Effect of connection type on galvanic corrosion between lead and copper pipes

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Pipe connectors can influence galvanic corrosion between lead and copper pipes by distancing the lead from copper pipe, introducing a third metal, and forming crevices. In this study, the effects of distance, connector material, and crevices on galvanic corrosion were examined, and bench-scale comparison testing of commercial connectors was conducted using real tap waters. Brass connectors only slightly decreased (< 25%) the galvanic current that sacrifices lead pipe, with higher reductions for new brasses with higher zinc content. Crevices in brass connectors contained water with extremely high levels of lead (up to $9.4 \times 10^6 \mu g/L$), and in bench-scale tests, connections with crevices caused approximately four times more lead release to water than did direct connections.

The practice of partial lead service line replacement (PLSLR), which involves replacing a portion of a lead service line with new copper, has come under scrutiny because of concern over elevated lead in water in both the short and long term (Cartier et al, 2012; Giammar et al, 2012; Brown et al, 2011; Triantafyllidou & Edwards, 2011; USEPA, 2011). Longer-term problems can arise from direct galvanic corrosion between lead and copper pipe or from deposition corrosion from copper onto lead (Giammar et al, 2012; Triantafyllidou & Edwards, 2011; Britton & Richards, 1981).

STUDY BACKGROUND

Research is needed to better understand how different types of connectors might influence the resulting galvanic corrosion by

- breaking the electrical connection between the copper cathode and the lead anode via an insulator or a dielectric,
- changing the distance between the lead anode and copper cathode of the galvanic cell,
- introducing a third metal if a conductive connector is used, and
- introducing a crevice.

The authors analyzed commercially available connectors and connectors used in previous research (Cartier et al, 2012; Hu et al, 2012; Wang et al, 2012; Triantafyllidou & Edwards, 2011) and found wide variation in connector material (e.g., brass, plastic), connector length (0–5.5 in. [0–14 cm]), and the presence or absence of a crevice or broken electrical connection.

Study objective. The goal of the current study was to develop a mechanistic understanding of the factors influencing galvanic corrosion arising from PLSLRs using short-term bench-scale studies. Results were used to interpret longer-term comparison studies of lead contamination of water using several commercially available connectors in two different laboratories and water supplies in Blacksburg, Va., and Montreal, Que.

MATERIALS AND METHODS

Mechanistic tests. The effects of distance and connector material were investigated by connecting 6 in. (15.2 cm) of copper pipe to 2.5 ft (76.2 cm) of lead pipe. The connector distance was varied, and plastic connectors were compared with red, yellow, and dezincified yellow brass. Galvanic currents were measured using a digital multimeter when pipes were filled with fresh Blacksburg tap water (chloramines; alkalinity of 40 mg/L; pH of 7.8; zinc orthophosphate corrosion inhibitor). Crevise corrosion was tested in several commercially available connectors during a seven-week dump-and-fill experiment in Blacksburg tap water using 1.5-ft (45.7-cm) lengths of lead and copper pipe. Galvanic currents were measured using external wires, and rig construction allowed for measurement of crevice pH using a microelectrode, as well as sampling for analyses of anions by ion chromatography and total metals by inductively coupled plasma/mass spectrometry (ICP/MS).

Comparison testing. To extend the mechanistic insights to practical situations, a 26-week bench-scale study of simulated PLSLRs with copper was conducted. Dump-and-fill pipe rigs were constructed using commercially available brass connectors and 2.5-ft (76.2-cm) sections of lead and copper pipe. Rigs were filled with Blacksburg tap water or aerated Montreal tap water (free chlorine < 0.3 mg/L; alkalinity of 100 mg/L; pH of 8.5). Differences in corrosion rate were assessed via galvanic current and lead release to water analyzed by ICP/MS.
CONCLUSIONS
Mechanistic studies and short-term bench-scale studies of simulated PLSLRs with copper in two real tap waters yielded the following conclusions.

- As distance separating lead and copper increases, galvanic current tends to decrease. In this study, at a separation distance of 12 in. (30.5 cm), 80% reduction in current was achieved.
- As a connector material, new brass may offer slight benefits over direct connection to copper in terms of decreasing galvanic corrosion. These benefits are greatest when the zinc content of the brass is high, and may dissipate with time as brass dezincifies.
- Creation of a crevice involves the outer wall of the lead pipe in galvanic corrosion and lead leaching to potable water and also creates a small volume of water.

![FIGURE 1](image-url)

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REFERENCES


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**FIGURE 1** Connector comparison testing in Blacksburg, Va., (A) and Montreal, Que., (B) tap water

- **Cu**—copper, **Pb**—lead