRA File: LPPC

Thomas A. Enslow
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1225 8th Street, Suite 550
Sacramento, CA 95814

Re: Comments on California Department of Housing and Community Development consideration of the use of PEX as potable water pipe

Dear Mr. Enslow:

The California Department of Housing and Community Development ("HCD") has been considering the approval of Crosslinked Polyethylene (PEX) potable water tubing for several years. During this time, I have written comment letters raising fundamental concerns over the public health, consumer protection and environmental effects of PEX. Comment letters of mine that have been submitted to the California Building Standards Commission (BSC) include:

July 23, 2001	Environmental effects of California adoption of PEX for potable water.
April 3, 2002	Information on environmental effects of PEX use for potable water.
January 13, 2003	Additional information substantiating the potentially significant public health, consumer protection, and environmental effects of adopting PEX pipe for potable water use.
September 9, 2003	Environmental effects of California adoption of PEX-AL-PEX for carrying potable water.

The thrust of my comments have been 1) that HCD had a real obligation to conduct an independent assessment of several issues prior to granting broad approval of PEX for potable water use in California, and 2) those issues should be resolved by HCD using a open, objective process as provided by the California Environmental Quality Act (CEQA). This previous communication is still relevant and is incorporated in my current comments.

1. <u>HCD's environmental record is incomplete and does not serve as a basis for PEX approval.</u>

In February 2004, HCD published "HCD Literature Search Concerning on (sic) the Use of PEX as Potable Water Pipe" which is a summary of the Department's study on several issues, most notably an effort to rebut points raised in my earlier communication. Apparently, the "Literature

Search" (LS) and some correspondence with PEX manufacturer Uponor Wirsbo and NSF International are the full extent of HCD's research as indicated by HCD's response to a Public Records Act request submitted by the law firm of Adams, Broadwell, Joseph and Cardozo.

The LS itself cites only a handful of external references and does not contain a list of documents, nor does it identify the persons conducting the search or describe their qualifications to reach the conclusions rendered. Several state agencies are mentioned, but the names or qualifications of the persons advising HCD are not given. Repeatedly, the LS denies a problem stating ""the literature shows" or the "literature indicates" without giving any list of how extensively the literature was actually consulted.

The LS does not meet CEQA disclosure standards for an EIR: Guidelines section 15129 requires an EIR to "identify all federal, state, or local agencies, other organizations, and private individuals consulted in preparing the draft EIR, and the persons, firm, or agency preparing the draft EIR, by contract or other authorization." Section 15087(c)(5) requires a location readily accessible to the public where "all documents referenced in the EIR will be available for public review". The purpose is to let the public know who is advising the lead agency.

The "Literature Search" document is opinionated, argumentative and factually unsound. By its tone and reliance on irrelevant facts, the HCD document seems to have been drafted by someone more used to marketing plastics than protecting Californians. This anonymous document is completely unsuited to serve the state as a basis of decision making on the important subject of public health consumer protection, and environmental quality.

In this letter, I present the main issues that HCD must consider before approving PEX and address the errors in the HCD LS where appropriate.

2. Mechanical Failure

The issue of mechanical failure involves the complex of factors that affect the service life of PEX installations and the mode of failure.

In brief, PEX is subject to oxidative chemical attack by chlorine in drinking water and by oxygen both from water and from the surrounding air. The attack is accelerated by heat and exposure to ultra violet rays in sunlight. Pipe manufactures blend antioxidants in the pipe to resist the oxidative attack, but these AO are gradually consumed and the pipe matrix eventually fails.

The "Literature Search" erroneously concludes that chlorinated water is no problem.

In earlier comment letters, I cited extensive information about the role of oxidation in potential mechanical failure. HCD simply ignores this real issue; the LS states "1. PEX is not a similar plastic as PB as suggested by Thomas Reid." and "2. PEX is not subject to attack by chlorine in water as suggested by Thomas Reid."

In fact, the literature shows that industry experts share my concern over PEX attack by chlorine in water:

1) "Environmental factors, and their effect on piping materials, such as installation methods and operating conditions have been well characterized. The influence of the transported fluid on piping materials is becoming better understood, particularly for PEX tubing. The chlorine residual employed to disinfect potable water is known to increase the oxidative potential of the water in question. The effect of the chlorine residual on PEX pipe has been shown to be primarily an oxidative one. Estimated pipe test lifetimes have been directly correlated to the level of oxidative strength of the potable water." ("Oxidative Resistance of Sulfone Polymers to Chlorinated Potable Water", S. Chung, J. Couch, J.D. Kim, K. Oliphant and P. Vibien, Jana Laboratories Inc., 280B Industrial Parkway S., Aurora ON, Canada and J. Hung, M. Ratnam and W. Looney, Solvay Advanced Polymers, LLC, 4500 McGinnis Ferry Road, Alpharetta, GA; Society of Plastics Engineers Annual Technical Conference (ANTEC) 2003.)
2) "Like other polyolefin products, the base PEX polymer, without additional additives, offers little resistance to oxidation, and would oxidize in the presence of typical chlorinated potable water. For this reason, all PEX manufacturers use engineered additive packages containing antioxidants. The antioxidants are sacrificial in nature and serve to protect the PEX polymer from chlorine's oxidative attack." ("Comparison of the Two Nationally Accepted Rating Systems for Chlorine Resistance of PEX Water Piping", Frank R. Volgstadt; Plumbing Engineer, April 2004)
3) "Hydrocarbons (such as PEX) break down (age) as they eventually combine with oxygen (oxidize). To prolong this process, plastic pipes are infused with an antioxidant (AO) package of chemicals which stabilize the finished product against such oxidative break down. Chemists have, in a sense, discovered the fountain of youth for plastics among the wide range of antioxidants. The performance of plastic pipes depends on the adequacy of the antioxidant stabilization package, the distribution of antioxidants within the product, and the ability of the antioxidant to remain within the material for a long periods of time when exposed to harsh environments." (http://www.tesmar.com/html/in_defense_of_silane.html; "Tom Tesmar is an industry consultant specializing in the field of emerging technology for heating and plumbing systems. Tom can be reached at Tesmar Application Technology, 595 Tower Road, Hudson, WI 54016")
4) Noveon IP, the successor to B.F. Goodrich's plastic pipe resin business and a major manufacturer, patented a tube design with "The inner tubular core of protective polymer is high-density polyethylene and chlorinated polyethylene contiguous with the inner surface of the PEX." and claimed, "ADVANTAGE The tubing or pipe has improved resistance to chlorine and hypochlorous acid contained in potable water." ("Pipe or tubing of crosslinked polyethylene, useful

for potable water applications and hot water heating systems, has wall of uniform thickness and contains dispersed carbon black" US Patent 20040020547.)

5) The problem is indeed so well known in industry that a specific standard testing method has been formulated: "Standard Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Tubing and Systems to Hot Chlorinated Water" ASTM F2023-04.

For the record, HCD needs to acknowledge that oxidative failure, particularly provoked by chlorinated water, is a real problem for PEX piping.

PEX use history in Europe and for radiant heating is not a guarantee of service in United States potable water applications.

PEX proponents and HCD rely on PEX history of use in Europe and for radiant heating in North America. There are several important differences between that history and use of PEX for potable water in California.

Typical radiant heating systems have a closed loop where water is heated and recirculated. Under this condition, the oxygen and chlorine originally in the water are rapidly used up and consume a proportionately small amount of the pipe's supply of antioxidant (AO). Potable water, however, continually supplies oxygen and chlorine and continually consumes AO. Using PEX radiant heating experience in Europe and North America as a proof of suitability for potable water is unwarranted. As explained below, a closed system with depleted chlorine may last 300 years; an open system with the same water and a small chlorine residual may last 10 years.

Similarly, PEX potable water use in Europe is not analogous to use in North America. Public water supplies in the U.S. are more chlorinated than in Europe and European treatment tends to use alternatives to chlorine.

> "The level of free chlorine, which is used as a disinfectant for water, is higher in the US as compared to Europe." (Long Term Durability of Cross-Linked Polyethylene Tubing Used in Chlorinated Hot Water Systems, T. S. Gill and R. J. Knapp, Wirsbo Company, Apple Valley, MN, Steven W. Bradley, Bradley Consulting Group, College Station, TX, W.L. Bradley, Texas A&M University, ANTEC 1998)

> "Ozone has been used for several decades in Europe for taste and odor control, color removal and disinfection." ... "In Europe, 50% of water distribution systems use chlorine dioxide as the residual disinfectant Source: Trussell, R., Control Strategy 1; Alternative Oxidants and Disinfectants, 1991, (Drinking Water Chlorination White Paper, A Review of Disinfection Practices and Issues, The Chlorine Chemistry Council, Arlington, VA)

Industry's failure with Polybutylene (PB) is an important object lesson.

Industry has been trying to deal with this problem and has certainly seen the risks of learning the hard way as in the case of Polybutylene (PB) pipe. Industry has tried to distance PEX from PB for marketing reasons (see e.g. Differences Between PEX and PB Piping Systems for Potable Water Applications TN-31/2004, Plastic Pipe Institute (PPI) 1825 Connecticut Ave., NW, Suite 680, Washington, DC 20009 P: 202-462-9607 F: 202-462-9779, www.plasticpipe.org), but the fact remains that PEX has the same inherent liabilities as PB. In the race to market in North America, has engineering kept up with marketing? Where is PEX on the learning curve now? What is the benefit for California to be an "early adopter" of PEX for potable water.

This letter points out several areas of unresolved liabilities for PEX mechanical failure. I preface this discussion with two observations: 1) California's delay in approving PB turned out to have saved its citizens untold headaches and saved industry millions in additional claims; prudent delay in approving PEX may have similar benefits. 2) Industry has not been candid with HCD about the nature of its product or the changes it makes as product deficiencies have arisen. HCD's present record does not show California consumers that a diligent, independent investigation has been done by HCD on their behalf.

PEX and antioxidant additives are subject to chemical attack.

PEX potable water piping will fail when the antioxidant (AO) is no longer sufficient to protect the PEX polymer itself from oxidation and consequent loss of mechanical strength. The question of mechanical failure largely hinges on the adequacy of AO protection. This means that PEX failure is not a matter of "if" – PEX always fails – rather a matter of "when." The relevant issue is thus the conditions that make premature failure more likely.

Polyolefin oxidation is mediated by free radicals generated by oxygen, other oxidizers such as chlorine in various forms, and ultraviolet light. The AO functions by trapping the free radical in a stable form that prevents attack on the PEX and stops what is usually a chain reaction. The AO has only so many active sites capable of this sacrificial function.

The first factor is the choice and amount of AO molded in when the pipe is made. Once PEX is crosslinked, it can no longer be formed as can PE, PB, PVC, or CPVC. Thus the final blend of AO must be made when the product is formed. This inherently leads to product variability: "In the past, many of the failures of plastic pipe were largely due to lack of adequate AO stabilization. Sometimes inadequate stabilization was added to the 'recipe', or sometimes the antioxidants were consumed in the extrusion process." (T Tesmar, op. cit.)

A second factor is exposure to ultraviolet light (mostly as sunlight) prior to or after installation. Ultraviolet light produces abundant free radicals and rapidly consumes AO. Even a short exposure can significantly affect PEX service life. For PEX tubing formulated with no UV barrier, it appears that a one week exposure (84 hours) is sufficient to deplete the AO present and cut the resulting pipe lifetime by a half under test conditions (Chlorine Resistance Testing of UV Exposed Pipe", J. Couch, M. Toro, K. Oliphant and P. Vibien, Jana Laboratories Inc., Aurora, Ontario, Canada, ANTEC 2002.) PEX is frequently left exposed. I have personally observed construction sites where PEX laid under slab is pulled up for future connections and left exposed for the length of time from pipe installation, slab pour, framing, and sheathing. In tract housing this can be a month or more or exposure – that exposed segment of PEX will arguably have a far shorter life.

Alternate methods of PEX manufacture aggravate lifetime prediction.

Yet another factor to consider is the variation in PEX manufacturing, even as to crosslinking methods. Tubing sold for potable water is largely Engle or Silane crosslinked to convert starting polyethylene to PEX. As explained more later, the difference is that Engle uses peroxide compounds mixed in the pipe to initiate bonding between PE chains and Silane uses silicone bonding to link chains.

The competing manufacturers using different methods argue that their own product is superior in performance. Logically, there are likely to be different susceptibility to oxygen diffusion, loss of antioxidant during manufacture, and even oxidative resistance (chain termination). At present, I can't distinguish a preference for one method over the other. Consultant Tom Tesmar cautions "accept the fact that technology will continue to advance. As we have seen time and time before, a 'Cash Cow' can grow feathers and begin to look more like a 'Turkey'!" ("In defense of silane", op. cit.) Perhaps this is also a summary of the history of plastic pipe.

Composite PEX-AL-PEX is also subject to oxidative attack.

HCD is also considering a composite PEX-AL-PEX which is a thin walled aluminum tube with PEX on the inside and outside. At first blush, the aluminum layer strengthens the pipe and prevents diffusion of oxygen from the outside, but the interior PEX layer is still subject to oxidative degradation from chlorinated water. When the interior layer cracks, the aluminum layer is exposed to water and will itself be subject to corrosion. PEX-AL-PEX should also be subjected to real-world lifetime test conditions.

ASTM F2023 establishes standard conditions for testing PEX in chlorinated water, but does not assure in-service lifetime.

A key factor is the deliberate use of chlorine as a potable water disinfectant. The disinfection results from chlorine residual acting as a strong oxidizer in water. The role of chlorinated water in attacking polyolefin pipe has only been slowly revealed; ASTM F2023, "Standard Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Tubing and Systems to Hot Chlorinated Water" was only published in 2000.

This standard is a measure of resistance to oxidation – correlated with pipe lifetime, but clearly not a direct measure of lifetime. Claims of 50-year or 90-year lifetimes are all – 100% of them – based on extrapolation from short term tests. Extrapolating from a test producing failure in a few months to predict a lifetime of 50 years or more is extremely sensitive to error. [ASTM F2023-04 Section 15.1.2, Table 2: twelve pipe samples failed under standard test conditions with times ranging from 871 to 1490 hours (36 to 62 days).] Note that ASTM F2023-04 is a standard test method (how to test a product), not a material standard (product pass-fail). For obvious reasons ASTM includes a disclaimer.

> "The performance of a material or piping product under actual conditions of installation and use is dependent upon a number of factors including installation methods, use patterns, water quality, nature and magnitude of localized stresses, and other variables of an actual, operating hot-and-cold water distribution system that are not addressed in this test method. <u>As such, the extrapolated values do not constitute a representation that a PEX tube or system with a given extrapolated time-to-failure value will perform for that period of time under actual use conditions</u>." (ASTM F2023-04, emphasis added)

This caution is echoed elsewhere when claims of long product life are made.

> "The information in this note is offered in good faith and believed to be accurate at the time of its preparation, but is offered without any warranty, expressed or implied, including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE." (PPI op. cit. emphasis original)

Low pH (acidic) water accelerates chlorine attack on PEX.

The ASTM standard reflects the metric Oxidation Reduction Potential (ORP) as a way of integrating water pH and chlorine concentration (Appendix X2). ORP is a measure of the overall oxidative strength of the water and is reported in units of mille volts (mV). Because chlorine acts as an acid, lower pH water (more acid) leaves a greater proportion of the chlorine present in the aggressive hypochlorous acid form:

> "At a pH of 6.5, chlorine exists almost completely as HOCl. At a pH of 8.5, approximately 90% of the HOCl is converted to the OCl-. The HOCl, considered to be a much more potent oxidizer than the OCl-(11), is believed to be the primary species responsible for chlorine induced oxidative degradation. The oxidizing aggressiveness of chlorinated potable water varies widely with pH. Testing is generally conducted at lower pH values so that the chlorine is largely present as HOCl and the water, therefore, is in a more aggressive state in terms of oxidation." (Chlorine Resistance Testing of Cross-Linked Polyethylene Piping Materials, P. Vibien, J. Couch and K. Oliphant, Jana Laboratories Inc., Aurora, ON, W. Zhou, B. Zhang and A. Chudnovsky, University of Illinois at Chicago, Chicago, IL, USA, 60607, ANTEC 2001)

"The hypochlorous acid is 80 to 300 times more oxidative than the hypochlorite ion." (The Use of Oxidation Reduction Potential (ORP) in the Testing of Plastic Pipe in Hot Water With Chlorine, Steven W. Bradley, Bradley Consulting Group, College Station, TX, Lori McPherson, George Fischer Inc., Tustin, CA, ANTEC 1998)

Ironically, low pH or slightly acid potable water is cited as a major reason to use plastic pipe rather than copper pipe. As discussed below, the effect of low pH in the normal range of drinking water may be even more significant for PEX pipe than for copper.

The effect of ORP is dramatic. Chung, et. al. exposed PEX to a range of ORP at elevated temperatures (as in ASTM F2023-04), found failure rates on a log scale, and estimated the effect of ORP on relative lifetime at a temperature corresponding to potable hot water use. In their Table 3., Chung et. al. show a projected range of PEX service lifetimes over a factor of 229 depending on ORP. This means that the base case (slight acidity no chlorine) is predicted to last 229 times the case with slight acidity and 5 ppm Cl. The key finding is that even low chlorine levels and low pH cut PEX life roughly 30-fold.

"Table 3: Estimated Test Lifetimes at 60°C as a Function of Test Water Quality

PH	Chlorine Level (mg/L)	ORP	Relative Estimated Test Lifetime @ 60°C
6.5	5	887	1
6.5	3	873	1.2
8.5	5	778	3.7
8.5	3	758	4.6
6.5	0.1	715	7.7
6.5	0	430	229

Source: "Environmental Factors in Performance Forecasting of Plastic Piping Materials", Chung, et. al. 2003 op. cit.

Strongly oxidative conditions are found in California public water supplies.

California water supplies, particularly ground water supplies, can have strongly oxidizing conditions from low pH and high chlorine residual. Chung et. al. results show a dramatic effect at 0.1 ppm Cl, increasing as Cl concentration increases. A typical chlorine residual in the City of Sacramento, for example, is 0.5 ppm with pH averaging 7.4 (well water) or 8.5 (treated river water) (James Young, City of Sacramento, Water Quality Operations, Chemist, pers. comm. 3/25/05, Operational Statistics, Fiscal Year 2002/2003, City of Sacramento, Department of Utilities). Using the chart FIG. X2.1 Relationship of pH/Free-Chlorine to ORP in Deionized Water in ASTM F2023-04, this puts the ORP for Sacramento water at 550 mV (river) and 750 mV (wells). Typically, 18% of Sacramento water comes from wells. Moreover, many communities throughout California use wells as a primary source of drinking water.

The test conditions in ASTM F2023-04, Section 9, specify test fluid for RO or DI water (laboratory pure water) and alternately for tap water.

> "The pH and free-chlorine concentration combination shall yield a minimum ORP of 825 mV for the test fluid, see Note 5." "Tap water shall have a pH in the range from 6.5 to 8.0 and contain the necessary free-chlorine to maintain an ORP of 825 ±30 mV, see Note 5." "NOTE 5—At the time this test method was originally approved, several test laboratories had existing experimental data developed under varying test conditions, not necessarily in strict accordance with this test method.
>
> "It is suggested that future testing be conducted at conditions that are as aggressive, or more aggressive than plumbing piping might encounter in actual service; specifically, with a test fluid having a pH of 7 or lower and a free-chlorine concentration of 3 PPM or higher. Test data developed with a less aggressive test fluid having a pH higher than 7 or free-chlorine content less than 3 PPM, or both, or prepared from locally available tap-water, may provide higher extrapolated values. However, such higher values may not necessarily be representative of better performance. It is important to be aware of and consider the specific test conditions when comparing data from different materials or laboratories.
>
> "Prior data obtained with test-fluid having an ORP of 750 mV or higher still provides a conservative extrapolation for potable-water conditions found in most areas of the United States." (ASTM F2023-04)

How does Sacramento water compare with these test conditions? First off, Sacramento well water at 750 mV is around the aggressive level of "prior data" discussed in ASTM F2023-04; ASTM may consider that value to be "conservative", but is a very realistic problem for California. Second, Sacramento well water isn't far behind the current ASTM F2023-04 test-fluid 825 mV level in actual impact on PEX Estimated Relative Lifetime.

"Table 2: Relative Expected Test Lifetime at 60°C for a range of ORP's

ORP (mV)	840	825	800	775	750	500
Estimated Relative Lifetime (ERL)	1	1.2	1.6	2.2	2.9	57

Source: "Environmental Factors in Performance Forecasting of Plastic Piping Materials", Chung, et. al. 2003 op. cit.

Using data from Chung, et. al. 2003, we see that the ratio of relative lifetimes for 750 mV and 825 mV is 2.4 (2.9/1.2), meaning that the new "more aggressive" ASTM test conditions are only 2.4 times harder on extrapolated PEX lifetimes by comparison with Sacramento well water. This does not leave much of a margin for error. The data suggest that <u>PEX in Sacramento with well water would last about one-tenth as long</u> as PEX with river water (ERL at 550 mV is 32).

The ASTM F2023 standard is an important recognition of a serious problem with polyolefin plumbing materials. It is relatively new and its genesis reflects the evolving nature of the industry. Although ASTM F2023 addresses the key oxidation issue (chlorine), it is still a short term laboratory test which relies on elevated temperature as a way to forecast premature failure. It does not reflect the effect of exposure to UV light or organic solvents in installation. These will reduce antioxidant concentration by degradation or accelerated leaching and presumably shorten pipe life.

Mechanical failure has economic, public health, and environmental impacts.

PEX is subject to several modes of failure, described in ASTM F2023 and other sources. The particular concern is for "environmental or oxidative failure (Stage III), n—failure in the tubing wall characterized by a large number of cracks emanating from the interior surface of the tubing wall …" In service, this failure mode usually produces catastrophic failure leading to water damage, possible black mold, and at least temporarily rendering the dwelling uninhabitable. The serous impact of failure on the California consumer warrants a close look by HCD based on independent review of the proposed products.

Conclusion regarding Mechanical Failure.

The antioxidant in PEX pipe is like a burning fuse to PEX failure. The amount of antioxidant in place when the pipe is made effectively determines length of the fuse; the oxidative environment acts like wind blowing on the flame, speeding the burning fuse. Pre-installation exposure to UV light shortens the fuse. High chlorine, high temperature, high dissolved oxygen, or low pH all burn the fuse faster. All PEX will fail, it is only a question of when. All current North American PEX installations are like a bunch of bombs with burning fuses -- we just can't see how long they have to go.

Only recently have we begun to see how dramatically these environmental conditions affect pipe lifetime. Only recently has there been a standard test, but ASTM warns, " … extrapolated values do not constitute a representation that a PEX tube or system with a given extrapolated time-to-failure value will perform for that period of time under actual use conditions."

So far, HCD has not made even a half-hearted attempt to gather relevant information. HCD has not placed an obligation of disclosure on all PEX manufacturers that will be marketing in California. Despite product improvement and industry optimism, there is a need for HCD to consider how PEX should be used in California and under what conditions to mitigate potential for mechanical failure and consequent impact on the consumer.

3. Potential Adverse Health Issues

The Housing and Community Development "Literature Search Concerning on (sic) the Use of PEX as Potable Water Pipe" purports to rebut several public health concerns raised by my earlier letters. Oddly, most of the Literature Search rebuttals are to statements I never made. It seems that HCD tries to set up straw men that would be easier to knock down or perhaps the persons preparing the Literature Search did not have access to the actual text of my letters. This illustrates the consistent flaw in HCD's decision making process: lack of insightful and independent analysis.

HCD has squandered an opportunity to ask PEX manufacturers for information and thus to inform the California consumer. The Literature Search is based on a series of email and correspondence between Bill Staack at HCD and representatives of Uponor Wirsbo (a PEX manufacturer) and NSF International. HCD does not receive a complete reply to its questions and lets the matter slip.

The Arizona PEX lawsuit raised issues that HCD has not addressed.

Defren v. Trimark, an Arizona lawsuit in 2002 revolved around a PEX potable water installation. Uponor Wirsbo, the PEX manufacturer, was involved as a third party defendant. The home owner sued the home builder claiming among other things that "Plaintiff and her teenage daughter have been diagnosed with chemical poisoning and have been directed by their joint physician to vacate the house" (Defren v. Trimark, Complaint, p2 item 11). In the course of its defense, Wirsbo disclosed information to the court in Arizona that has apparently not been subject to further review by HCD.

I describe the significance of this disclosure in my January 13, 2003 and April 14, 2003 letters. The disclosure sheds light on the problem of chemical leaching from PEX pipe and permeation of PEX pipe by chemicals in the surrounding environment.

HCD has not followed up on the new information provided to it. The full extent of inquiry is an email from Mr. Staack to Rich Houle, Uponor Wirsbo Director of Codes and Standards asking for comment on a supposed statement of mine regarding "poisoning" in the Defren v. Trimark case (I did not use this phrase in my letters). In response September 11, 2003, Mr. Houle incorrectly states that the litigation did not involve poisoning, when in fact that was the major claim by the plaintiff. Mr. Houle did not comment on the levels of MTBE Wirsbo knows to leach from the pipe, saying only that the water in question in litigation "meets all state and federal guidelines for safe drinking water". Not true in California.

Engle method PEX-A contains reaction byproducts that will leach into drinking water.

The Engle method involves extruding the pipe resin with a peroxide catalyst and other additives which leaves chemical fragments in the completed pipe. Uponor Wirsbo is the manufacturer of AQUAPEX and is one of the largest North American PEX distributors. AQUAPEX is made from PEX-A, cross linked polyethylene manufactured through the Engle method.

The chief chemicals expected to leach from PEX-A are Methyl-tert-Butyl ether (MTBE), tert-Butyl alcohol (TBA), and various benzene-type or phenolic aromatic hydrocarbons which may be fragments of antioxidant additives. This material will leach from PEX-A or PEX-AL-PEX pipe made with PEX-A.

Wirsbo refused to disclose to HCD what levels of these compounds may be present. As reported previously, in Defren v. Trimark, Wirsbo's own tests showed high levels of these compounds and NSF International disclosed at lease some similar results. In response to HCD query, Dave Perkiss, NSF International, did not comment on my report that NSF Tests on PEX leachates had observed MTBE with normalized concentrations of 15, 17, 22 ppb, but merely asserted that NSF results for PEX-A are below its 50 ppb health effects level (Dave Perkiss, email to Bill Staack sent Sept.. 15, 2003). Presumably, NSF International routinely approves pipe with levels of MTBE up to 50 ppb.

The NSF results are normally kept secret, considered the property of the manufacturer. The few results we have were disclosed by Uponor Wirsbo in defense of litigation. For this reason, we can't see the full extent of MBTE and TBA leaching.

European studies of several plastic pipes similarly concluded that PEX may leach MTBE and other VOCs in significant amounts. One study found that "VOCs leaching from PEX pipes gave an intense odour of test water. Several of the migrated VOCs were not identified. Oxygenates predominated within the identified VOC with methyl tert-butyl ether (MTBE) as a major component." (Potential water quality deterioration of drinking water caused by leakage of organic compounds from materials in contact with the water, Lars J. Hem, Aquateam AS, P O Box 6875 Rodeløkka, 0504 Oslo, Norway, E and Ingun Skjevrak, Regional Food Control Authority, Stavanger, Norway)

Hem, et. al. concluded "According to the EU council directive, the drinking water shall have a taste and odour acceptable to consumers, and there shall not be any abnormal change in the taste (EU, 1998). This means that when organic compounds from materials in contact with the water leach VOCs in an amount that gives unacceptable taste and odour to the water, this is in conflict with the EU council directive. ... VOCs from PEX pipes in in-house installations may also be present to an extent that is in conflict with the directive. " (op. cit.)

Another European study by some of the same authors reiterated these conclusions and reported that MTBE leached from some PEX pipes in concentrations as high as 47.6 ppb. (Skjevrak, et al, Volatile Organic Components Migrating from Plastic Pipes (HDPE, PEX and PVC) into Drinking Water, Water Research 37 (2003), pp. 1912-1920.)

The few tests released by NSF International have also confirmed the MTBE and NSF may leach in significant amounts. For example, a July 3, 2000 NSF test of Wirsbo AQUAPEX, found this particular pipe to leach MTBE in a normalized concentration of 17 ppb and to leach TBA (identified in the test as 2-Methyl-2-Proponol – another name for TBA) in a normalized concentration of 6900 ppb.

HCD ignores the significance of the acknowledged leaching.

PEX-A based potable water systems will likely deliver MTBE levels in the range of 5 to 50 ppb depending on standing time, for the first half year of use or possibly longer. HCD dismisses a PEX-A leaching concern, apparently buying in to the manufacturer's and NSF claim that the lower US EPA action level (20 ppb) is based on taste and odor and hence of no regulatory or public decision-making significance. The industry thinking being that "as long as it is not a strong poison, it is O.K".

It is preposterous for a state agency, HCD to take this approach. Commonly installed PEX-A is known to leach MTBE and TBA at levels well above the state's own public health guidelines and above the state and the US EPA levels for protection of consumer taste and odor.

For MTBE: The California Office of Environmental Health Hazard Assessment ("OEHHA") has adopted a public health goal (PHG) for MTBE of 13 ppb for drinking water. "A Public Health Goal (PHG) of 0.013 mg/L (13 ug/L or 13 ppb) is adopted for methyl tertiary butyl ether (MTBE) in drinking water. The PHG is based on carcinogenic effects observed in experimental animals." (Public Health Goal for Methyl Tertiary Butyl Ether (MTBE) in Drinking Water, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Pesticide and Environmental Toxicology Section, Anna M. Fan, Ph.D., Chief Deputy Director for Scientific Affairs, George V. Alexeeff, Ph.D., March 1999). The California Department of Health Services (DHS) has similarly set a health-based Maximum Contaminant Level (MCL) on MTBE of 13 ppb. DHS has also set a secondary MCL on MTBE of 5 ppb for taste and odor.

For TBA: The state establishes an action level of 12 ppb and offers public water suppliers the optional health effects language for customers, "Some people who use water containing tert-butyl alcohol in excess of the action level over many years may have an increased risk of getting cancer, based on studies in laboratory animals." (Appendix A-3: State Regulated Contaminants with No MCLs i.e., "Unregulated Contaminants" Monitoring required by Section 64450, Chapter 15, Title 22, California Code of Regulations.)

The public health guidelines, MCLs and action levels represent the state's considered efforts to protect consumers. It makes no sense whatsoever, for a state agency to cavalierly disregard the protective guidelines and allow deliberate installation of a product that exceeds levels the state has set to protect health or that the state and US EPA have set to protect taste and odor.

Organic chemical leaching from PEX may have a cumulative effect.

MTBE is found in many water supply systems. This is the main reason MTBE was discontinued as a gasoline oxygenate additive: it migrates rapidly when released into the ground water environment and it is difficult to remove from the water. Indeed, Rich Houle, Wirsbo Director of Codes and Standards, states that "published records from the City of Scottsdale [AZ] regarding its water supply acknowledged the presence of MTBE in wells serving the Scottsdale area" (Houle, op. cit.).

California has set a primary MCL of 13 μg/L (2000) that addresses health concerns and its public health goal is also 13 μg/L, sets a secondary MCL of 5 μg/L (1999) that addresses taste and odor concerns, and sets detection limit for purposes of reporting (DLR) of 3 μg/L. The DLR is the level at which DHS is confident about the quantity being reported. Results at or above the DLR are required to be reported to DHS; some laboratories may report results at lower concentrations.
(http://www.dhs.ca.gov/ps/ddwem/ chemicals/MTBE/mtbeindex.htm)

As of May 2, 2005, the DHS database of MTBE monitoring results identified 109 public drinking water systems with consistent MTBE detections. In 28% of these systems MTBE was found in concentrations above the public health goal; in 53% of these systems MTBE was found in concentrations above the taste and odor MCL. Counties found to exceed the public health MCL include Los Angeles, San Diego, Kern, Monterey, San Francisco, Riverside, Sacramento, El Dorado, Orange, Yuba, Madera, San Benito, and Siskiyou. (DHS MTBE Monitoring results, Update: June 9, 2005)

MTBE contamination potentially affects a substantial population. MTBE is the major component of Reformulated Gasoline, which was required for major urban areas. The US EPA states, "Due to its widespread use, reports of MTBE detections in the nation's ground and surface water supplies are increasing." In California, MTBE has been found in more than half of the reservoirs and has caused water supply curtailment in Santa Monica, South Lake Tahoe, Santa Clara County and Sacramento.

HCD needs to consider the cumulative effect of even low levels of MTBE leaching from PEX combined with the levels already found in drinking water. For the roughly half of samples with detections, the PEX pipe need contribute only from 1 to 8 μg/L to bring water from the taste and odor threshold to the public health threshold. MTBE permeation from PEX exposure to contaminated water is another cumulative source. Will HCD disapprove the use of PEX in areas where water supplies are already known to be or may potentially be contaminated with MTBE?

PEX permeability is an acknowledged industry problem.

Polyethylene permeability is a major limitation to its use for food packaging and other applications where oxygen and water vapor need to be excluded. One approach in packaging is to add a second layer of a less permeable plastic. PEX manufacturers are adopting this approach to limit oxygen diffusion in PEX tubing for use in radiant heating. Although the focus is primarily on keeping oxygen levels low in closed loop systems, the results indicate the permeation potential for PEX potable water supply pipe.

> "In recent years it has been discovered in Europe, after enormous corrosion and subsequent sludging problems developed in systems utilizing oxygen permeable plastic tubing in "closed systems", that plastic tubing allowed enough oxygen permeation through the pipe wall to cause corrosion in the system."

> "The German Industry standards (DIN) have determined that an oxygen diffusion rate of 0.1 mg/liter/day or less at a water temperature of 104 degree F. (40 degree C.) in plastic tubing is considered a safe level to prevent oxygen corrosion in heating system components. For comparison: The amount of 5 milligrams of oxygen per liter per day caused by oxygen diffusion through the pipe wall is equivalent to completely draining the heating system and refilling it with fresh water every other day during the heating season." (Metal-plastic multilayer pipe having form stability for plumbing and hydronic heating, US Patent 20020007861).

Oxygen PEX diffusion in ordinary potable water pipes may be on the order of several mg O2/liter void volume per day. Disregarding chemical interactions, the rate of diffusion is roughly proportional to the inverse square root of the molecular weight. Based on similar polarity to PEX, benzene would move at 64% of the rate of oxygen. Alkyl substituted benzenes (e.g tetra methyl benzene) would move at 45% of the rate of oxygen. This suggests that a PEX tube exposed to a 0.2% benzene concentration in a termiticide or in gasoline, would produce benzene in drinking water at around 10 ppb after standing overnight, and upwards of 100 ppb standing for a week. This result is in line with the lab tests from the Arizona litigation which found alkyl substituted benzenes at roughly 70 to 220 ppb. Because the reservoir of chemical in the environment is so large, permeation is expected to continue for many years and hence is a long tem exposure.

Comparing permeation potential for benzene in this range, PEX in contaminated ground may easily exceed the state MCL of 1 ppb or the US EPA MCL of 5 ppb.

PEX is permeable to chemicals in the environment.

Permeation is the phenomenon where relatively low molecular weight substances migrate through a seemingly solid polymer barrier. Permeation is a concern where the ground and groundwater are contaminated with petroleum compounds, with the gasoline additive MTBE, or with pesticides, particularly termiticides. Although most domestic plumbing will be within the structure itself, the approval considered by HCD includes external exposure from the water metered to the structure or under slab for slab on grade home construction.

"Permeation may do little if any harm to the material, but it may have application-related effects. The permeating chemical may transfer into a fluid on the other side of the pipe. In general, thermoplastic pipes should not be used where a permeating chemical could compromise the purity of a fluid such as potable water inside the pipe ..." (Thermoplastic Piping For The Transport Of Chemicals, January 2000) Although technically no longer thermoplastic after crosslinking, PEX is included in the cited discussion.

The PEX Industry acknowledges the limitation and warns "Do not allow tubing to come in extended contact with any of at least the commonly encountered construction materials listed below: (This list is not all-inclusive.) Pipe thread sealing compounds; Fire wall penetration sealing compounds. Exception: water soluble, gypsum-based caulking;

Petroleum-based materials such as: Kerosene Benzene Gasoline, Solvents, Fuel Oils, Cutting Oils, Asphaltic Paint, and Asphaltic Road Materials." and "Do not place any PEX tubing in heavily contaminated soils or other heavily contaminated environments." (The Plastic Pipe and Fittings Association, 2002 Installation Handbook: Cross-linked Polyethylene (PEX) Hot and Cold Water- Distribution Systems, page 4.)

PEX is permeable. PEX manufacturer Uponor Wirsbo says so: "The permeable characteristics of cross-linked polyethylene tubing prohibit installation in soil or ground water contaminated with solvents, fuels, organic compounds or other detrimental materials. Where such conditions are suspected, chemical analysis of the soil or ground water should be performed before installation". (Defren v. Trimark, Wirsbo disclosure statement, page 3.) Will HCD require such testing in California for PEX under slab installation?

4. Potential Fire Hazard Issues

The substitution of a plastic product for a metal product poses the obvious concern for fire safety. The plastic pipe carrying water is not likely to be flammable, but exposed to heat in a fire, the plastic pipe will rapidly rupture, draining or de-pressurizing the system and creating openings in wall studs which may encourage fire spread.

The Model code attempts to address some of these concerns by requiring fire stopping at pipe penetrations. It would be appropriate for HCD to seek comment by California fire officials on the likely efficacy of these fire prevention mechanisms, particularly in light of the high seismic activity and associated risk of structure fire in most of the state. Options for fire stopping materials for PEX are limited because many types of fire stopping materials are incompatible with PEX, will void the manufacturer's warranty, and may cause premature failure. Will HCD identify which fire stopping materials are appropriate for use with PEX and certify those as adequate to protect the public from fire risk?.

5. Potential Solid Waste Impacts

Solid Waste Management is important to California. Construction waste and demolition debris are a major portion of the waste stream and much effort has been made in the past decade to increase the amount of construction materials that can be recycled and diverted from the landfill. While Copper piping is eminently recyclable, there is currently no recycle market for PEX. Due to the crosslinking manufacturing step, PEX cannot be remelted like ordinary polyethylene and is inherently unsuited for reuse and virtually impossible to recycle.

The Commission should consider the impact that replacing a recyclable building product with a non-recyclable product may have on the increasing solid waste disposal problem facing the state.

* * *

In conclusion, we have been trying to get HCD to consider important information on public health and consumer protection. The level of documentation reflected by the "Literature Search" does not meet the usual standards of independent review and public disclosure that would be required for a state agency making an important decision.

Sincerely,

Thomas S. Reid