
**Analysis of Copper Pipe Distribution System
at 1723 Alberni Street
Vancouver, BC**

Prepared for The Park
c/o Vancouver Condominium Services
Bunny Porteous

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Project Number: 20090605



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24th November, 2009

The Park
C/O Vancouver Condominium Services
#400 – 1281 West Georgia Street
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Attention: Ms. Bunny Porteous

**RE: Analysis of the Copper Pipe Distribution System at The Park – 1723 Alberni Street,
Vancouver, B.C.**

Dear Ms. Porteous,

Following our investigation of the plumbing system at The Park, located at 1723 Alberni Street in Vancouver, British Columbia, we are pleased to present our report. Our investigation involved testing of water samples collected at the building, destructive testing of a limited number of pipe samples, and a review of available historical data related to leaks. The Park is a 23-storey residential building located in Vancouver, B.C. The 23-story building contains a total of 150 suites. At the time of this report, the building is approximately 11 years old. The domestic water system consists of copper pipes for the mains and plastic piping for in suites.

This report outlines the following: a description of the existing plumbing system at The Park, a description of the typical causes of corrosion in Greater Vancouver, and a description of any problems specific to this building discovered through our investigation. A method of problem resolution is presented with our recommendations.

**Description of the Plumbing Distribution System at The Park – 1723 Alberni Street,
Vancouver, B.C.**

A typical water distribution system includes both hot and cold water supply pipes. Any building over 12 storeys will normally have separate pressure zones within the building because city pressure is usually inadequate for the entire system. In these cases a booster pump is used to obtain adequate pressure to all fixtures. The Park is twenty three storeys and has three zones.

The cold water supply system provides water at the temperature supplied by the city. The cold water piping system is laid out as follows: The mechanical room is located on the roof. The building has three zones: The first zone is the 3rd to the 9th floor, the second zone is the 10th to the 18th floor, and the third zone is the 19th to 25th floor. The main distribution floors are located at the 4th, 11th and 19th floors. The hot and cold water mains come down from the mechanical room on the roof to the main distribution floors. The main horizontal supply pipes then run in the ceiling of the main distribution floors to the risers. From these main lines, vertical risers run down the building, supplying water to the various fixtures of each suite in that zone. It is not possible with this type of pipe design to manually turn a single suite's water supply on and off at will.

The hot water system starts from the domestic hot water storage tank located on the roof mechanical room. Main horizontal supply pipes run alongside the cold water lines in the ceiling of the main distribution floors with vertical risers running down from the main lines through the building in each zone. The only difference between the hot and cold water systems is that the hot water lines are connected to return lines, which run back to the storage tank. Typically, a pump provides constant circulation of water from the hot water tank, through the horizontal pipe and then back through the return lines to the tank. This constant circulation maintains the temperature of the water in the supply pipes to provide hot water on demand. Without re-circulation or heating of supply lines, it could take up to five minutes of running a faucet to get hot water

Corrosion in a Typical Distribution System

For any water distribution system using copper pipes, the rate of corrosion is dependent upon four factors: the chemical composition of the water, the temperature of the water, the velocity that the water travels inside the pipes, and the presence of any electrolytic effects.

The chemical composition of the water is determined by the acidity (pH), the presence of corrosives (oxygen and chlorine), and the presence of any substance that may deposit on the inside of the pipe forming a protective layer.

One of the drawbacks of the glacial water from the Greater Vancouver reservoir is that the water is quite acidic. Glacial water also has oxygen present as would exist in an open water system.

The above factors make the drinking water in Vancouver very corrosive. Other parts of the country do not experience the same problem because most water systems are not as acidic and are not as "clear". In most other major cities, deposits of lime and other minerals build up on the inside of the pipes and form a protective layer. In Vancouver, domestic water pipes dissolve from the inside causing a gradual thinning of pipe walls.

The temperature of the water is also important. Corrosion is a chemical reaction: the higher the temperature of the medium, the faster the rate of corrosion. The effect is that hot water pipes

corrode faster than cold water pipes.

The velocity of the water inside the pipes is important in two ways. High velocity water causes increased friction inside the pipe and any dissolved solids will scour the pipe wall. This causes a general wearing away and thinning of pipe walls. Another consideration is that as high velocity water travels around bends and discontinuities in the pipe, changes in pressure are created. A large enough change in pressure will cause cavitation (water vapour bubbles forming in the pipe). The effect of cavitation is noisy pipes and more importantly, an increase in the rate of pitting of the pipe wall. Cavitation will occur at lower velocities in hot water. The overall effect of a higher velocity of water flow is an increased rate of corrosion.

A final consideration is that of electrolytic effects. If two dissimilar metals are in contact with each other in a water solution, a "wet-cell" battery is created and an electric current flows; while deposits form on one of the metals, the other metal dissolves. Unfortunately, the electric potential of iron and copper is such that if iron (or steel) is in contact with copper piping, the copper will dissolve. Steel contacts copper pipe at pumps, hangers, wall studs, or wiring conduits.

Of the four factors that affect the corrosion rate, two of them cannot be altered; chemical composition and water temperature. The chemical content of the water is determined by the Greater Vancouver Regional District (GVRD). Treating the water as an end-user is possible; however, permission must be gained from every resident in the building prior to its installation. Experience has shown that this permission is difficult to obtain. The second unalterable factor is the temperature of the hot water. This is governed by what is expected from the users as "hot" water. Generally, the set point of the hot water tank must be maintained between 130°F and 140°F to avoid complaints.

The other two factors that affect corrosion rates, velocity of the water and electrolytic effects, can be minimized by a proper design. Dissimilar metal contact can be avoided by using plastic or copper pipe hangers or by insulating non-copper pipe hangers and wires from direct contact with copper pipes. Installing dielectric unions to isolate steel fittings from the copper system will also mitigate corrosion caused by contact of dissimilar metals. The velocity of the water can be decreased by enlarging the size of the distribution pipes.

Although corrosion of copper pipes is presently a common problem in Vancouver, a proper design can minimize the factors contributing to the accelerated corrosion rate and thus give the new system an extended life expectancy.

Water Testing at The Park – 1723 Alberni Street, Vancouver, B.C.

Six water samples were taken from Suites 701, 1102, 1405, 2005, 2507 and the common room at The Park. The following results were obtained:

Table A-1. Copper and PH Content in Water From Suite #701(mg/L)

	Copper Content (mg/L)	pH
"Standing" Hot Water (unflushed)	0.1	6.5
"Direct" Hot Water (flushed)	0.05	6.0
"Standing" Cold Water (unflushed)	0.3	6.5
"Direct" Cold Water (flushed)	0	6.0

The average pH of the above samples was 6.25

The average Copper Content of the above samples was 0.11 mg/L

Table A-2. Copper and PH Content in Water From Suite #1102 (mg/L)

	Copper Content (mg/L)	pH
"Standing" Hot Water (unflushed)	0.1	6.0
"Direct" Hot Water (flushed)	0.3	6.0
"Standing" Cold Water (unflushed)	0.1	6.0
"Direct" Cold Water (flushed)	0	6.0

The average pH of the above samples was 6.0

The average Copper Content of the above samples was 0.13 mg/L

Table A-3. Copper and PH Content in Water From Suite #1405 (mg/L)

	Copper Content (mg/L)	pH
"Standing" Hot Water (unflushed)	0.1	6.0
"Direct" Hot Water (flushed)	0.1	6.0
"Standing" Cold Water (unflushed)	0	6.0
"Direct" Cold Water (flushed)	0	6.0

The average pH of the above samples was 6.0
The average Copper Content of the above samples was 0.05 mg/L

Table A-4. Copper and PH Content in Water From Suite #2005 (mg/L)

	Copper Content (mg/L)	pH
"Standing" Hot Water (unflushed)	0.1	6.0
"Direct" Hot Water (flushed)	0	6.0
"Standing" Cold Water (unflushed)	0	6.0
"Direct" Cold Water (flushed)	0	6.0

The average pH of the above samples was 6.0
The average Copper Content of the above samples was 0.03 mg/L

Table A-5. Copper and PH Content in Water From Suite #2507 (mg/L)

	Copper Content (mg/L)	pH
"Standing" Hot Water (unflushed)	0.3	6.5
"Direct" Hot Water (flushed)	0	6.0
"Standing" Cold Water (unflushed)	0.1	6.5
"Direct" Cold Water (flushed)	0	6.0

The average pH of the above samples was 6.25
The average Copper Content of the above samples was 0.1 mg/L

Table A-6. Copper and PH Content in Common Room (mg/L)

	Copper Content (mg/L)	pH
"Standing" Hot Water (unflushed)	0.1	6.0
"Direct" Hot Water (flushed)	0.1	6.0
"Standing" Cold Water (unflushed)	0.1	6.0
"Direct" Cold Water (flushed)	0.1	6.0

The average pH of the above samples was 6.0

The average Copper Content of the above samples was 0.1 mg/L

Note: Results shown in above table are based on the analysis of tap water samples taken by our firm. All values have an experimental error of +/- 0.2.

The levels of dissolved copper in the majority of the above samples were not found to be significantly high. To put these copper content readings in perspective, the maximum allowable level of copper in the "B.C. Drinking Water Quality Standards" is 1.0 mg/L, although it is not uncommon in Vancouver to find "stale" water samples showing copper levels above this range due to high levels of corrosion. High levels of dissolved copper often indicate an accelerated rate of corrosion, typically involving thinning of the pipe walls throughout rather than simply localized pitting.

It should be noted that the concentration of copper in the GVRD reservoir is typically in the range of 0.003 mg/L or lower. This means that virtually all of the copper measured in our tests was dissolved from the pipes inside the building (GVRD distribution pipes are not copper).

The pH levels shown confirm that the water is quite acidic, which makes the water corrosive.

Destructive Testing of Pipe Samples at The Park – 1723 Alberni Street, Vancouver, B.C.

Three samples of pipe were obtained for testing. The samples were collected by an independent plumbing company and location of the samples was chosen randomly. A description of the three samples that were provided is shown in Table B.

Table B. Description of Pipe Samples

Sample	Description/ Location	Hot/Cold	Pipe Diameter (inches)	Sample Length (inches)
A	4 th floor Cold Main	Cold	2½"	11"
B	4 th floor Hot Main	Hot	2½"	13"
C	4 th Floor Recirculation line	Hot	1½"	23"

Destructive testing involved both macroscopic and microscopic examination. Microscopic examination of the samples determines the nature of the pitting. For example, velocity related pitting generally due to undersized pipes leaves a specific signature or type of pit-shape.

Macroscopic evaluation of the pipes involves visual inspection of pipe samples measuring the wall thickness of the pipe at various locations, examining different types of failures (outside of pitting), checking for patterns of corrosion or scouring, and determining the number of pinholes in the sample.

The results of the examination are shown in Table C.

Table C. Summary of Results from Pipe Sample Examination

Sample	Hot/ Cold	Original Thickness (mm)	Wall Loss %	Penetration Pits/inch	Non Penetration Pitting - Description
A	Cold	2.05	1%	N/a	No significant pitting. Normal wear of pipe.
B	Hot	2.05	3%	N/a	No significant pitting. Normal wear of pipe.
C	Hot	1.52	3%	N/A	No significant pitting. Normal wear of pipe.

*Results shown in above table are based on the analysis of a half-pipe segment from each sample.
 Wall loss shown has an experimental error of +/- 5%.*

There were a limited amount of samples due to the difficulty of shutting down the domestic water system to obtain pipe samples. From the samples that we obtained there does not appear to be any significant pitting or erosion.

Thinning of the pipes can most often be attributed to the quality of workmanship during installation or is an indication of either scouring or dissimilar metals causing electrolytic corrosion. The level of thinning in the samples range from 1 percent to 3 percent wall loss. The average wall loss is about 2 percent which is not significant.

Historical Data at The Park – 1723 Alberni Street in Vancouver, B.C.

From the claim history provided and conversations with the Property Manager, Bunny Porteous, there have been two leaks in 2009, and an additional three leaks in the past five years. All the leaks occurred in suites. The costs associated for the three leaks prior to 2009 were over \$70,000. The cost of leaks in 2009 to date are not fully available as yet, but it is our understanding that they are in the hundreds of thousands of dollars.

General Assessment at The Park – 1723 Alberni Street, Vancouver, B.C.

A summary of the results of our analysis follows:

- ❖ None of the three pipe samples showed evidence of significant corrosion pitting or erosion.
- ❖ From the limited pipe samples, the copper mains appear to be in adequate condition for the age of the samples.
- ❖ The amount of thinning of pipe walls was not significant in the pipe samples. The level of thinning in the samples range from 1 percent to 3 percent wall loss. The average wall loss is about 2 percent.
- ❖ Dissolved copper levels show that the level of corrosion is not substantial at this time. The rate of copper dissolving will likely increase in the future.
- ❖ We were not provided any plastic piping during our assessment. All of the leaks that were reported to date occurred in suites. This may be due to the design or installation of the in suite plastic piping.
- ❖ The historic data indicated that there are only a few leaks in the past five years but the cost associated with each leak is substantial. This is mainly due to the damage to the interior finishes in the units as result to the leaks. The system is also very susceptible to leaks whenever the system is shut down for any leak repair. We experienced this while obtaining the pipe samples and the water system was shut down. The cost for the repair of leaks may justify a complete plumbing renovation. The plumbing renovation should be designed in a manner so that the system is more robust.

- ❖ Corrosion in copper piping generally follows a pattern of three phases: initial fluctuating leak frequency, followed by steady state (almost predictable) leak frequency; followed by the final stage of exponentially increasing leak frequency. This building's copper main lines are in the beginning stages of corrosion.

Recommendations at The Park – 1723 Alberni Street, Vancouver, B.C.

The system will experience leaks sometime in the future that will lead to the water system being shut down. As we experienced, the system being shut down may cause another leak that can cause substantial damage as it did in the past. Given the high cost of these leaks, an economic argument can be made to justify a replacement. The high cost of repairs is to some extent a result of the building layout and existing finishes in the suites.

In simple terms, our analysis shows minor corrosion in the main copper lines and the system at present is experiencing relatively infrequent leaks and can be expected to experience leaks at the same rate, slowly increasing in the future. The main lines will last approximately another ten years.

From the leak history it appears that the in suite plastic piping may be the more weaker part of the domestic water system. Consideration should be given to replace only the in suite plastic pipes.

It should also be noted that extraordinary circumstances might cause a large number of leaks all at once. There may be a pressure spike from the GVRD supply, large thermal movement of the building due to extreme temperature swings, or even a minor seismic event.

Cost Estimate

A complete domestic water pipe replacement scheme will likely cost in the range of \$750,000.00 including engineering fees. This figure can be made more accurate once some design decisions are made.

The cost of the leaks at present would easily economically justify the replacement of the system to avoid future leaks.

We trust this meets your requirements at this time, and should you have any questions or concerns, please contact our office.

Sincerely,

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