Insulated Water Service Line Products – A Cost-Effective Approach to Protect Water Distribution Systems from Stray Electrical Currents

White Paper

Mueller Co.
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Overview

Stray electrical currents present the possibility for a costly and dangerous hazard, one that could and should be prevented with proper products and maintenance, but the costly and potentially dangerous effects of stray electrical currents warrant the study of this specific phenomenon. The three main problems created by stray electrical currents are shock hazards, accelerated corrosion of metal water pipes, and water quality problems such as the presence of lead or copper. This paper will review some of the main causes and results of stray currents, as well as protection choices for water pipeline systems.

Stray Currents – A Definition

Stray currents are electrical currents that flow through the ground and water piping system due to wire damage or improperly installed or maintained electrical systems. These currents are a mix of alternating current (AC) and direct current (DC) and can cause stray current corrosion when metallic service pipes are connected to metallic mains.

Causes of Stray Currents

Although the American Water Works Association (AWWA) opposes the policy of grounding electrical circuits to pipe systems that convey drinking water, it is still common practice to ground wires to water pipes. Compounding the issue, the National Electrical Code still calls for grounding a building's electrical system to a combination of electrodes including metal water pipes. By grounding electrical circuits to water pipes, service pipes and water mains become part of the electrical path for AC and DC currents.

Faults in the grounding system can cause large portions or even all of the current to flow through the water pipes to the earth.

If several buildings receive electricity from a common transformer, the water pipes can become a conductor between the buildings served by the transformer. This results in stray currents flowing through the services and mains that connect the buildings.

Stray currents are often found on water pipes in the general vicinity of electric railway tracks and near cathodic protection systems used to protect gas mains. Stray electrical currents can occur wherever metal water pipes coexist with an electrical system.

Background

In 1995, the American Water Works Association issued a revised policy recommending the isolation of metallic service lines from metallic mains. The AWWA also advised against the common practice of grounding electrical utility services to water pipes in buildings. Electrical systems had been grounded to water pipes for years without apparent issue; however, this was before the proliferation of solid-state electronic equipment that resulted in an acceleration of the corrosion process.

Electrical utilities supply power in the form of alternating current. The corrosion that occurs on water piping as a result of AC stray currents occurs slowly, but the aforementioned introduction of solid-state electronics in the 1950s and '60s changed stray currents from primarily AC to a mix of AC and DC. Electronics produce direct current from the AC supplied via utility lines. Some of this direct current finds its way back into the utility's wiring system and ultimately shows up on water pipes in the form of a measurable mix of AC and DC stray currents. Although both AC and DC components are associated with shock hazards and water quality issues, it is the DC component of stray currents that has been proven to increase the effects of corrosion.

While "hot soils" are generally considered to be the primary factor in the corrosion of water pipe systems, it should be noted that water systems may also be experiencing accelerated rates of water main corrosion because of the effects of stray currents. "Hot soils" are those that contain ingredients which cause metal pipes to prematurely corrode and deteriorate.

The wrapping or bagging of a metal pipe is a common way to protect the pipe from hot soil conditions, but wrapping or bagging that is incorrectly applied or that has been compromised may actually accelerate the corrosion process at breaks in the protection. Soil-related corrosion occurs at a fairly constant rate; however, the rate of corrosion from stray currents increases as the currents increase, so the stronger the amperage (current flow), the faster the rate of corrosion (See Table 1). The presence of strong stray currents may significantly shorten the expected service life of a piping system based solely upon soil conditions.

Even if there is no visible evidence of corrosion on pipes, stray currents may still pose a threat to the quality of tap water. These stray currents result in "blue water," caused by the presence of copper compounds, or traces of lead.

Stray currents may also create a potentially serious shock hazard for water sector personnel working on service lines, particularly if a line is broken or a curb valve is replaced. In some cases, stray currents may be strong enough that merely touching the service line could be hazardous. Meter changeouts can be dangerous if metallic yokes or grounding straps are not in place as the meter is removed.

The Galvanic Corrosion Process

According to the Institute of Electrical & Electronics Engineers (IEEE) regarding electrical grounding and corrosion, "The effect of the grounding installation on corrosion must be considered. Systems, equipment and lighting sometimes unknowingly contribute to galvanic corrosion of underground conductors, structures and piping. Galvanic corrosion is caused by electrically connected dissimilar metals which form a galvanic cell."

If copper piping is connected to an iron main, the physical characteristics of the different metals cause one to corrode sacrificially while the other metal remains comparatively unaffected. Which metal corrodes and which is unaffected depends on the relative position of each metal on a scale called the "galvanic series." **(See Figure 1)**

Zinc is closer to the "corrosion" end of the galvanic series than iron or steel, so it is commonly used to protect those metals; zinc corrodes sacrificially to protect iron and steel.

In the case of iron and copper (and copper alloys such as brass or bronze), iron is closer to the "corrosion" end of the galvanic series so it will corrode sacrificially to protect copper or its alloy. For this reason, most of the corrosion in a water system will occur on iron mains.

Figure 1: **The Galvanic Series of Metals**

Most Reactive
Potassium
Sodium
Calcium
Magnesium
Aluminum
Carbon
Zinc
Iron
Tin
Lead
Hydrogen
Copper
Silver
Gold
Least Reactive

Shock Hazards

As previously defined, stray currents are a flow of electricity in a metal piping system. This flow is similar to an electrical circuit supplying electricity to a light bulb. If the circuit is broken, the electricity stops flowing; but if both ends are touched, a person may receive a shock. A person may also receive a shock by touching only the "hot" wire, as a path is created from the wire through the body to the earth. **(See Table 2)**

A comparable situation can occur if a metallic service line is broken or if a curb stop or meter is removed from the line, creating an open circuit in effect. If sufficiently strong currents are present and a worker touches the pipe ends, a shock might be received that is serious enough to cause a medical emergency. Under some conditions a worker might receive a serious shock just by touching the pipe in one place, similar to touching a "hot" wire.

Normally a meter changeout should not create an "open circuit" situation as long as a metallic yoke or ground strap bridges the gap left by the meter, and the yoke or strap is making good electrical contact with the service piping. Even then the "hot" wire-type situation may exist.

Tests have shown that the flow of stray current through water within a pipeline is negligible; water is a poor conductor of electricity, and mineral coatings that form within some pipelines tend to provide some insulation. However, stray currents may flow through some soils quite easily. To prevent stray currents from jumping around the insulator through the soil, it is important that insulated fitting be wrapped according to the ANSI/AWWA C209 Standard for Cold Applied Coatings.

Table 2: **Effects of Electrical Current in the Human Body**

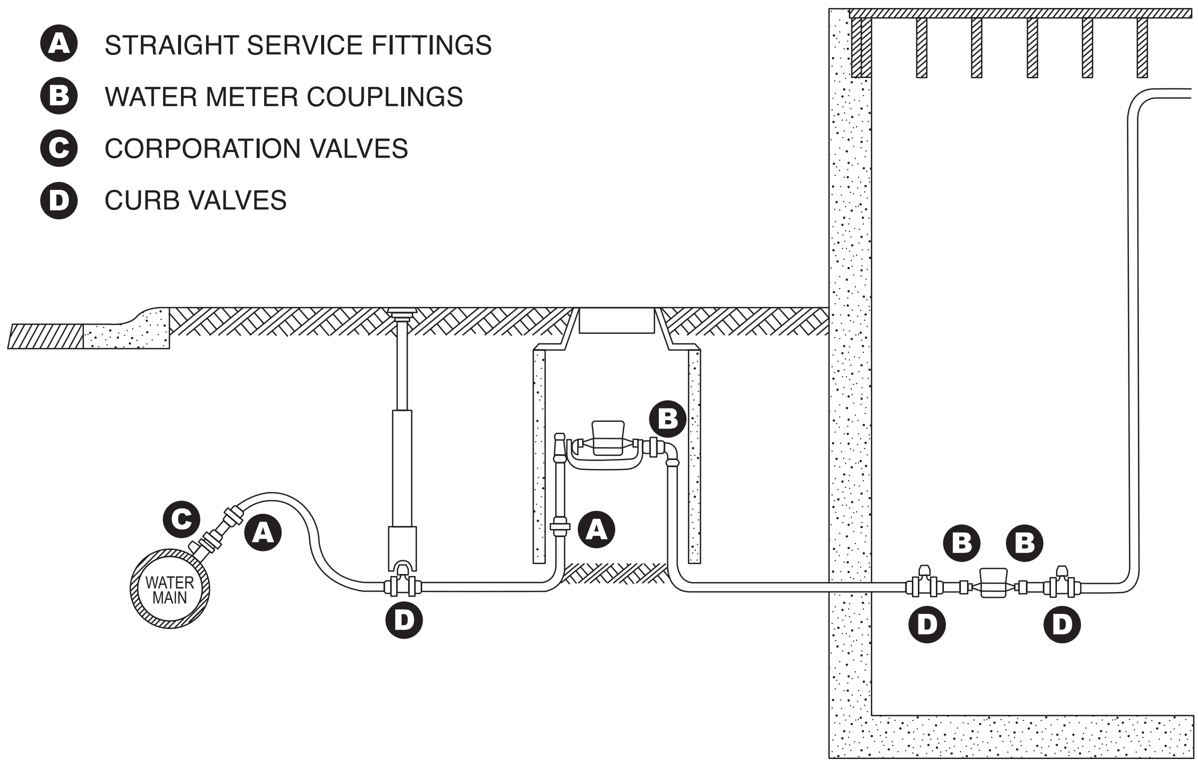
Current	Reaction
Below 1 Milliampere	Generally not perceptible
1 Milliampere	Faint Tingle
5 Milliampere	Slight shock felt. Not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6 to 25 Milliampere (women)	Painful shocks. Loss of muscle control.
9 to 30 Milliampere (men)	The freezing current or "let go" range. If extensor muscles are excited by shock, the person may be thrown away from the power source. Individuals cannot let go. Strong involuntary reactions can lead to other inuries.
50 to 150 Milliamperes	Extreme pain, respiratory arrest, severe muscle reactions. Death is possible.
1.0 to 4.3 Amperes	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur. Death is likely.
10 Amperes	Cardiac arrest, severe burns, death is probable.

Cost-Effective Control of Stray Currents

Mueller® insulated products, in effect, "open the circuit" so that AC and DC electrical currents cannot flow between the copper service piping and the iron main. A Mueller insulated product can be placed at many locations along the service line depending upon where meters, valves and other fittings are located and where the fitting will best protect personnel from any potential shock hazard.

In addition to using a special nylon material as an insulator, Mueller Co. designed its insulated service products to place components in compression as opposed to placing the insulating joint in shear. These engineered insulated service products also utilize bronze components to absorb the tensile, shear and bending forces commonly found in service lines. The design of Mueller Co.'s insulated products has proven reliable; it is based on a technology that Mueller Co. invented and introduced to the natural gas industry more than 50 years ago.

TYPICAL LOCATIONS FOR INSULATED PRODUCTS



A variety of Mueller products offer the insulating feature, including corporation and curb valves, couplings, unions, and meter connections. The decided cost benefit of using Mueller insulated products is the ability to retrofit existing copper service lines. Changes to installation service practices are minimized, re-training of installation service personnel is reduced, and the need to revise specifications is decreased. Existing copper services can be retrofitted in many cases by simply adding a Muller insulated coupling to the existing corporation, curb or meter valve. Any required excavation is minimal, determined only by access to the three-to-six feet of service pipe needed to perform the mandatory wrapping of the pipe in the area of the insulator.

Summary

Although the incidence of the more corrosive form of stray currents (DC) in water piping systems has increased, a practical means of reducing their potentially dangerous and costly effects is available in the form of Mueller insulated products. Proper wrapping techniques of affected service piping in the area of the insulator is also required to protect water quality, preserve the integrity of the water piping system, and ensure the safety of water sector personnel.

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About Mueller Company

Mueller Co., LLC is a subsidiary of Mueller Water Products, Inc. (NYSE:MWA), a leading manufacturer and marketer of products and services used in the transmission, distribution and measurement of water in North America. Our broad product and service portfolio includes engineered valves, fire hydrants, metering products and systems, leak detection and pipe condition assessment. We help municipalities increase operational efficiencies, improve customer service and prioritize capital spending. Visit us at muellercompany.com

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