15. COPPER PIPE

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The purpose of this report is to inform Councillors in respect to the use of copper pipe in private plumbing systems and corrosion failures that are occurring in some installations using it.

COPPER PIPE CORROSION AND ITS CAUSES

Copper pipe has been used in water plumbing systems for many decades. Generally it has performed well, but like all engineering materials it has limitations and corrosion is recognised as one of these. Put simply in non scientific terms, copper as a pure metal corrodes, but normally the copper surface quickly chemically reacts with air and water to form a protective film that prevents further corrosion forming. If, for some reason this film does not form (totally, or at isolated spots) the metal continues to corrode. Copper corrosion occurs in two forms:

(a) *Blue water corrosion*: this is a result of an overall attack on the bore of the pipe and causes taste problems and staining of bathroom porcelain, etc. It has been prevalent in some town supplies for many years (eg Auckland), but has not been a problem in Christchurch's supply.

(b) *Pitting corrosion*: generally occurs in cold water lines in buildings. It can result in pin holing of the pipe wall. It can cause serious structural damage from water leakage inside a property, which may not be covered by the insurance policy held by the owner. This form of corrosion is present in Christchurch and is the focus of this report.

Copper pipe pin holing corrosion has been occurring for many decades but the issue has had a raised profile in Christchurch in recent years. Overall however, the number of failures in Christchurch City Council water pipes that have occurred is relatively small, and the number is in line with the failure rate experienced by other areas in the country. In most cases the actual cause of the failure is not determined or reported. Because Home insurance policies seldom cover damage from failures due to wear and tear (including corrosion), there have been several cases where consequential damage from copper pipe corrosion has resulted in legal action against Councils, Manufacturers and Suppliers. A Fair Go programme a number of years ago, and a class (legal) action instigated in Christchurch four years ago naming the Christchurch City Council as the third defendant has raised the awareness of the issue locally. To our knowledge, no lawsuit involving copper plumbing tube product liability has been successful in New Zealand. However there is a well-publicised case in the USA where a water utility agreed to pay $US6 million to settle a lawsuit arising from blue water. It was claimed the blue water was caused by corrosion in copper piping due to a lack of chlorine disinfection in the supply water.

In the last 10 years in the order of 25 cases have come to the Councils attention. In these cases failure has occurred between two and seven years after installation. Virtually all the known failures are in the western and southern Christchurch districts. Failures are not known to have occurred in the Northern and Eastern suburbs. With the class action (mentioned above) involving the Council the second defendant (the pipe manufacturer) contended that the cause of the pitting failures was low pH (ie. acidity) in some Christchurch water. The Council's insurance company handled the case (in respect to the Council's interests), and an out of court confidential settlement was reached that did not involve the Council (or its insurance Company) paying out any money.

Christchurch water has been extensively chemically and biologically analysed for decades and to our knowledge the characteristics of the water has not changed in anyway that would affect the its corrositivity.

THE CAUSES OF PITTING (PIN HOLING) CORROSION

It is well known that leaks can arise from pitting corrosion. Its incidence however is unpredictable and random in nature. There is no doubt that water chemistry is a major influence. At the present time however, the root cause of pitting is not fully understood. There is substantial evidence that the pitting corrosion mechanism is due to electrochemical action, but there is also evidence demonstrating a link between the pitting and microbiological activity within the potable water network.

(a) *Water Chemistry factor*: Anions (ie negative ions) dissolved in water, and the pH (acidity) of the water, are major triggers driving the corrosion process of copper in contact with water. The anions commonly present in potable water that are known to affect pitting are *sulphate*, *chloride*, and *bicarbonate*. The ratio of these anions, and the pH of the potable water, are interdependent in some rather obscure manner. The water pH is implicated in the initiation stage, the propagation stage, and the re-passivation (ie stifling of corrosion) of pits in copper tubes. The complex inter-relationships between the anion ratios and pH, and their pitting propensity are still

being researched presently. Thus the factors that affect corrosivity of a drinking water supply are not presently well understood. For instance, the reliance upon the well-known Langelier Index to assess the corrosivity of a drinking water supply by some Local Authorities and Government departments is quite erroneous.

(b) *Microbiological factors*: In the 1990's researchers in Germany (where copper pipe pitting is serious) proposed that pitting in cold water may be attributable to microbiologically Influenced corrosion (MIC). This was contrary to conventional wisdom, because it was previously believed that copper killed bacteria. The MIC mechanism has now been studied extensively around the world in recent years, and it now holds some credence. However it is by no means accepted universally as the root cause of pitting corrosion.

Other factors within the private plumbing system that are thought to influence pitting are:

(a) *Design & Installation of Plumbing systems*. Horizontally installed, intensively branched piping with dead-ends can create pockets of stagnant water and low flow velocities which can influence corrosion.

(b) *Commissioning of Plumbing Systems*. Any delay after pressure testing of the plumbing system with water, resulting in the water lying stagnant in the copper pipes, creates a potential risk for the development of biofilms and MIC. Plumbing systems should be put into service immediately or drained and cleaned pending occupation of the building.

(c) *Operating conditions in service.* If water is known to be conducive to corrosion the water in the plumbing system should not be left stagnant for long periods. Frequent flushing of cold water lines is preferable.

POSSIBLE COUNTER MEASURES

Chlorination of Water. If MIC is the accepted mechanism of copper plumbing pitting corrosion, then chlorination of the water supply would appear to be one way to reduce its incidence. Chlorination, it could be assumed, would kill off the bacteria causing the corrosion. However, the copper corrosion problem has continually existed in the Auckland water supply despite full chemical treatment and regular chemical and microbiological monitoring of the supply. The explanation may be that other biofilms present on the walls of older pipes consume the chlorine and effectively de chlorinates parts of the supply. Thus, adopting a chlorination regime for a water supply does not provide an immediate guarantee that MIC will not affect copper pipework. Nevertheless there is evidence that chlorination is beneficial at reducing copper corrosion, but there is no published evidence that chlorine residual alone is sufficient to eliminate the problem. Clearly in the Christchurch context, the possibility of chlorination would prompt considerable community debate.

Other Disinfectants. Ozone and Ultraviolet are alternatives to chlorination for eradicating bacteria that may be present at the water source, and they may be more acceptable to Christchurch in that they do not leave a residual in the water. Because of this they are not suitable for killing bacteria that are beyond the pumping station in the pipe network or within private plumbing systems.

Adjusting water Chemistry. Maintaining the pH (measure of acidity/alkanility) of water to the range 7.5 to 8.0 (alkaline) appears to be ideal to help minimise the risk of corrosion to metals, including copper. Low pH (acidic) can be a factor in the initiation and propagation of general and localised corrosion of materials, including copper. The 2000 (year) NZ Drinking Water Standards recommends a pH range of 7.0 to 8.5, (alkaline) while the 1995 Standard had the range 6.5 to 8.5. With these standards pH is an aesthetic determinant and not one of Health Significance and thus it is there for guidance only rather than a need to comply. The vast majority of Christchurch's water is in the 7.0 to 8.5 range, but a few shallow wells in the west and South Christchurch districts have water below 7.0. A pH of 6.7 is the lowest in Christchurch. The area of Christchurch known to experience pipe failures approximately corresponds with the areas that have these shallow wells. Thus there appears to be correlation between low pH and pipe failures in Christchurch.

The Ex Waimairi District Council injected very small quantities of Sodium Hydroxide into the water at five pumping stations to maintain a minimum pH of 7.0. This practice has continued, [except drilling deeper wells (higher pH) at two of these sites and mixing the water with the shallow well water has resulted in adjustment now only being undertaken at three sites]. Thus the correlation between water pH and failures is blurred by the realisation that the failures have occurred where pH adjustment to above 7.0 has been occurring.

Lining copper pipe. No doubt an effective pipe lining is available, or can be developed, but the commercial viability of applying it (to the pipe) and pipe remaining competitive is probably the issue here. During the last 12 months the Water & Waste Unit has been co-operating with the Copper Research Council (an Australian based Organisation that represents the Copper industry) to undertake a series of trials (at two sites) with copper pipes internally coated with different linings. The purpose of the trials is to determine the effectiveness of a number of linings to inhibit corrosion. These trials have not yet been completed, but early indications are that some of the coatings at one site are helping to reduce corrosion, but at the other site none of the coatings are helping. Again, the site where the least benefit is being gained is where pH adjustment is occurring.

Alternative plumbing materials. While, for many years copper was one of the few viable options for plumbing systems (particularly hot water), there are now a number of other alternatives (plastic and composite plastic/metal) on the market. Failures of some of these systems have resulted in notable ligation cases around the world, but on the other hand, some, to date, have been found to be successful.

WHAT ELSE COULD BE DONE?

Monitoring for bacteria in the water. Quality testing of Christchurch water is predominantly focused on the requirements of the NZ Drinking water Standards. This is based on coliform counting of water samples, combined with testing for chemical constituents of health significance. These are relatively low cost, high volume tests. There are more sensitive (and expensive) microbiological tests in existence to detect bacteria strains. However it is still not known what bacteria strains are involved with Microbiological Induced Corrosion of copper. Consequently, improved laboratory testing and microbiological testing in the districts experiencing problems would add a considerable cost which may not necessarily elucidate the situation any better.

Initiating or Co-operating with research. As mentioned earlier Christchurch City Council is presently co-operating with the Copper Research Council with trials in Christchurch. Given the worldwide issue that copper pipe corrosion is, and the amount of research presently being undertaken worldwide (much of it funded by the copper industry), it is unlikely that direct Council initiated research would further the cause greatly.

Replace shallow wells with deeper ones. As mentioned, most of the known failures have occurred where shallow wells with lower pH (than the deeper wells) are utilised. Adjusting the pH upward in it self does not appear to reduce the risk. But there may be other subtle (chemical or microbiological) differences that are contributing. Thus retiring these shallow wells and replacing them with deep wells may assist. However this is not an easy solution to implement and it would not be certain that it would resolve the problem. The geology of the areas concerned is such that the deep aquifers are not present at all the pumping sites, and only one very deep aquifer (~140metres) is present at most of the rest. Also there is a big question mark as to whether the deep aquifer would be able to have the total amount of water required, safely abstracted from it. The capital cost would be in the order of $2.5million. This option would possibly be worth investigating further if the exact mechanism for inducing copper corrosion was known.

THE PIPE SUPPLIERS PERSPECTIVE

It is understood that three manufacturers supply copper tubing to the Christchurch market and this is retailed through normal plumber's merchants.

While the overall failure rate of copper plumbing systems is small, one of the issues facing the suppliers of the pipe is that of liability when failure occurs. The Commerce Act requires merchants to supply goods that are fit for the use they are intended, and thus the manufacturers need to be satisfied that they are not liable for the cost of pipe failures, because their product is ruled to be not suitable for use with Christchurch water. It is known that some suppliers have reimbursed some house owners who have suffered failure, but these have been on the basis of no liability admitted and the terms of the settlement remain confidential.

For these reasons it is not known if reimbursement covers the full costs (unlikely), nor the number of reimbursements paid out. One of the problems for the supplier is that repairing the pipe often involves extensive removal of wall linings etc and subsequent reinstatement and redecoration. Carpet renewal has been also mentioned on at least one instance. Thus the cost of repair (which is not normally covered by Household Insurance) can be above $10,000. The actual cost of the copper pipe may be relatively small, but one reimbursement requires a very large number of sales to recover from such a loss.

There is also clearly the issue of the market perception of the supplier's product.

For these reasons about two years ago one of the manufacturers verbally indicated that it was considering withdrawing form suppling the Christchurch market. Another manufacturer has recently written, advising of its intention to withdraw the supply of copper tubing, but replace it with an alternative product range.

THE PUBLIC PERCEPTION OF THE ISSUE

As stated earlier Council Officers have become aware of twenty-five cases of copper pipe failure in Christchurch in the last 10 years. There are no doubt a number of other failures that we are not aware of. The people concerned are understandably upset and become irritated by the pipe supplier's stance that pipe is of good quality and Christchurch water is causing the failure. Similarly the Councils stance (to date) that the water is of good quality and that random failure of copper plumbing is, unfortunately, to be is expected is also not well received. Attempting to explain the subtleties of water chemistry, MIC attack, and that the reason for copper water pipe failure is not fully understood to people facing a large repair bill, does not go down well.

The commercial sensitivity of the issues has made it extremely hard to get good information from the community or the suppliers. Thus, establishing (or estimating) the actual rate of copper pipe failure, and determining patterns in respect age to failure, whether failure rates are uniform over time, or (say) concentrated on individual batches of manufacture is very hard to gain. Similarly for these reasons Council Officers were requested (by the Copper Industry) about two years ago to not raise the issue on our own in the public arena, pending an agreed strategy between the manufacturers and Council. The manufacturers however have not been forthcoming in pursuing the preparation of this strategy.

SUMMARY

A number of pinhole failures of copper pipe in plumbing systems have been occurring in parts of Christchurch over recent years. Such failures are not unique to Christchurch, but are occurring (apparently) unpredictably and randomly throughout other parts of the world. The reasons for these failures and the exact mechanism that causes the problem are still not fully understood. The characteristics of Christchurch water that effect corrosion have not changed over the many years that monitoring has been taking place. A number of changes could be undertaken to the water supply that may reduce the risk, but none of them are known to be a sure cure. Some of these changes involve chemical treatment that would probably be unacceptable to the community. Alternative products (to copper) are available on the market for plumbing pipework.

Recommendation:

1. That the Information be received.

2. That officers continue to monitor research in the area of copper pipe corrosion and report back on any significant advances in the understanding of the issues.

3. That the Council continue to co-operate and participate, as it can reasonably do so, with investigation and research work being undertaken into the specific nature of copper corrosion with Christchurch water.

Chairman's Recommendation:

1. That the above recommendation be adopted.

2. That the practice of adding sodium hydroxide to water supplies be discontinued and residents in the affected areas be advised of this change by public notice in City Scene for information and comment purposes.