Condominium Home Owners Association
A non-profit association serving strata owners since 1976
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Headline: **Corrosion of Copper Water Pipe in the Lower Mainland**
Common Property Requires Mutual Responsibility – Be Informed

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Greater Vancouver's water is naturally acidic (low pH) and lacking in dissolved minerals (soft). These properties result in water that is aggressive or corrosive to metal plumbing and fixtures. The water distributed from the Greater Vancouver Regional District (GVRD) and throughout municipal systems behaves as a solvent and leaches copper from pipes. This is in fact the cause of blue-green staining of porcelain sinks, bath tubs, laundry and sometimes hair. This continued dissolution however has much more insidious consequences, that being the reduction in service life and leakage of copper pipe.
Large buildings such as apartments and condominiums with hot water recirculation systems are particularly susceptible to early corrosion related copper pipe failures, and are commonly known to require complete retrofitting 12 to 15 years after construction. This is a non-compensible circumstance from an insurance point of view and inevitably becomes work financed by a Strata's maintenance fund or special assessment.

Despite the GVRD's current and future efforts to commission pH level adjustment systems (corrosion control), workmanship and design can contribute to the early demise of copper pipe water distribution systems in large buildings and thus, GVRD's new Capilano and Seymour water treatment schemes should not be relied upon to eliminate the challenges associated with our abundant and unique water.
This article discusses some of our experiences with leaks in copper pipe water distribution systems. It is intended as a source of information which might aid owners in managing concerns related to this specific industry.

EXPLANATION OF CORROSIVE WATERS

Fig 1 – Rubber hose clamped on a leaking cold bend in copper pipe (tubing). The leak was so pervasive that a funnel was installed to remove the water drip. This is not long-term management of copper tube corrosion. The GVRD derives the water supplied primarily from reservoirs associated with the Capilano, Seymour and Coquitlam

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watersheds. In this regard, the GVRD accesses an abundance of rainfall and retains surface waters in primarily granitic basins for relatively short periods of time prior to treatment and distribution. Whereas well waters in contact with limestone would tend to dissolve carbonates, the GVRD's water supply is considered extremely soft or low in dissolved minerals. In addition, dissolved gases contribute to the aggressiveness of the water. Near saturation levels of dissolved oxygen contribute to corrosivity of metals (oxygen supports the cathodic reaction in a metallic corrosion cell). Moreover, comparatively high levels of dissolved carbon dioxide tend to depress the pH of water due to the formation of carbonic acid. Some additional depression of pH may occur because of chlorination for disinfection. The pH scale refers to a measure of acidity or alkalinity of a substance. The scale ranges from 0 (maximum acidity) to 14 (maximum alkalinity). The aesthetic objective (A.O.) for drinking water is pH of 6.5 to 8.5. The A.O. specifications are subjective limits that may affect the acceptance of water by consumers but exceeding A.O.'s do not present health hazards. The pH of GVRD's water has historically ranged from 6.0 to 6.3 and is frequently measured at less than 6.0.

Soft, acidic waters are aggressive to copper; they literally have the ability to dissolve copper and retain the metal ion in solution. Whereas hard waters would tend to precipitate solids on the interior surface of a copper tube and thus shield the copper from dissolution, the GVRD's potable water tends to continuously strip oxides of copper from the wetted surface. Minor surface variations exacerbate this effect and result in localized corrosion or pitting. Pitting to perforation is the most common form of attack that results in leaks in copper pipe in the Lower Mainland

FACTORS WHICH CONTRIBUTE TO LEAKS

Although the complexity of water chemistry and the resultant degradation of copper due to corrosion are fundamental contributors to the reduction of copper piping service life, other factors, broadly characterized as design or workmanship, can impact longevity.

Design

Erosion-corrosion failures typically occur due to the use of pipe with too small a diameter. The elevated velocity of water in the distribution system tends to continuously scour the surface and accelerate thinning, especially at changes in direction. Erosion-corrosion may also occur when operating conditions are changed, for instance when larger pumps and hence greater flows are added to an existing system. A user may enjoy the increased "performance" of a modified system, however the reduction in service life implication may be unknown to the user/owner.

Corrosion-fatigue is a phenomenon whereby cracks in the copper tubes propagate because of cyclic loading. This progressive fissuring is dramatically accelerated by the simultaneous activity of corrosion. Corrosion-fatigue is a very common problem in recirculating hot water systems due to the heating and cooling (expansion and contraction) combined with:

- the use of short, rigid branch lines from risers
- the lack of properly designed expansion loops or offsets
- missing, loose or improperly installed riser clamps
- the lack of water hammer arrestors.

All of the above factors can contribute to repeated movement, most commonly due to the expansion and hence elongation of tubing when it warms while transmitting hot water. If the expansion/elongation is not accommodated or restrained, flexure about elbows in the pipe advance cracks through the pipe wall.

Fig 2 – Copper pipe wall in section. Typical corrosion fatigue cracks extending from corrosion pits on the internal diameter. Magnification approximately 65 X.

Workmanship

The demise of a copper pipe water system can also be related to issues of installation and workmanship.

Burrs created by the cutting operation on the inside diameter of tubing which are not removed by reaming tend to upset the smooth flow of water in the copper piping. The interruption of smooth flow can result in localized turbulence, the consequence of which can be erosion-corrosion thinning.

The use of excessive flux must be avoided in the course of installation. Soldering flux is a chemically active, corrosive substance utilized to promote wetting of the surface to be joined with solder. Excessive flux typically results in puddles, runs or deposits on the inside of the tubing and promotes an undesirable chemically active surface where corrosion and pitting initiate.

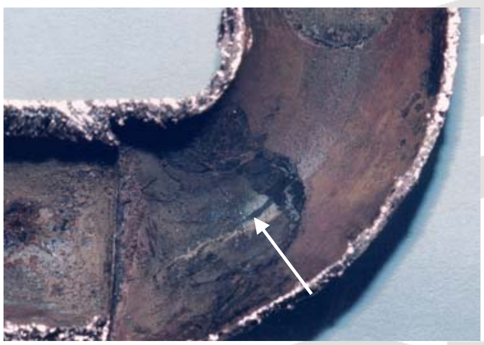

Fig 3 – Close-up view of crack (see arrow) which initiated in residual flux puddle.

In a similar vein, overheating of petroleum or organic base fluxes can result in carbonaceous films formed adjacent to the joint. Carbonaceous films and heavy oxide layers from overheating tend to be noble with respect to copper, that is, they promote corrosion of the copper around them due to galvanic action. The so-called galvanic cells which may be formed between the carbon or oxide (cathode, noble) and the copper (anode, active) result in corrosion penetration.

DISCUSSION

Particular challenges concerning the distribution of water in condominiums versus single, stand-alone dwellings exist. The long risers, branch-runs and continuously recirculated hot water systems used in condominiums mean that the forty-year or more service life of copper tube in single dwellings is not attainable. Service life as short as 5 to 9 years and more typically 12 to 17 years are consistent with Levelton's experience.

No engineered material is impervious to degradation and in the writer's opinion, replacement with copper is preferred to replacement with polymeric materials. Much of the dislocation associated with re-piping is the extent of intervention necessary to complete the job. Buildings are not engineered for re-piping and often new pipe chases are constructed which can have adverse sound transmission or fire code compliance implications. Due to the fact that re-piping facilities has been a $10 million per year industry in the past, strata and owners are compelled to participate in planning for re-piping. Awareness is an important tool in this regard and engineering advice can help. While a corrosion engineer may aid in establishing condition and remaining service life, a mechanical consultant will benefit the outcome of re-piping. Provincial resources and compliance with the B.C. Plumbing Code alone are not enough to ensure a desirable outcome.

Just as maintenance and preservation of a complex requires perspective, so does management of the water distribution. It is recommended that:

- Water leaks and samples removed at the time of repair be preserved and documented for future study. The leak history of a complex will be most telling as to the decision to re-pipe.
- A corrosion consultant be employed to ascertain the condition of the piping and develop a sound basis for re-piping, if necessary. Typically, an investigation strategy will sample more hot water pipes than cold.
- A mechanical consultant be utilized to administer a re-piping contract. A strata council cannot and should not expect themselves to be versed in all aspects of code compliance. Intervention of this nature should be monitored and managed to facilitate a better outcome.