Aaron,

Pursuant to our discussion this afternoon, attached is an informational memo that I wrote a couple years back on the factors associated with dielectric couplings and their possible use in partial lead service line replacements. This was written when the issue came up in some public meetings in the DC Water program, and was prepared as a background briefing for the program managers. Since that time, the issues surrounding partial lead service line replacements and the potential for lead release due to galvanic corrosion has only gotten more heated. In an effort to resolve the matters, perhaps optimistic, the Water Research Foundation is sponsoring a research project to specifically examine the issue of galvanic corrosion. Co-Principal Investigators of this project (WaterRF Project 4349, which is just getting started) are myself, Abigail Cantor (Process Research Solutions, LLC) and Dan Giammar (The Washington University in St. Louis).

Another thing I'd like to bring to the committee's attention is a recent guidance manual issued by AWWA (M58) titled "Internal Corrosion Control in Water Distribution Systems" which gives a good literature overview of several topics that the committee is interested.

regards, Greg Welter

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MEMORANDUM

Non-use of Dielectric Couplings in Partial Lead Service Line Replacements

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Introduction: - The objective of WASA lead service replacement program, which has been in operation from late 2003 to the present, has been to replace all lead service lines in public space with copper piping. Where WASA has been successful in obtaining customer authorization for work on the private property, the entire lead service line from the water main in the street to the first fitting inside the house has been replaced. However, in most cases, the private customers have not signed agreements providing such authorization, so the replacement has been limited to the service line in public space, from the main in the street to the property line.

Purpose: - The question addressed herein is whether to use a totally plastic dielectric coupling to effect a non-metallic separation at the point where the new copper piping is joined to the existing lead pipe. WASA's practice has been to not use dielectric couplings in the LSR program, both prior to 2006 when the program was mandated under the EPA Lead and Copper Rule, and during the current voluntary program since January 2006. The decision not to use dielectric couplings was made early in the program in 2004, was confirmed in 2005, and has been revisited in 2008 after the subject was raised in public meetings.

There are two principal factors that have been considered in this decision:

1. Water Quality - This issue concerns whether galvanic action at the point of contact between two dissimilar metals would result in the release of significant lead content to the water, and whether use of a dielectric coupling would prevent this release. To prevent the possibility of galvanic action due to the direct contact of dissimilar metals, a totally plastic coupling would be needed, so as to prevent any dissimilar metals contact between the existing lead pipe and any metal components of the coupling and between the new copper piping and any metal components of the coupling. (Note: There are some commonly used metal couplings with non-metallic insulators that are used in some plumbing applications; however, they would not accomplish the objective of eliminating direct contact of dissimilar metals and be suitable for buried applications.)
2. Electrical Safety - It has been standard practice throughout the United States for household electrical systems to utilize a "ground" connection via the buried water piping system as a safety measure. Use of a non-metallic dielectric coupling could make this grounding ineffective.

Water Quality: - The question of potential adverse lead release following partial replacements, due to galvanic action and other causes, was discussed by EPA in the preamble to its issuance of the updated Lead and Copper Rule in 2000. Based on its review of several studies, EPA concluded that partial replacements would have positive health benefit and that elevations in lead content were transient.

The issue of the potential adverse galvanic action effect was reviewed by EPA and WASA when the District of Columbia LSR program began. EPA commissioned a study of the effect by a research contractor, Dr. Steven Reiber. A draft report from this study (attached) was released and reviewed by EPA and WASA in September 2005. The findings of the study were summarized as follows:

> "In brief, this study has shown that grounding and/or impressed currents moving along LSLs [lead service lines], and eventually leaving the pipe to ground, have no meaningful impact on internal pipeline corrosion and do not contribute to metals release. Secondly, while the study found that galvanic impacts can be substantial on unpassivated lead surfaces, the magnitude of the impact on aged and passivated LSL surfaces is so minimal as to be inconsequential relative to lead release."

Based on this finding of no significant adverse water quality effect and on consideration of potential safety hazard from interfering with electrical grounding systems (discussed below), WASA decided to continue with its existing practice of not using dielectric couplings.

(It should be noted, however, that the EPA contract researcher, Dr. Reiber, while finding no significant adverse galvanic effect on lead release in his studies, went on to say that use of a dielectric separation would eliminate the potential for such effect. In the final November 2006 version of the report, Dr. Reiber mistakenly wrote that it was "standard policy for DC WASA to use dielectric couplers when performing partial LSL replacements." This incorrect information was apparently conveyed to Dr. Reiber by another researcher at WASA, who was mistaken in his understanding of the actual construction practice.)

Electrical Safety: - Historically, the National Electrical Code (the NEC, promulgated by the National Fire Protection Association, and adopted by local governments) required that household electrical systems use the buried metal water service line as a grounding electrode. The NEC defines the use of the underground metal water supply piping as an acceptable ground in the following provision:

> "**Metal Underground Water Pipe** A metal underground water pipe in direct contact with earth for 3.0 m (10 ft.) or more (including any metal well casing effectively bonded to the pipe) and electrically continuous (or made electrically continuous by bonding around insulating joints or insulating pipe) to the points of connection of the grounding electrode conductor and the bonding conductors." (Sect. 250.81 (a))

The current NEC (as well as the 1996 NEC currently in force under District of Columbia law) identifies other acceptable grounding electrode system; however, it requires that if other grounding electrodes are present and available, the water pipe must be bonded to them. At the time of construction of most of the homes that are involved in the LSR program, the underground metal water supply pipe would have been the only grounding electrode provided.

This electrical grounding practice has always been controversial. The American Water Works Association (AWWA) issued an opposing Policy Statement in 1966, with reaffirmation in 1971, 1980, 1987, 1995 and 2003, principally out of safety concerns to water utility workers in the case of dangerous current being carried in the public water piping if the electrical system wiring were defective. An AWWA Research Foundation investigation of this issue concluded that:

> "Serious shock incidents occur at a rate of approximately one incident per 200,000 domestic services per year, which translates to approximately 360 shock incidents in the U.S. water utility annually."

Nonetheless, in nearly all communities the practice of electrical system grounding via the metal water supply service is accepted. In fact the International Plumbing Code (2000), to which the District of Columbia subscribes, includes the provision:

> "**Existing Piping Used for Grounding** Existing metallic water service piping used for electrical grounding shall not be replaced with nonmetallic pipe or tubing until other approved means of grounding are provided."

In reviewing this issue in 2008 for the WASA LSR program, we reviewed the measured lengths of the private portion of the water service in the more than 14,000 water services that have been addressed to date. We found that approximately 40% of these private side service lengths were less than ten feet (the minimum required for effective grounding under the NEC.) This would indicate that for approximately 40% of homes, if the customer did not agree to replace the private side lead service and if WASA were to utilize a dielectric coupling at the property line in its replacement of the public portion of the lead service, then the customer would have to undertake the expense of having a contractor install a replacement ground electrode.

Practice by Other Utilities: - A brief telephone survey was conducted of the practice of some other utilities. Locally, representatives of utilities serving Howard, Fairfax, and Arlington Counties and the City of Alexandria confirmed that they do not use dielectric couplings on water service connections. WSSC, which serves Prince Georges and Montgomery Counties, also does not use dielectric couplings in most instances. In some cases, where they have special concerns about soil corrosivity to the pipe external surfaces, dielectric

fittings may be used at the corporation tap to the water main, in conjunction with other corrosion prevention measures; however, this is not done for either water quality or electrical safety considerations.

We also contacted two utilities that have conducted concerted lead service line replacement programs and who were subjects in the AWWA Research Foundation study of electrical hazard issues - Louisville, KY and St. Paul, MN. Representatives of both utilities indicated that they do not use dielectric separation. The St. Paul representative noted that they need electrical continuity in their service lines for buried pipe location and for use of welding equipment to thaw frozen services in extreme winter conditions.

Cost Impacts: - The product cost of an all-plastic dielectric coupling is actually less than that quoted for the metal couplings that are currently being used in the LSR program. The price quoted for the all plastic coupling (Ipex Inc. universal transition coupling UTC 255210) at $27.06 compares favorably with prices quoted for the metal coupling of $40 to $50 (AY McDonald #4758C-66, ¾" x 1"), and there would be no impact on labor cost for installation. Therefore, the cost for use of a dielectric coupling would be slightly less than the metal fitting, but negligible compared to the total cost of the service line replacement. (It should be noted that WASA has no experience with use of the all-plastic coupling, and how its service life might compare with the metal coupling.) However, there would be a significant cost ($500 - $1,000) for an electrician to install a compliant grounding electrode at all partial replacements with private water service line lengths less than 10 feet.

Appendix #1:
Current specification requirements for water service fittings

Specification SECTION 02650 - WATER SERVICE CONNECTIONS of the various WASA lead service replacement contracts defines the requirements for the water service connection work for the LSR program. Specifically, section 2.1 on Materials has contained only a brief reference requirement for couplings as follows:

> "D. Copper-to-Copper Couplings per D.C. Plumbing Code
> E. Copper-to-Non-Copper Couplings per D.C. Plumbing Code"

There is actually not a document that is titled "D.C. Plumbing Code" per se. Rather, the District of Columbia has adopted the 2000 International Plumbing Code (IPC). There are minor supplemental requirements in the District of Columbia Building Code Regulations (2003, DCMR 12), but none that deal with pipe couplings.

The applicable provision in the 2000 IPC would be under Section 605 - Materials, Joints and Connections.. Subsection 605.22 reads as follows:

"605.22 Joints between different materials. Joints between different piping materials shall be made with a mechanical joint of the compression or mechanical-sealing type, or as permitted in Sections 605.22.1 and 605.22.2. Connectors or adapters shall have an elastomeric seal conforming to ASTM D 1869 or ASTM F 477. Joints shall be installed in accordance with the manufacturer's instructions.

> **605.22.1 Copper or copper-alloy tubing to galvanized steel pipe.** Joints between copper or copper-alloy tubing and galvanized steel pipe shall be made with a brass converter fitting or dielectric fitting. The copper tubing shall be soldered to the fitting in an approved manner, and the fitting shall be screwed to the threaded pipe.
>
> **605.22.2 Plastic pipe or tubing to other piping material.** Joints between different grades of plastic pipe or between plastic pipe and other piping material shall be made with an approved adapter fitting."

Except in the case of Copper-Galvanized connections covered in Subsection 605.22.1, there is no reference to a dielectric fitting or separation. The fittings described in 605.22.1 are those typically used in interior plumbing for connection of a iron pipe to copper tubing at water heaters (and are described further in Appendix 2 to this memo). The two references made in the main paragraph to elastomeric seals are not dielectric separators, but instead are sealing gaskets for pipe fittings. (ASTM D 1869 is entitled "Rubber rings for asbestos-cement pipe" and ASTM F 477 is entitled "Elastomeric seals (gaskets) for joining plastic pipe.")

The national standard used by manufacturers of piping components for buried water services, is the AWWA Standard C800 - Underground Service Line Valves and Fittings. The current version of this standard (C800-05) contains information on such components as curb stops, service saddles, meter setters, and others, generally emphasizing details of threaded connections. Appendix material includes information on copper water tube, red brass water pipe, steel pipe, and plastic pipe and tube. There is no reference to dielectric elements. There is a brief discussion of lead pipe as a "special issue" in the preamble to the standard, which read as follows:

> *Lead Fittings.* All references to lead fittings have been removed from C800 and the attached appendices. The AWWA Standards Department has available to users of C800 copies of C800-84 information that contains reference to lead fittings.

Appendix #2
Descriptive and functional review of alternative dielectric and non-dielectric fittings

The purpose of this appendix is to describe four types of pipe couplings which are relevant to the discussion of dielectric couplings for possible use in partial replacements to join new copper tubing to existing lead pipe in the LSR program. The four coupling types are:

1. Standard lead to copper buried water service coupling
2. Dielectric lead to copper buried water service coupling
3. Dielectric union for internal plumbing (copper to steel)
4. All plastic universal transition coupling for buried service.

1. Standard lead to copper buried water service coupling

This is the coupling that has been used in the LSR replacement contracts, and has been accepted based on contractor submittals per Specification 02650 - Water Service Connections. This is a brass coupling designed for buried use on a water service line. It has a flared end for copper tube connection on one end and a mechanical compression fitting for lead pipe connection on the other. On both ends there is direct contact between the brass component of the coupling and the copper or lead pipe material. An example of this coupling as provided by the AY McDonald Co. is shown in Figure 1 below.

2. Dielectric lead to copper buried water service coupling

AY McDonald Co. also makes a dielectric version of this coupling, in which the only difference is the insertion of a plastic component between the two ends of the brass coupling. The purpose of this dielectric coupling is to provide electrical separation in the service line, if the water utility wishes to isolate its system from the electrical grounding system of the customer. In this coupling, there is still direct contact between the brass components of the coupling and the pipe materials that it is connected to, so in theory there is still the potential for a galvanic couple effect that could release lead to the water. (However, the Reiber research quoted in the main memo indicates that this galvanic action should be of very limited extent and duration.) An example of this fitting is shown in Figure 2. (This figure, obtained from manufacturer's catalogue actually depicts different end connectors that would be applied for copper/lead transition. The actual end connections would be as shown in Figure 1.)

Figure 1. Standard buried service coupling; copper x lead

Figure 2. Dielectric buried service coupling

3. Dielectric union for internal plumbing (copper to steel)

A more common plumbing application is the dielectric union that is often used in indoor plumbing for connecting to dissimilar pipe materials, typically in the installation of a water heater. This fitting is not designed for buried use. While the objective of this fitting is for dielectric separation for the purpose of prevention of galvanic action, there is contact between similar metals. The union itself is made up of two different metals that are compatible with the pipe materials that are being joined, with the separator inserted between the two ends of the fitting. The dielectric union is depicted in the two photos in Figure 3.

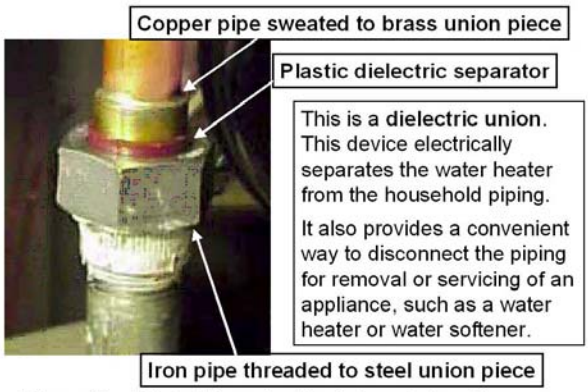

Figure 3a. Dielectric union for internal plumbing

Components Of A Dielectric Union:
The big **nut** clamps the **brass** part to the **steel** threaded part.
The black **washer** and purple **insulator** keep the brass and steel parts from touching.
The brass part gets soldered to a copper pipe. The steel part is threaded onto a piece of steel pipe.

Figure 3b. Dielectric union for internal plumbing

4. All plastic universal transition coupling for buried service (totally plastic dielectric coupling presented in main memo)

For the objectives of this application (i.e. joining of copper to lead pipe in a buried application with no direct metal to metal contact that could theoretically cause a galvanic reaction), an all-plastic fitting would be needed. Figure 4 (below) depicts a universal transition coupling manufactured by IPEX Inc. Except for the stainless steel gripping ring there are no other metal components in this fitting. There is no direct metal-to-metal contact between the fitting and the pipe materials or the joined pipes. The stainless steel gripping ring would not cause a galvanic reaction because the steel components are not contiguous across the fitting and are not in contact with the water.

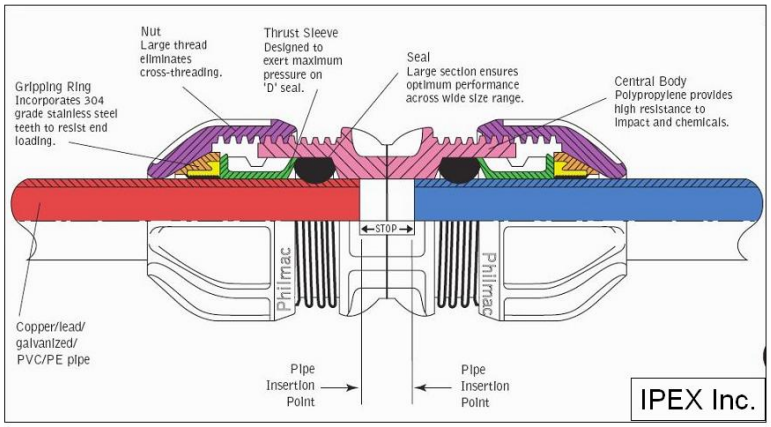

Figure 4. All-plastic universal transition coupling