Effects of Electrical Grounding on Pipe Integrity and Shock Hazard—A National Survey

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The practice of using metallic water piping as part of the grounding system of a building has been common place for more than 80 years [1]. When grounding to the water pipes was first implemented, the water industry was persuaded by the electric utility industry to believe that grounding effects were small and out-weighed by concerns for the safety of mutual customers. Over the years, electrification of society has increased and the validity of the original assumptions used to persuade the water industry are today questionable. Since 1927 policy statements issued by AWWA opposed to the practice have been periodically issued [2].

The objectives of this research were to investigate on a nationwide scale the effects of grounding electrical systems to water systems in terms of shock hazards to utility employees and reduced service live of the pipe due to possible external corrosion caused by the current flow. Information on the effects on water quality was gathered from the literature and the participating utilities.

Table 1. Alphabetical Listing of Participating Utilities

Blacksburg-Christianburg-VPI Water Authority, VA
City of Altamonte Springs, FL
City of Cape Coral, FL
City of St. Louis, MO
Dallas Water Utilities, TX
Denver Water Department, CO
Detroit Water and Sewerage Department, MI
East Bay Municipal Utility District, CA
Indianapolis Water Company, IN
Irvine Ranch Water District, CA
City of Kansas City, MO
L.A. Department of Water and Power, CA
Louisville Water Company, KY
Marin Municipal Water District, CA
Omaha Metropolitan Utilities District, NE
Onondaga County Water Authority, NY
Orange County Public Utilities Division, FL
Pinellas County Water System, FL
Tualatin Valley Water District, OR

Shock Hazard and Grounding

As explained by Warren [3] and Waters [4], alternating currents are exchanged along water services and distribution piping when houses and buildings share electrical transformers. If a house or building is served by its own electrical transformer, then currents are not exchanged via the water system. In most populated areas, between 4 and 20 buildings are served by the same transformer. Meter readers and field crews routinely interact with water meters and service piping and receive electrical shocks ranging from slight tingling sensations to permanent and temporary numbness in limbs. The most serious problems occur when the neutral path to a consumer shared-power transformer is high resistance ("open") and work is performed on the water meter or service. In this situation, all of the current from the building is returning through the water system and this is when the potential for the greatest danger exists.

Statistics have been presented on the rates of occurrence and fatal accident factors for consumer electrical shock incidents in Israel from 1960 to 1969 [5]. Electrical accidents involving taps and water pipes had the highest rate of occurrence (24.3% of all accidents) and the third highest rate of mortality (1.4%). "Faulty earthing" (i.e. grounding) ranked No. 1 among the seven factors considered and was present in 58% of the fatal accidents in Israel for the nine-year period. Conditions and codes in Israel may be different as compared to the United States, but the statistics are quite sobering.

Project Approach

In order to assess the magnitude of the problem nationwide, the research program included participation by twenty utilities geographically dispersed throughout the U.S. A list of the participating utilities is given in Table 1. The participating utilities include large and small water systems with a range of climatic conditions, urban and rural situations, and provided a broad basis for comparison and data.

The project includes an information gathering phase, in addition to field and laboratory testing conducted at nineteen of the twenty participating utilities. The information gathering phase included a review of the open literature and collection and compilation of the utility internal information. The utility internal information was collected as part of a mail in survey of questions which addressed problems associated with shock and corrosion related failures due to grounding and during the on-site field testing phase.

Utility Survey

A utility survey was developed and distributed to the 20 participating utilities. Selected results of the survey related to shock incidents and corrosion are presented in Figure 1 and Figure 2. The results of the utility survey indicated that most shock incidents occur during meter removal and work on service piping. This is because the worker is in close electrical contact with both sides of the meter piping and is standing in a puddle of water, which served to lower the resistance to ground of his body.

Many of the survey questions dealt with the shock incidents and shock prevention protocols. Other questions were designed to address the incidence of shock on all types of utility piping (transmission, distribution and service) including identifying incidents where meters were involved. More than 86% of the utilities have had some shock incident. Eighty-two of the 86% of all shock incidents occur during meter removal. Despite this high level of shock incidents, only 68% have some sort of protocol or procedure for prevention of shock. These results indicate that there is a significant incident rate of shock incidents in the water utility industry due to grounding.

Additional survey questions asked about the occurrence of distribution main failures due to grounding or unknown stray currents. Approximately 55% of the participating utilities surveyed suspected grounding or stray current as the reasons for some of their failures in the previous five years. The results indicated that although some utilities are certain that grounding causes pipe failures, a significant portion of the water utility industry is unsure of any relation which grounding might have with premature failures of distribution piping.

Summary and Conclusions

The amount of current which flows through the utility worker is dependent on his/her resistance to earth relative to that of the piping system (grounding electrode). The resistance to ground of a grounding electrode is a function of the soil resistivity and the size and shape of the conductive material which is in contact with the soil. Low resistivity soils and large surface areas of bare metal produce low resistance grounding electrodes. However, with the increased use of non-metallic (dielectric) piping underground for distributions systems and the use of well coated or wrapped metallic piping, the water piping may no longer serve suitably low resistance grounding electrode. Therefore, the threat to utility workers is increased so long as water piping is used as grounding electrode over which current can flow. The best solution is prevent and prohibit currents from flowing on water pipe. Other results indicate that:

1) Alternating and direct currents are present in water service and distribution piping due to shared transformers in electrical distribution systems.
2) Vitual DC is present due to speed controlled electronics and appliances.
3) Alternating current causes corrosion albeit at much lower rate as compared to direct current. The rate is material dependent. For iron, copper and lead, alternating current corrodes at about 1% of the rate of a similar amount of direct current.
4) Utility employees are exposed to a variety of shock hazards ranging from slight tingling to temporary and permanent impairment of limbs. The worst incidents occur when neutral connections to power transformers are "open" or disconnected.
5) More than half of the participating utilities feel that some of their corrosion failures on service and distribution piping are due to grounding currents.

Acknowledgments

The authors would like to acknowledge the AWWAFR Project Officer Roy Martinez and the technical review and oversight of the Project Advisory Committee, Mr. John Ackerman and Mr. Bob Behnke of St. Louis County Water Authority, Mr. Richard Bonds of Ductile Iron Pipe Research Association, and Mr. Don Goff of U.S. West Communications. Our sincerest thanks and appreciation to the field crews, foremen and managers of the participating utilities and the homeowners who allowed the Research Team to use their homes as test locations.

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Figure 1. Participating Utilities Reporting Shock Incidents Related to Removing Water Meters in the Past Five Years.

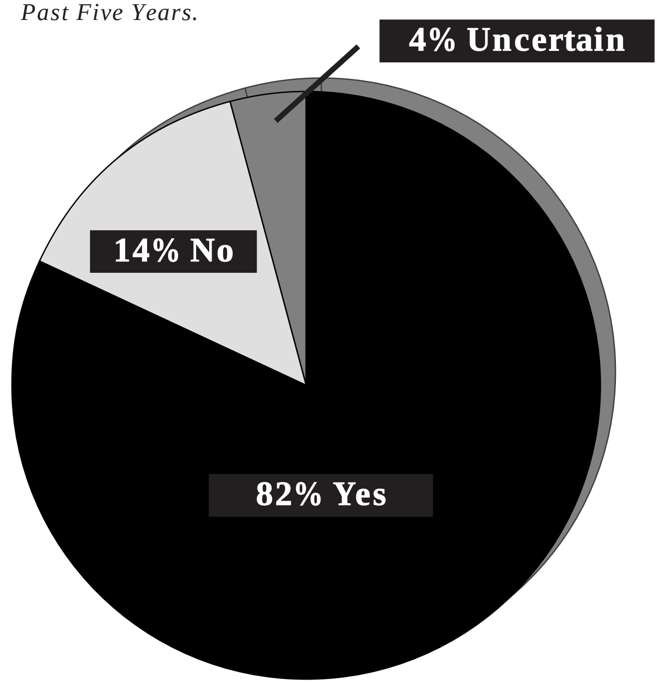

Figure 2. Participating Utilities Reporting Corrosion Failures of Distribution and Service Piping Due to Grounding Effects in the Past Five Years.