GT ENGINEERING

June 28, 2005
05-023.RC

California Building Standards Commission
915 Capitol Mall, Suite 200
Sacramento, CA 95814

RE: Use of PEX for potable water plumbing

Chair and Members of the Commission:

At the behest of the California Pipe Trades Council, I have been requested to submit this letter regarding potential biological issues with use of cross-linked polyethylene (PEX) piping. It is my understanding that the Commission is considering authorization of wider application of PEX piping in potable water applications. Based on my own personal testing, along with review of pertinent literature, the following thoughts and opinions are provided for consideration during your review process.

My professional background since 1988 has been as a consultant dealing with forensic analysis of materials failures and engineered systems, serving as an expert consultant to manufacturers, industry, the Federal Government and the insurance industry. On numerous occasions I have been retained by legal counsel and have provided expert testimony on issues involving degradation and/or failure of materials. A pertinent part of my experience is in dealing with corrosion and water chemistry. From 1976 to 1985 I held progressive scientific posts at Battelle Pacific Northwest Laboratory, eventually becoming a staff scientist and then manager of the Corrosion Research and Engineering Section. I am currently a founding principal with GlobalTox/GT Engineering. The company has two areas of focus. GlobalTox staff includes toxicologists, certified industrial hygienists, and pharmacology. GT Engineering staff deal with hard sciences including metallurgy, materials science (plastics/polymers), chemistry and mechanical engineering. Together we address the range of human exposure along with the engineering side of how the exposures develop. For example, from friction surfaces such as brakes to asbestos exposure, from batteries to gaseous emissions, and from piping systems to bacterial exposure. Current projects include spread of Legionella in the water systems of a high rise complex and exposure to bacterial growth in open loop hydronic heating systems piped with cross-linked polyethylene (PEX).

My personal concern with biological growth in PEX piping stems from numerous litigation cases over the last two years involving PEX piping failures in Washington State. I was retained by counsel for homeowners associations in these cases. Initially the issue was failures of the PEX piping in hydronic heating systems, leading to property damage. Our evaluations of the heating systems determined that there were also potential biological issues. This was first evident with the observation of biofilms found in the heating system pipes. Attachment 1 is a picture of a water sample drawn from a hydronic

18372 Redmond-Fall City Road • Redmond, Washington 98052 • Tel 425-556-5555 • Fax 425-556-5556

heating loop. The heating systems utilized an open loop design, meaning that the water from the hydronic heating system is supplied by and returned to the potable water in the domestic water heater. Biofilms formed despite the system design which allows for refreshing the chlorine content in contact with the piping. Water samples were acquired from three condominium complexes. Sampling strategy was based on having a 95% probability of drawing at least one infected sample assuming a 10% infection rate. Analysis was conducted for the presence of a broad range of bacteria, rather than for a specific pathogen, such as Legionella. This was to establish the ability to grow potentially pathogenic species in the subject environment, rather than search for specific pathogens. Our results were that after 2 to 3 heating seasons a number of the tested systems exhibited bacterial counts of 10,000 to 100,000 CFU/cm^2 (colony forming units per square centimeter of growth media). At the 100,000 CFU/cm^2 level issues with pathogens found capable of affecting immune system compromised individuals, such as those on chemotherapy, arise.

Interestingly, there was also other overt evidence of biological growth in the PEX piped heating systems. The systems contained brass flow-check valves. Attachment 2 shows a picture of what was observed on some check valves; there were pin-hole penetrations through the valve bodies. Metallurgical analysis demonstrated that the brass was subject to microbiologically influenced corrosion (MIC). That is the development of bio-slimes in the piping had allowed growth of biota that promote corrosion of metal components. I recently published a peer reviewed article on this finding.[1]

The research literature suggests that there should be concern with application of certain types of plastic piping in domestic water systems. The Ministry of Public Housing, Urban Planning and Environment (The Netherlands) commissioned a study directed specifically at the issue of biological film formation and pathogenic bacteria viability as a function of pipe materials[2]. This study, conducted by Kiwa N.V., a water research consultancy, provides some thought-provoking results. Eight materials in the domestic water piping market were tested, including variants of crosslinked polyethylene (PEXa, PEXc), polybutylene (PB), polypropylene (PP), chlorinated polyvinyl chloride (CPVC), polyethylene/aluminum composite, copper (Cu) and stainless steel (SS). The study showed that under static conditions polyethylene derived pipes (PEXa and PEXc) provided the highest biofilm formation potential of any of the eight materials tested. Even though their analysis showed that the copper piping tested likely had residual oils (which would promote biofilm formation) the PEXa (crosslinking by the peroxide method) tubing still exhibited several times the biofilm formation potential of the copper. Further, this research established that colony counts of inoculated bacteria generally correlated with the propensity for biofilm formation. The paper also showed that certain biota were particularly sensitive to the presence of copper, e.g. no Pseudomonas bacteria

[1] R.A. Clark and D.R. Clark, Microbiologically Influenced Corrosion in Hydronic Heating Systems, Journal of Failure Analysis and Prevention, V. 4 No. 4, Aug. 2004, pp. 38-42

[2] H.R. Veenendaal and D. vander Kooij, Biofilm Formation Potential of Pipe Materials in Plumbing Systems – Measurement Results and Evaluation, Kiwa, June 1999

survived in the copper systems. In their summary of results, the authors' state: "The PE-based materials displayed the strongest biofilm formation and the strongest promotion of the growth of Legionella bacteria."[3]

This study concludes with a recommendation that the static test results become the basis for comparative assessment of piping materials. The reasoning presented is: "The microbiological quality of the water in drinking water installations is (virtually) not inspected and the protection of the microbiological quality therefore rests entirely on prevention."[4]

Other research supports similar conclusions. A well referenced review paper by Momba et al[5] summarizes the many aspects which can affect water quality. This paper notes, "The most alarming results are the presence and multiplication of pathogenic and opportunistic pathogens such as..... occurring within the biofilms." The paper goes on to identify the "factors contributing to biofilm formation" one of which was "the kind of piping material used in the system". It was noted that "Biofilm formation is usually encouraged on the surface of a plumbing material if that material is able to supply the required nutrients for bacterial growth. In countries such as the United Kingdom, the influence of piping material is examined....before their use is permitted." In a later discussion on plastic piping "Despite their many advantages, they also contribute to biofilm formation in drinking water." Addressing control strategies for inhibiting bacteriological deterioration of drinking water the authors emphasize the need to prevent biofilm formation including "Efforts should be made to utilize materials in the network which will suppress the attachment of bacteria...".

There are numerous references in the literature that link the growth of pathogens with biofilm formation. There are also references that specifically identify benefits to the presence of certain metallic elements in inhibiting or eliminating some pathogens of concern. A recent government funded Italian study[6] points out the benefits of having residual copper levels of >50μg/L on inhibiting Legionella and possibly reducing coliform bacteria. A study commissioned by the International Copper Association (ICA)[7] determined that in most cases bacteria grew more on plastic materials than on copper.

In attachment 3 a sheet from an advertising newsletter published by Noveon Europe, B.V.B.A. is provided. Figure 1 on the subject attachment provides a comparison from a referenced study of the bacterial growth in different piping materials. In this case

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[3] Ibid, p. 24
[4] Ibid, p. 40
[5] MNB Momba et al, An Overview of Biofilm Formation in Distribution Systems and its Impact on the Deterioration of Water Quality, Water SA Vol. 26, No. 1, Jan. 2000
[6] Paola Borella, et al Legionella Infection Risk from Domestic Hot Water, Emerging Infectious Diseases, Vol. 10, No. 3, March 2004
[7] J.T. Walker and C.W. Keevil, The Influence of Plumbing Material, Water Chemistry and Temperature on Biofouling Plumbing Circuits with Particular Reference to the Colonization of Legionella Pneumophila. Part 2 1993 ICA Project 437

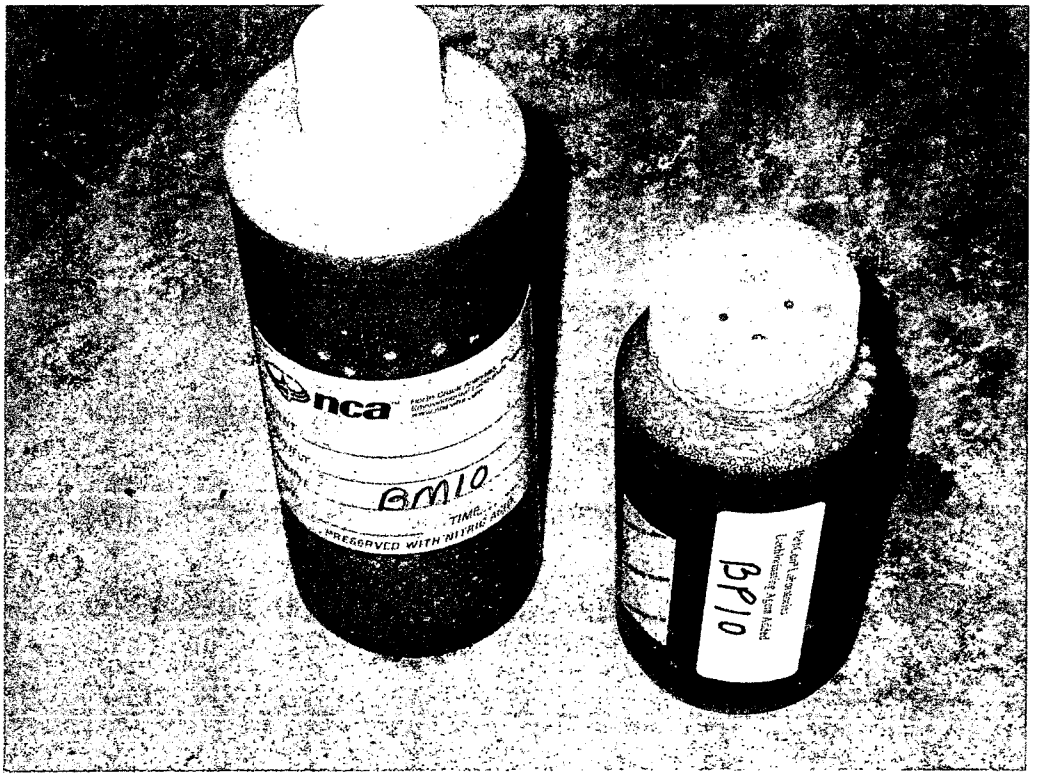
Noveon appears to be extolling the virtues of CPVC (chlorinated polyvinyl chloride). However, note the extremely high bacterial growth values for polyethylene. Noveon previously marketed Flexet™ resin for the manufacture of PEXb (silane crosslinked polyethylene) piping for domestic water applications in North America. Their clients included some of the largest manufacturers of PEX piping including Plasco, Bow, IPEX (Kitec), and Vanguard. Noveon currently markets PEXb resin under the trade name TempRite® to producers such as Bow and IPEX. IPEX is the producer of Kitec® PEX/Aluminum/PEX piping. This composite piping has the same PEX composition in contact with the water as piping without the internal aluminum layer. Therefore its properties with respect to biological growth would be no different than other PEX piping products.

From my personal experience and as evident in the technical literature, there are issues with the promotion of biofilms in cross-linked polyethylene piping. It is established fact that biofilm formation is linked to the growth of bacteria, including known human pathogens. As referenced above there are definite concerns with the qualification and choice of piping materials being expressed in an effort to assure safety in domestic potable water. On the converse side of allowing plastic piping in potable water systems, such a choice also brings about the less obvious, but potentially important, loss of the bactericidal properties that are inherent in using copper piping. A further consideration should be that the commonly used methods of sanitizing systems, exposing them to high heat or high levels of biocide chemicals (e.g. super chlorination) can damage PEX while having virtually no effect on service life of metal piping. I urge the Commission to fully study the ramifications of extending the allowed application of PEX piping. Possible advantages in ease of installation and front-end construction costs may have long term consequences in public safety and durability.

Sincerely,
GT ENGINEERING
(a subsidiary of GlobalTox, Inc.)

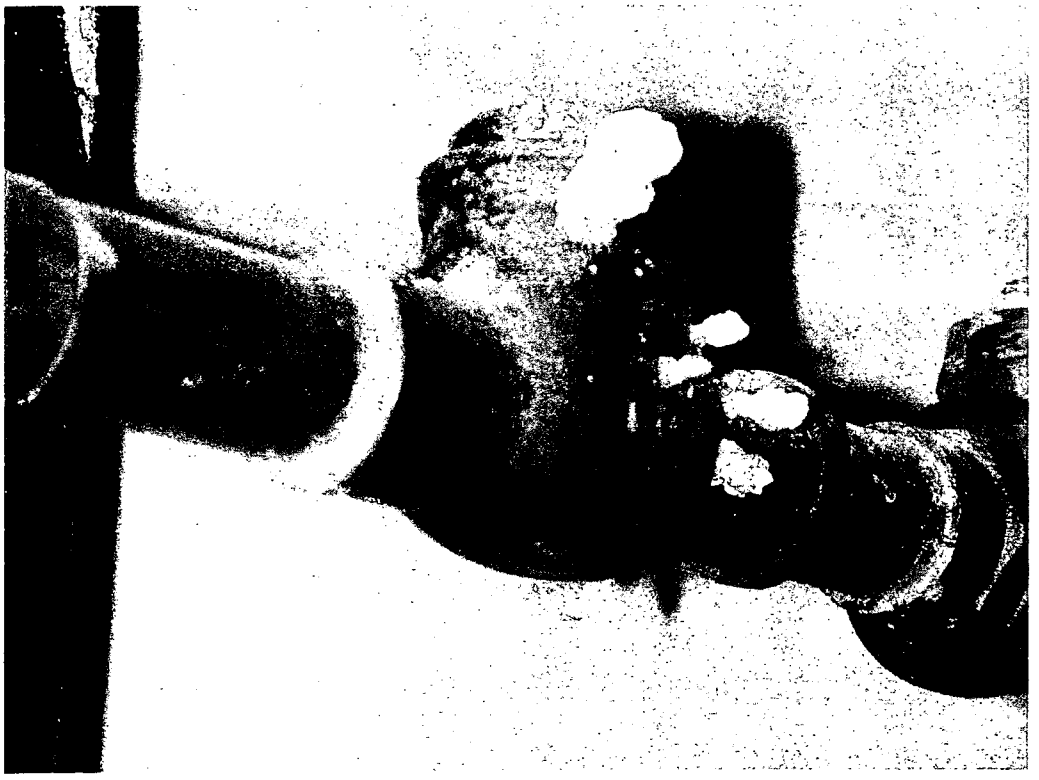
Robert A. Clark, Ph.D.
Principal – Materials Scientist

Attachment 1



Water sample acquired from open loop heating system plumbed with PEX tubing. Dark color is from biofilm/slime growth in the PEX tubing. (Blueberry Place 9-28-03 DSCN0843)

Attachment 2



Microbiologically induced corrosion (MIC) has resulted in through wall pitting of a brass check valve in a PEX plumbed hydronic heating system. (Plum Grove 12-18-02 DSCN2568)

NEWSFLOW

January 2002 edition n° 1

CPVC and bacteria build-up

Recent outbreaks of legionella in Western Europe and other health issues associated with bacteria, have led to heightened awareness of the effect of piping materials on bacterial growth. Studies have shown that bacteria build-up with CPVC is far lower than with alternative piping materials such as copper, steel and other thermoplastics. Below are some results and conclusions of 3 different studies.

Study 1: Health concerns*

"CPVC piping supports the lowest bacterial growth compared with traditional piping materials." (see figure 1)

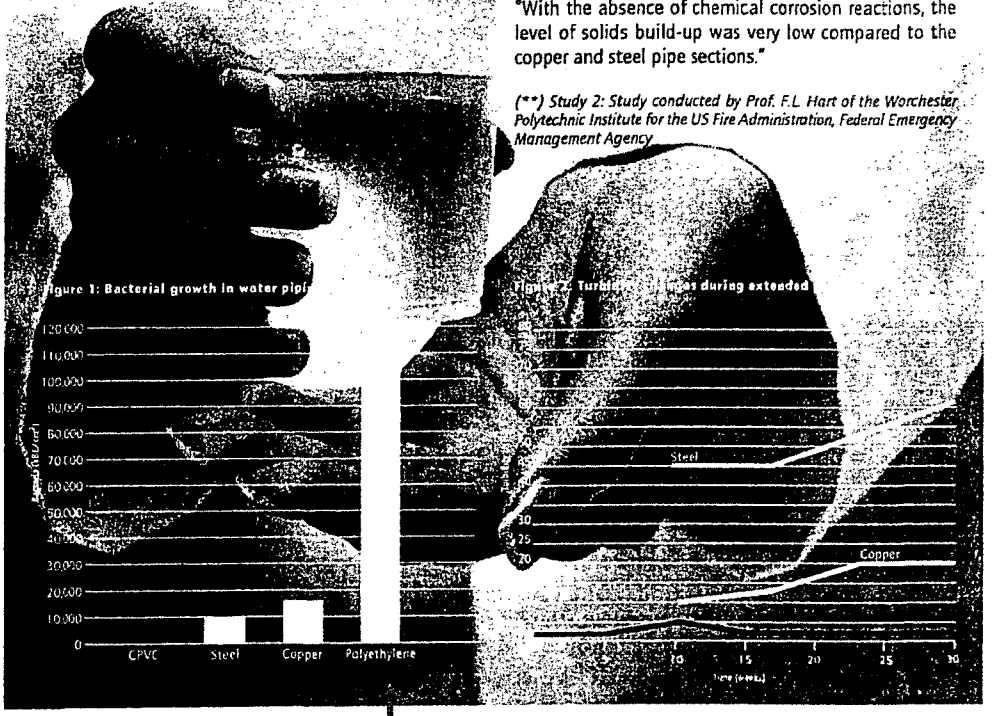
(*) Study 1: Bakterielle Oberflächenbesiedlung in trinkwasserdurchströmten Schlauch-und Rohrleitungen; Dr. Georg-Joachim Tuschewitzki; Privatdozent am Hygiene-Institut der Universität Bonn; 23.10.1989.

Study 2: Water deterioration from extended stagnation conditions in steel, copper and CPVC pipes**

"The clear winner in terms of water deterioration in this laboratory study is the CPVC pipe. As can be seen, very little deterioration occurred, even after extended stagnation." (see figure 2)

"With the absence of chemical corrosion reactions, the level of solids build-up was very low compared to the copper and steel pipe sections."

(**) Study 2: Study conducted by Prof. F.L. Hart of the Worchester Polytechnic Institute for the US Fire Administration, Federal Emergency Management Agency.



noveon
The Speciality Chemicals Innovator ™

Noveon is a major supplier of PEX resins to the North American market.