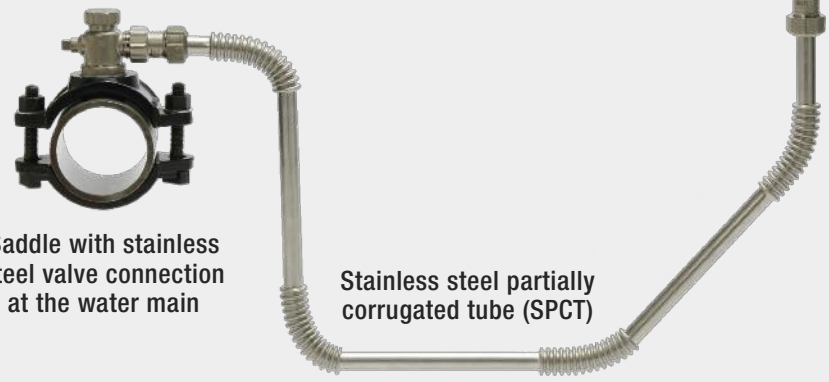
INTERNATIONAL MOLYBDENUM ASSOCIATION
THE VOICE OF THE MOLYBDENUM INDUSTRY

Better service lines with moly

Almost nothing is more important than water. Yet, water transmission systems worldwide lose billions and billions of liters of water a year to leakage. The solution to reducing this leakage is multifaceted but replacing existing service lines with molybdenum-containing stainless steel has proven highly successful.

On average, municipal water distribution systems lose a third of their treated supply to leakage, and many lose well over half. This leakage wastes billions of dollars each year in resources and makes communities worldwide vulnerable to drought and water scarcity. For instance, earlier this year in the US state of Arizona, lawmakers announced they will begin limiting building permits for new construction around the city of Phoenix due to lack of water. A four-year moratorium on building permits across southern France also went into effect this year because of drought.



"Climate change is set to increase pressure significantly on people's access to water and sanitation unless governments do more to prepare key infrastructure now" – the United Nations

Although methods for finding and fixing leaks are improving steadily, many are too small to locate. These tiny leaks often waste clean drinking water for years on end. Identifying and repairing leaks places stress on water utility resources, which are already stretched to meet other competing priorities. For areas with growing populations, drought or dwindling resources, leakage can reduce their resilience during times of crisis and affect whether there's enough water for continuous service.

Water-stressed areas serviced by municipal systems employ various techniques to preserve their precious supply – from recycling storm and wastewater to limiting plant watering, car washing, and even residents' bathing times. But what if these systems could reduce the loss of the water they are already paying to treat and distribute? Some utilities report that 95% of all leaks occur in the last few meters of distribution, in the service lines that connect water mains to individual buildings. Could replacing service lines with "better" materials be the answer to preventing water leakage?

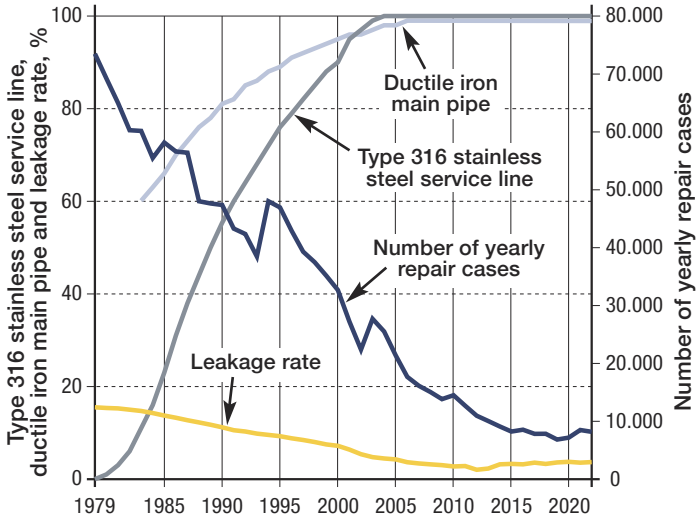
Stainless steel service lines: the beginnings

Tokyo was the world's first city to become aware of the difference a dramatically better material can make. Facing strong population growth and limited water supply, the Tokyo Bureau of Water Works (TBWW) decided to tap into its existing resources by eliminating leakage. TBWW wanted a strong, ductile, hygienic tube that could resist near-daily earthquakes with minimal upkeep. In 1980, after years of research, Tokyo began replacing its lead service lines with Type 316 stainless steel tubes.

In the 1990s, the stainless steel tubes were improved by adding several sets of folds, known as corrugations, allowing hand bending. This flexibility reduces the number of fittings needed for many installations and increases resistance to ground movement and seismic activity. The product is known as stainless steel partially corrugated tubing, or SPCT.

More than 40 years since the project began, and with 100% of the service lines under its jurisdiction replaced with Type 316 stainless steel by the early 2000s, Tokyo has massively reduced leakage and maintenance needs. Together with ductile iron mains, leak detection, and rapid repair techniques, the leakage rate decreased from 15.4% in 1980 to 3.7% in 2022. Most of the remaining leaks are caused by tubes of other materials, for example, under private roads, where TBWW did not have the

Repair cases and leakage rate in Tokyo (source: TBWW).

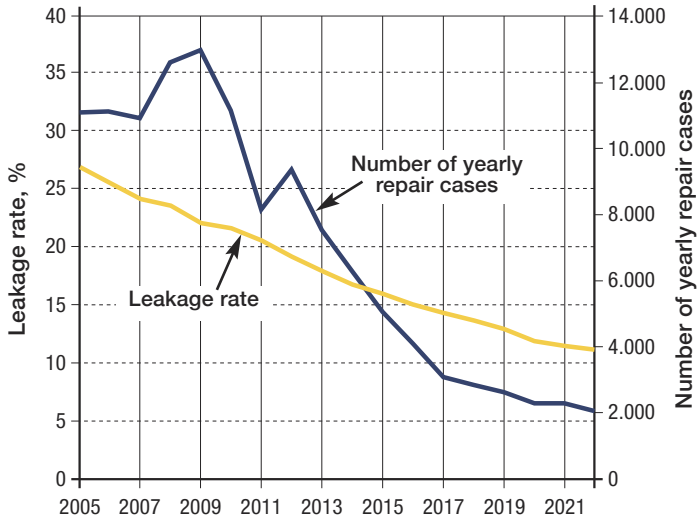


jurisdiction to install stainless steel lines. Overall, Tokyo documented a 90% reduction in repair cases since 1979, saving hundreds of millions of USD annually.

The capital of Taiwan, Taipei, has also achieved great results with SPCT. In 2002, the island suffered a severe drought that depleted its water reserves, resulting in 49 days of intermittent supply. Intermittent supply, where water use is restricted to certain hours of the day or week, risks public welfare and health and can damage the water distribution system.

Taipei's system leaked 28% of its water at the time. Looking for ways to increase its resilience, the Taipei Water Department (TWD) trialed stainless steel service lines,

Repair cases and leakage rate in Taipei (source: TWD).



given their superb performance in several Japanese cities and Seoul, South Korea. Following successful testing, the utility began installing SPCT in 2006 as part of a 20-year leakage reduction project. As of 2022, with 2/3rds of the system replaced with stainless steel service lines, leakage has more than halved to 11%. When a more severe drought overcame Taiwan in 2014, Taipei had no disruption to service, and TWD could even sell surplus water to their neighboring utility. Additionally, over the past four years, TWD had on average only 20 leakage cases/year related to the nearly 200,000 stainless steel service connections installed by now, an order of magnitude fewer than typical with competing materials.

What other materials are available for service lines?

Service lines are made from several materials, including plastics, copper, galvanized steel, and formerly lead. Among these, plastic tubing has enjoyed significant market growth due to its light weight, flexibility and low upfront material cost, jockeying to become the dominant material for system upgrades worldwide. However, the properties of plastics for water distribution, like high-density polyethylene (HDPE) and cross-linked polyethylene (PEX) differ from manufacturer to manufacturer and even from product batch to product batch. While formulations are continuously improving, this variation makes an accurate forecast of service life difficult. Despite a commonly stated durability of 50 years, premature failures occur frequently. They are often attributed to embrittlement and subsequent cracking caused by exposure to chlorinated water from the inside of the tube or longitudinal cracks, initiated on the outside by punctual pressure of sharp rocks, if the tube is not carefully embedded in a thick layer of fresh granular backfill.

Areas with contaminated soil, like former industrial sites, cannot use plastic pipes because it is susceptible to the penetration of harmful hydrocarbons like gasoline, which can contaminate the water supply. Herbicides and biocides can also migrate through the wall. Some plastic tubing, such as PVC, is outlawed in certain areas due to its high permeability. Service lines installed close to the surface or above ground can melt during a wildfire or burst during a freeze. Plastics also are less effective for identifying leaks with acoustic signatures and vibrations, as sound propagation is suppressed in these materials.

Copper is another popular material for service lines in some regions. Generally, copper tubing performs well and lacks many problems associated with PEX and other plastic tubing. However, some soils and waters react with copper and produce premature pitting, which results in hard-to-find pinhole leaks. Stainless steel offers the best strength, flexibility, longevity, and corrosion resistance for service lines. Inherent material ductility combined with corrugations means the tubing resists earthquakes, soil settling, traffic movement, and bursting during a freeze. SPCT is nearly three times as strong as copper and many times stronger than PEX.

Strength comparison

	Yield strength (annealed)	Ultimate tensile strength (annealed)
Type 316 stainless steel	205 MPa	515 MPa
Copper	70 MPa	220 MPa
Plastic (PEX)	19.3 MPa	26 MPa

Non-reactive: critical for hygiene and corrosion resistance

Stainless steel is prevalent in the food, beverage, and pharmaceutical industries because of its inertness. The combination of chromium from within the stainless steel with oxygen in the air forms a passive layer on the stainless steel surface, preventing any reaction with external media and avoiding corrosion. The result is a practically non-reactive material, safe for long-term contact with various potable liquids.

Although all stainless steels have an inert passive layer, different alloys offer different levels of corrosion resistance. Tokyo and Taipei use Type 316 stainless steel for their service lines, an austenitic alloy containing 2% molybdenum that resists corrosion associated with chlorinated municipal waters and a wide variety of soils. In 10-year buried tests of various kinds of metal tubes, this alloy performed best at ten different test sites across Japan, some with very high chloride and sulfate concentrations.

Type 316 stainless steel service lines are more expensive than plastic lines and sometimes more expensive than copper – or so it seems. There are several reasons why the upfront material cost is not representative of the true cost: Materials are only a fraction of the total installation costs, which include digging trenches, backfilling around the tube with fresh aggregate and resurfacing the road. Some utilities require a protective outer tube to avoid puncturing by stray rocks. Corrugated stainless steel tubing is fitted similarly to copper or PEX lines, but installation is generally

quicker, reducing labor costs. Thanks to its durability and longevity, stainless steel's maintenance and replacement costs are drastically reduced compared to competing materials. That also means fewer repairs, which often require road closures and movement of heavy vehicles, all of which stress the environment and people. Finally, saving water is not only a financial benefit, but with the accelerating effects of global warming, it also improves the resilience of water systems and reduces the pressure on an increasingly scarce resource.

SPCT finds new markets

SPCT has demonstrated that it can eliminate severe water loss and high maintenance burdens and protect against seismic activity and drought. Italy has both seismically active and drought-stricken regions serviced by degraded systems in many cases. Concern over water scarcity following years of low rainfall resulted in calls to upgrade the country's aging water distribution systems.

Over the last year, six Italian water authorities have tested SPCT and four utilities are currently evaluating the next step: "proof of concept" trials with several hundred SPCT connections. A supply chain is in place to service the market initially with imports until the demand is high enough for local production. Indeed, CPC Inox, the prospective Italian SPCT producer, received the BFWE Innovation Award for Materials at the H_2O trade fair in Bologna this fall.

A regional supply chain is also developing in Zhuhai, China, where a factory is now producing SPCT for both the local market and exports. Official guidelines were published for installers to support adoption of the technology. SPCT was also highlighted during a presentation at a prominent water conference with industry experts and decision-makers from across the country present. Several Chinese utilities, as well as Australian water authorities, are in the process of evaluating potential trials.

Stainless steel for service lines is not expensive; depending on the location, it adds only 10 to 20% to the initial project cost. Over an anticipated 100-year service life, savings from reduced maintenance repair cases, leakage, and energy usage easily afford stainless steel service lines a lower cost of ownership than competing materials. SPCT is also fully recyclable at the end of its life. As governments and organizations reconsider their water efficiency practices, stainless steel provides an unprecedented opportunity for more long-lasting, resilient, and sustainable distribution systems. (Karlee Williston)

› **A trial installation in Italy.**