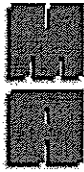

**Analysis of Copper Pipe Distribution System
at 1146 Harwood Street
Vancouver, BC**

Prepared for The Lamplighter – Strata Plan VR 178

Date: January 4, 2010
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4th January, 2010

The Lamplighter
1146 Harwood Street
Vancouver B.C.

Attention: Strata council

RE: Analysis of Copper Pipe Distribution at The Lamplighter – 1146 Harwood Street, Vancouver, B.C.

Dear Council Members,

Following our investigation of the plumbing system at The Lamplighter located at 1146 Harwood 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 review of the plumbing design and available historical data related to leaks. The Lamplighter is a 15-storey residential building located in Vancouver, B.C. The building contains a total of 115 suites. At the time of this report, the domestic water system is approximately 16 years old.

The investigation was requested following some recent pipe leaks. The owners were interested in the present condition of the plumbing system.

This report outlines the following: a description of the existing plumbing system at The Lamplighter, 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.

Description of the Plumbing Distribution System at The Lamplighter – 1146 Harwood 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 Lamplighter has 15 floors and is split into two zones but does not use a booster pump to obtain adequate pressure. The building uses the City's supplied pressure for the upper zone and uses a PRV (pressure reducing valve) to reduce the City's pressure for the lower zone.

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 in the parking level. The hot and cold water mains come up and have a horizontal supply to each level. The horizontal supply pipes run in the ceiling of each level. With this layout, each suite can be manually turned off.

The hot water system starts from the domestic hot water storage tank located in the parkade level mechanical room. Horizontal supply pipes run alongside the cold water lines in the ceiling of each floor.

In most buildings, the hot water pipes are connected to a hot water recirculation pipe and pump that allow the hot water to continually circulate through the building and maintain the water in the pipes as "hot". The Lamplighter does not use a recirculation system.

In this building the hot water lines have electric heat trace cable in direct contact with the outside of the pipe. This electrical heat tracing continually heats the pipes and keeps the water in the pipes hot so that the system can provide hot water on demand without having to drain off cold water in the pipes when turning on a hot tap.

It is important to note that the plumbing system at the Lamplighter was completely replaced approximately 16 years ago. As pipe systems corrode, they are eventually replaced in what is commonly called a "repipe project". As happened in the Lamplighter, all the supply pipes within the building were replaced to create a completely new domestic water pipe system.

The design for a repipe system is generally far more robust than what may be acceptable for new construction. Typically in new construction, a plumbing system will be adequate to meet code and no attempt is made to provide a prolonged life. The owner(s) involved in a repipe are usually more open to (or inclined to request) a more long term solution. This would involve requesting the designer to provide better materials and workmanship to assure a system that is better than what would be the minimum acceptable by code.

It is apparent that this more robust design methodology was attempted in the repipe design 16 years ago, as evidenced by the use of type K copper pipe. Type L copper is the minimum pipe wall size acceptable by code. Type K copper pipe is thicker walled than type L. The amount that it is thicker varies by pipe diameter used, but is in the range of 50 percent thicker. The only reason to use type K in this location would be to try to achieve a longer life.

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.

Without extensive testing, it is difficult to state which of the four factors is most important for a given building. What can be assumed is that the quality of the water in the Lamplighter (i.e. chemical composition) is virtually the same as that in similar buildings in the same area. The velocity that the water travels within the pipes is determined by code requirements and also would be similar to other buildings.

The remaining items to consider are the temperature of the water and electrolytic effects.

The temperature of the “hot” water must be maintained at a reasonable temperature (at least 130 F) to allow for what users consider “hot” as well as to minimize the risk of legionella bacteria growth. It must also be properly controlled to avoid the water becoming too hot, allowing potential scalding and an increased corrosion rate. One of the ways the water is heated (or maintained at a hot temperature) at the Lamplighter is through the use of the heat trace cable. As stated earlier, this is a relatively uncommon practice and may be a factor related to the corrosion rate and the life of the system.

Electrolytic effects usually involve dissimilar metals in contact with copper pipes inside the building. During our inspection we did not notice any dissimilar metal contacts in the areas of corrosion (leaks) and it is our opinion that this is likely not an issue in The Lamplighter.

Water Testing at The Lamplighter – 1146 Harwood Street, Vancouver, B.C.

Six water samples were taken from Suites #101, 307, 1102, 1405, 1503, and the laundry room. The following results were obtained:

Table A-1. Copper and PH Content in Water From Suite #101 (mg/L)

	Copper Content (mg/L)	pH
"Standing" Hot Water (unflushed)	1.0	6.0
"Direct" Hot Water (flushed)	0.1	6.0
"Standing" Cold Water (unflushed)	0.3	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 0.35 mg/L

Table A-2. Copper and PH Content in Water From Suite #307 (mg/L)

	Copper Content (mg/L)	pH
"Standing" Hot Water (unflushed)	0.3	6.0
"Direct" Hot Water (flushed)	0.1	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 #1102 (mg/L)

	Copper Content (mg/L)	pH
"Standing" Hot Water (unflushed)	0.3	9.0
"Direct" Hot Water (flushed)	0.3	9.0
"Standing" Cold Water (unflushed)	0	9.0
"Direct" Cold Water (flushed)	0	6.0

The average pH of the above samples was 8.25

The average Copper Content of the above samples was 0.2 mg/L

Table A-4. Copper and PH Content in Water from Suite #1405 (mg/L)

	Copper Content (mg/L)	pH
"Standing" Hot Water (unflushed)	1.0	6.5
"Direct" Hot Water (flushed)	0.3	6.5
"Standing" Cold Water (unflushed)	1.0	6.5
"Direct" Cold Water (flushed)	0.3	6.5

The average pH of the above samples was 6.5

The average Copper Content of the above samples was 0.65 mg/L

Table A-5. Copper and PH Content in Water from Suite #1503 (mg/L)

	Copper Content (mg/L)	pH
"Standing" Hot Water (unflushed)	0.6	6.0
"Direct" Hot Water (flushed)	0.1	6.0
"Standing" Cold Water (unflushed)	1.0	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 0.43 mg/L

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

	Copper Content (mg/L)	pH
"Standing" Hot Water (unflushed)	0.3	6.0
"Direct" Hot Water (flushed)	0.3	6.0
"Standing" Cold Water (unflushed)	0.6	6.0
"Direct" Cold Water (flushed)	0.6	6.0

The average pH of the above samples was 6.0

The average Copper Content of the above samples was 0.45 mg/L

Note: Results shown in above tables 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 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 in all the samples from each unit (except one) confirm that the pH levels measured are as would be expected in similar buildings and confirm our earlier assumption that chemical composition of the water is likely not an issue.

The samples from suite 1102 were found to be alkaline for three out of the four samples taken. This was an anomaly in the findings, and is likely related to the water storage tank inside that suite. Given the layout of the system, this anomaly does not affect the analysis and findings in the building as a whole.

Destructive Testing of Pipe Samples at The Lamplighter – 1146 Harwood Street, Vancouver, B.C.

Twenty-one 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 twenty-one 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	Line in hallway of 2 nd Floor outside Unit # 203.	Hot	1¼"	11"
B	Line in hallway of 2 nd Floor outside Unit # 203.	Cold	1-1/2"	11"
C	Line in hallway of 2 nd Floor outside Unit # 207.	Hot	¾"	16"
D	Line in hallway of 2 nd Floor outside Unit #207.	Cold	¾"	10"
E	Line in hallway of 7 th Floor outside Unit # 703.	Hot	1-1/4"	12"
F	Line in hallway of 7 th Floor outside Unit #703.	Cold	1-1/2"	16"
H	Line in hallway of 7 th Floor outside Unit # 707.	Hot	¾"	26"
I	Line in hallway of 7 th Floor outside Unit #707.	Cold	¾"	12"
J	Line in hallway of 7 th Floor outside Unit #705.	Hot	1"	22"
K	Line in hallway of 8 th Floor outside Unit # 803.	Hot	1-1/4"	15"
L	Line in hallway of 8 th Floor near Unit #803.	Cold	1-1/2"	14"
M	Line in hallway of 8 th Floor outside Unit # 807.	Hot	¾"	14"
N	Line in hallway of 8 th Floor outside Unit #807.	Cold	¾"	14"
O	Line in hallway of 15 th Floor outside Unit # 1503.	Hot	1-1/4"	8"

Sample	Description/ Location	Hot/Cold	Pipe Diameter (inches)	Sample Length (inches)
P	Line in hallway of 15 th Floor outside Unit #1503.	Cold	1-1/2"	8"
Q	Line in hallway of 15 th Floor outside Unit # 1507.	Hot	3/4"	9"
R	Line in hallway of 15 th Floor outside Unit #1507.	Cold	3/4"	12"
S	Main riser on 15 th Floor.	Hot	2"	9"
T	Main riser on 15 th Floor.	Cold	2.5"	10"
U	Main riser on 2 nd Floor.	Hot	3"	9"
V	Main riser on 2 nd Floor.	Cold	3"	14"

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	Hot	1.65	5	N/a	No significant pitting. Normal wear of piping.
B	Cold	1.83	3	N/a	No significant pitting. Normal wear of piping.
C	Hot	1.65	2	N/a	Small/medium sized shallow pitting occurring in a line on one side of the pipe. Accelerated corrosion on the exterior of the pipe where the heat trace was located.

Sample	Hot/ Cold	Original Thickness (mm)	Wall Loss %	Penetration Pits/inch	Non Penetration Pitting - Description
D	Cold	1.65	0.6	2	Small pits forming, early stage. Normal wear of piping.
E	Hot	1.65	2	N/a	One deep pit (through the pipe wall). A few small shallow pits formed throughout sample. Normal wear of piping.
F	Cold	1.83	3	N/a	No significant pitting. Normal wear of piping.
H	Hot	1.65	0.6	N/a	Small/medium sized pitting occurring in a line on one side of the pipe. Several pits are deep causing pin hole leaks. Accelerated corrosion on the exterior of the pipe where the heat trace was located.
I	Cold	1.65	5	N/a	No significant pitting. Normal wear of piping.
J	Hot	1.65	1	N/a	About 15 small pits throughout sample. A couple of the pits are deep and reach the other side of the pipe.
K	Hot	1.65	1	N/a	Accelerated corrosion on the exterior of the pipe where the heat trace was located. No significant pitting seen from the interior of the pipe.
L	Cold	1.83	0.5	N/a	No significant pitting. Normal wear of piping.
M	Hot	1.65	7	2	Small deep pits throughout sample causing several pin hole leaks. Accelerated corrosion on the exterior of the pipe where the heat trace was located.
N	Cold	1.65	2	N/a	No significant pitting. Normal wear of piping.
O	Hot	1.65	1	25	Small shallow pits forming, some of the small pits are combining to form larger sized pits.
P	Cold	1.83	4	N/a	No significant pitting. Normal wear of piping.
Q	Hot	1.65	1	N/a	Small/medium sized shallow pitting occurring in a line on one side of the pipe.
R	Cold	1.65	2	N/a	No significant pitting. Normal wear of piping.

Sample	Hot/ Cold	Original Thickness (mm)	Wall Loss %	Penetration Pits/inch	Non Penetration Pitting - Description
S	Hot	2.11	2	N/a	Many small shallow pits throughout half of sample. Erosion starting on the other half.
T	Cold	2.41	1	N/a	No significant pitting. Normal wear of piping.
U	Hot	2.77	0	N/a	No significant pitting. Normal wear of piping.
V	Cold	2.77	0.5	N/a	No significant pitting. Normal wear of piping.

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%.

Examination of the types of pits encountered determined that simple corrosion pitting (as opposed to pipe wall thinning) is evident in the majority of the samples. This is by far the most common type of pitting and is usually not related to water velocity. This confirms our earlier assumption (and the results of our review of the design drawings) that pipe sizing and water velocity are not an issue at the Lamplighter.

It should be noted that some degree of increased corrosion was noted on the pipes in the area where the heat trace cable was in contact with the pipe. This is likely due to the higher temperature in this location increasing the corrosion rate.

Other Observations

We were informed that corrosion and leaking had been noted adjacent to the metal connectors of the heat trace cable on the pipe. Our inspections could not verify this and we found no areas where metal connectors contacted the pipe. Please be aware however that we did not look at all pipes in the building and this condition may exist in areas we did not expose.

Information provided to us by the property manager indicated that there have been three leaks since last September (2008). The total cost of the repairs were approximately \$1,500. I understand there have recently been more leaks.

Three of the fifteen floors had localized increased rusting of the access panels. This is usually an indication of small leaks within the pipe chase.

General Assessment at The Lamplighter – 1146 Harwood Street, Vancouver, B.C.

A summary of the results of our analysis follows:

- ❖ Eight out of twenty-one pipe samples, thirty-eight percent, showed evidence of corrosion pitting.
- ❖ Dissolved copper levels show that the level of erosion is not critical at this time. The rate of copper dissolving will likely increase in the future.
- ❖ The historical data indicated the frequency of leaks would not warrant replacement at this time. However, leaks experienced to date will be typical of the continued deterioration of the system over the next few years, and their frequency will accelerate with time. It is our opinion that the existing level of corrosion and leaks is excessive for a repiped plumbing system of this age.
- ❖ As evidenced by the rust staining on the access panels, it is likely that some degree of pinhole leaks exist at various locations that are not severe enough at this time to be noticeable as leaks.
- ❖ Four out of the nine hot water line samples showed accelerated corrosion on the exterior of the pipe where the electric heat trace was located. This may likely reduce the life of the hot water pipes.
- ❖ Corrosion 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 has entered the stage of initial fluctuating leak frequency, it may enter the second stage quicker due to the accelerated corrosion noted earlier.
- ❖ We would estimate that the remaining useful life of the piping system is in the order of five to seven years.

It should 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.

Comments

Although the condition of the piping system is not critical at this time, there have been some leaks and these can be expected to continue.

Our firm has been involved in hundreds of repipe designs and installations since 1986 and we are not aware of any of our repiped buildings that have yet experienced significant leaks.

Based on our experience, the system seems to be failing prematurely. The only significant difference we noted with this system as compared to a more conventional re-piped system is the use of the heat tracing.

The use of heat tracing has been used by some designers in Vancouver in an attempt to decrease the rate of corrosion by eliminating the constant water circulation. It has been our opinion that a properly designed and installed recirculation system will adequately reduce the effects of erosion so that there would be negligible advantages in eliminating the flow of water required by recirculation.

Our examination of the pipes taken from the Lamplighter indicates that increased corrosion has occurred at the location of the heat trace cable. It is reasonable to assume that the increased temperature in this area is the likely cause.

Further testing can be carried out to determine the actual temperature of the pipe surface at the heat trace cable contact point. The resultant increase in corrosion and/or the theoretically predicted change in the expected life of the system would involve analysis by a specialist in metallurgy and/or chemistry and is beyond the scope of this report.

Please note however that to operate properly, the cable must be maintained at a temperature higher than that of the water within the pipe. Given this, if both a recirculation system and a heat trace system were optimally designed to maintain a specified temperature of water in the pipe, the heat trace system will have localized areas of the pipe that are at a higher temperature and a resultant higher localized corrosion rate.

In simple terms, although eliminating flow will decrease the rate of corrosion, the increased temperature required may have offset the advantages and actually decreased the life of the system.

I should note that there may also be other factors as yet unknown that may also be contributing to the shortened lifespan of the copper pipes.

Conclusions

Our estimate is that the system is in the early stage of corrosion failures. Although corrosion has not progressed to the point that the system needs to be replaced at this time, it is our opinion that the level of corrosion is higher than expected and an estimated remaining life for this system, five to seven years, seems low for a relatively recently repiped building.

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

Sincerely,

McCUAIG & ASSOCIATES ENGINEERING LTD.

Prepared by:

J.J McCuaig, P.Eng