Condition Assessment Of 40 Year Old Sewer Stacks In High Rise Buildings

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Summary: The condition of 40 year old sewer stacks in high rise buildings was evaluated using an electromagnetic non-destructive technique for copper pipes, and invasive cut-out sampling followed by grit blasting and direct physical measurement for cast iron pipes. The samples of approximately 10% of the total population revealed only isolated minor pitting corrosion for both the copper and cast iron stacks, with a negligible probability of failure in the short to medium term.

Keywords: Corrosion, graphitisation, condition, assessment, non-destructive evaluation

1 INTRODUCTION

High rise buildings (see Fig. 1 below) contain a vast array of service conduits – electrical, potable water, telephone and sewage to name a few. Electrical and telephone conduits contain cabling, whilst water and sewer conduits transport fluids under the force of gravity or under pumped pressure. The interaction between the conveyant and the conduit material (pipe) may significantly influence the performance and life of the pipe material.

Figure 1. Multi-storey building constructed in the 1960's

Following the failure of a small section of sewer pipes in a high rise building which caused major disruption to approximately 100 tenants for several days, it was decided to investigate the condition of sewer stacks in other buildings to determine their likelihood of failure.

1.1 Sewer stacks

Sewer stacks transport waste materials from toilets, baths, showers, laundry sinks, washing machines, kitchen sinks and dishwashers into buried sewer mains, and in turn, into the water authorities buried sewer network. Copper and grey cast iron were the materials that had been used in the buildings under investigation, with copper being the predominant material. In addition, copper had been used exclusively as the waste pipe in all the buildings. (see Fig. 2).

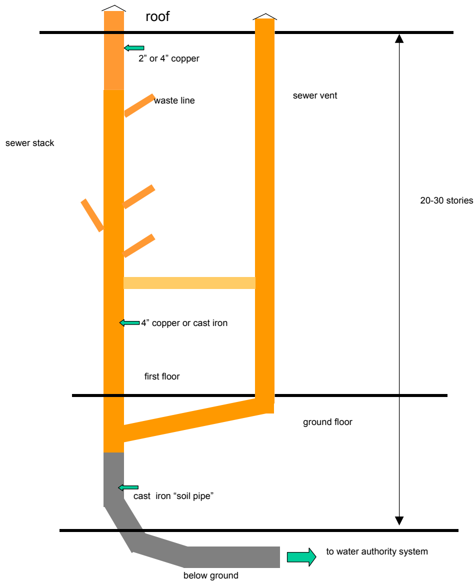

Figure 2. Schematic of Sewer Stack Configuration

1.2 Corrosion behaviour of copper and cast iron

1.2.1 Corrosion behaviour of copper

Copper is a materiel that has been used extensively in the water industry for well over 40 years and enjoys a reputation for good corrosion resistance, combined with ease of fabrication and widespread availability. Whilst the main use of copper is in reticulating drinking water supplies, it is also used for wastewater disposal.

Corrosion of copper in drinking water is sporadic and tends to occur mainly is soft, weakly buffered waters with low total dissolved solids. In wastewater, failure through pitting or other forms of corrosion is rare when normal conditions prevail. However, the use of strong household disinfectants such as bleach, products containing ammonia and strong acids can cause corrosion of copper water pipes. In some cases, this will increase the soluble copper content of the waste stream to a significant extent as well as causing localised attack of the tube itself.

1.2.2 Corrosion behaviour of cast iron

Cast iron exhibits excellent corrosion resistance when exposed to essentially atmospheric conditions, where water drains away easily. In such an environment the cast iron material undergoes only superficial rusting, and can perform satisfactorily for hundreds of years. If however, copper salts present in solution come into contact with cast iron material, galvanic corrosion can occur, whereby elemental copper plates out on the surface of the cast iron, which in turn undergoes corrosion according to the reaction $Cu^{2+} + Fe \Rightarrow Fe^{2+} + Cu$.

The final corrosion product of cast iron corrosion is a graphite-rich material, which maintains the exact shape and size of the original component, and also affords some degree of structural strength.

2 INVESTIGATIVE METHODOLOGY

2.1 Condition assessment techniques

Consideration of condition assessment techniques took into account the following:

1. Length of conduits (and relevance of spot measurements);
2. Diameter of conduits (nominally 100mm);
3. Access to surface of conduit (see Fig. 3);
4. Physical properties of copper and cast iron materials;
5. Corrosion behaviour of copper and cast iron materials;
6. Morphology of corrosion of copper and cast iron materials;

7. Need to minimise disruption to services;
8. Cost-effectiveness of technique.

Figure 3. Access to sewer stack was an important consideration

Techniques that were considered included:

1. Hand held ultrasonic testing;
2. Hand held low-frequency eddy current "Mainscan";
3. Cut-out sampling; and
4. Electromagnetic intelligent pigging.

Ultimately it was decided to use the "Saturn" electromagnetic probe supplied by Russell Technologies Incorporated from Canada for inspection of copper stacks (see Fig. 4), and cut-out sampling for inspection of bottom sections of cast iron stacks. The "Saturn" probe enabled the acquisition of essentially continuous wall thickness measurements when lowered down a sewer stack. However, due to the difference in physical properties between copper and cast iron, the same technique could not be used to ascertain the remaining wall thickness of the cast iron stacks.

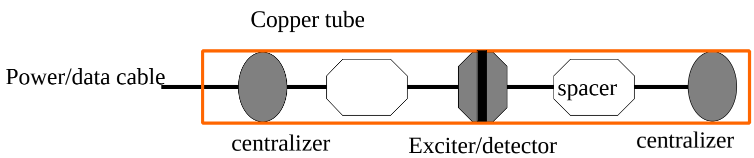

Figure 4. "Saturn" probe

Cut-outs was chosen for inspection of cast iron stacks primarily due to:

1. short section of pipe in stacks (approximately 3m);
2. inability of ultrasonics to provide meaningful wall thickness measurements on corroded cast iron;
3. consideration of the most likely corrosion mechanism operating for cast iron pipe; and
4. relatively high cost of procurement of hand-held eddy current device.

Cut-out samples were sectioned longitudinally to reveal internal surface, grit blasted to remove corrosion products, and pitting corrosion and wall thickness measured using micrometer dial gauge and vernier calipers.

3 RESULTS

Investigation of copper sewer stacks in 44 buildings revealed a total of 43 defects, all assumed to be attributable to corrosion, and none particularly severe and likely to impact on the life of the stacks in the short term. Figures 5 and 6 show graphical summaries of the results.

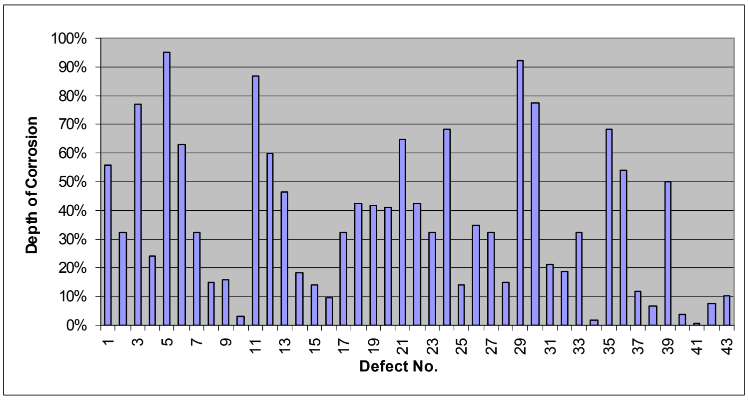

Figure 5. Depth of Copper Stack Corrosion Defects

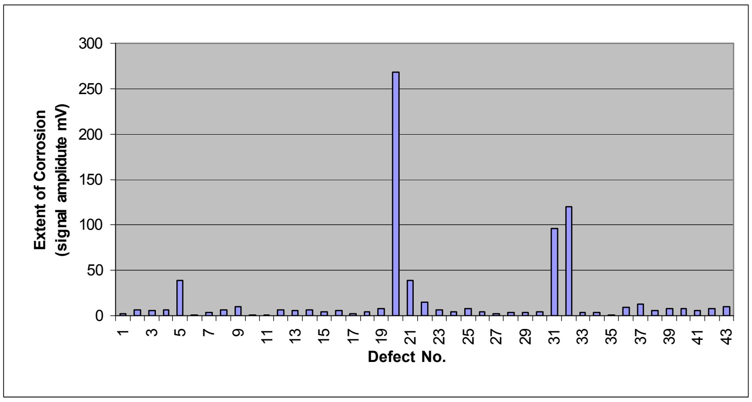

Figure 6. Extent of Copper Stack Corrosion Defects

These results show small localised areas of pitting corrosion, with only defect number 21 exhibiting any appreciable loss of volume. However, in combination with only 40% depth of corrosion, does not represent a significant defect.

Similarly, the cast iron sewer stack investigation revealed only minor pitting corrosion on a few samples. The results are tabulated below in Table 1.

Table 1. Results of Cast Iron Sewer Stack Corrosion

Sample code	Minimum Remaining Thickness (mm)	corroded after grit blasting (%)
1	4.5	33%
2	2.9	44%
3	3.8	17%
4	3.9	34%
5	3.0	46%
6	3.5	29%
7	5.8	15%
8	2.1	77%
9	4.7	60%
10	4.4	38%
11	4.1	25%
12	4.6	25%
13	3.7	31%
14	4.4	40%
15	0.0	100%
16	4.5	32%
17	2.9	74%
18	4.2	28%
19	3.2	51%
20	3.4	49%
21	3.8	38%
22	4.7	37%
23	3.7	34%
24	5.1	29%
25	6.8	26%
26	3.3	46%
27	4.4	35%
28	4.9	23%
29	5.3	35%
30	3.2	65%
31	3.4	45%
32	3.2	41%
33	3.5	45%
34	3.9	53%
35	3.7	38%
36	3.2	54%
37	4.7	44%
38	4.6	42%
39	3.5	40%
40	4.2	46%
41	2.5	51%
42	3.2	40%
43	3.3	42%
44	1.2	90%
45	6.1	9%

Samples 8, 15 and 44 exhibit considerable depth of pitting corrosion. However, in the case of samples 8 and 15, the pitting is confined to only a small area, resulting in minimal volume loss, and little reduction in structural strength. There is a greater loss of strength exhibited by sample 44. This can be appreciated by referring to Figs 7, 8 and 9.

Figure 7. Close up of sample 8 from building 37 showing minor pitting corrosion. Note inspection plate on right hand section.

Figure 8. Close up of sample 15 from building 16 showing inspection cover and small through-wall defect on bottom right hand photograph.

Figure 9. Close up of sample 44 from building 11 showing pitting corrosion. Also note the eccentric wall thickness.

Further investigation of sample 44 from building 11 revealed that it is located in a horizontal position conveying water from a laundry. The photograph below (fig. 10) shows the build up of predominantly cellulose material on the wall of the pipe.

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Figure 10. Close up of sample 44 from building 11 showing build up of waste material.

4 PERFORMANCE OF COPPER AND CAST IRON SEWER STACKS

In general, both materials have exhibited good corrosion resistance when used to convey sewage into the water authorities reticulation system. Very minor pitting corrosion was detected in sparse and isolated locations for the copper tubes, with no evidence of substantial pitting or general corrosion. Only one sample exhibited significant corrosion for the cast iron system, and this appears to be attributable to the accumulation of waste material in a horizontal section of the sewer stack system.

The results of the investigation also indicates that galvanic corrosion, caused by replating of dissolved copper material, is not active, primarily as a result of the good performance of the copper stacks.

Some cast iron stacks exhibit an eccentric bore which causes reduced wall thickness, a consequence of static casting process. When subjected to a corrosive environment and external loading this may lead to reduced life. It is not anticipated that pipes manufactured by centrifugal casting will exhibit eccentric bore.

5 CONCLUSIONS

1. Copper stacks investigated have undergone minimal corrosion
2. The vast majority of vertical cast iron stacks investigated have undergone minimal corrosion
3. Some cast iron sewer stacks (soil pipe) have an eccentric bore, which may lead to an earlier failure than would otherwise be realised.