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BRIEF REVIEW OF FUSIOTHERM REPORTS - UPDATE

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Project:	**FORTE APARTMENTS, 13 COLLEGE STREET, WELLINGTON**
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Review

This is a review of the report entitled Forte Apartment Building PP-R Pipe CCTV Inspection Report by Envirogroup Ltd dated 18 March 2020 and a Letter from Enthalpy Consultants Ltd dated 11 March 2020 peer reviewing that report.

My review is based on those documents, a discussion with Allan Davidson from Envirogroup about his findings, additional photographs supplied by Allan Davidson, discussions with the plumbers PPS Ltd, discussions with McKee Fehl Constructors, a site inspection of the water heating plant, and my own knowledge as the original designer of the system and with experience of other jobs where remedial work was required to Fusiotherm installations.

System Description

The domestic hot water system at Forte Apartments comprises four Rinnai Infinity HD250 hot water heaters installed on the roof with a storage cylinder in level 11 plant room and distribution pipework through the Level 11 ceiling to five vertical risers supplying hot water down the building with tap-offs for each apartment. At the bottom of the risers there is a hot water return loop bringing all the return legs to a common riser back to the storage cylinder via a hot water return pump.

Background

The Forte Apartments Body Corporate had experienced two or more leaks from the Fusiotherm main hot water supply pipework installed in the ceiling on Level 11 of the building. Envirogroup has a contract to maintain the hot water system including the pipework. They fixed the first leak but one or more other leaks occurred after that. (The number of leaks, the suspected cause, and the timing of the leaks is not disclosed in the report.)

Allan Davidson had had failures in other hot water systems mainly in Auckland and was concerned this system could have similar failures in the future. When I spoke to him he was particularly concerned about failures he had found in Fusiotherm hot water risers on other jobs. He said that plumbers usually used the cheap stab-in system to connect branch pipes

into the risers and this combined with large thermal expansions in the risers tended to rip the stab-ins from the main pipe causing leaks.

With this history, Envirogroup was engaged to investigate the risers and indicate whether further problems were likely.

Envirogroup subsequently prepared the report referenced above and this was peer-reviewed by Enthalpy Consultants.

Review of Envirogroup Report

The first part of the Envirogroup report looks at the operating parameters of the system and confirms that the system was operating within the pressure, temperature and velocity published specifications of the PP-R pipework.

The report also states, "We also note that PP-R product has considerably higher thermal expansion than copper pipe systems and requires specific techniques during installation, to mitigate risk of stress and damage from this expansion."

This is true of standard Fusiotherm Fusiolen PP-R pipe but not for the pipe installed for the hot water which is Fusiotherm Fusiolen faser composite SDR 7.4 (identified by the dark green stripes visible in the photos). This is fibre-reinforced to reduce thermal expansion. Page 55 of the attached Fusiotherm installation manual says the faser composite pipework expansion coefficient is nearly identical to that of metal pipes. (Plain PP-R is approximately 10x the coefficient of copper, while faser is only about 2x).

The report also says that copper oxides released by contact with copper pipework can degrade Fusiotherm pipework. I note that Envirogroup replaced some of the Fusiotherm pipework in the plantroom with copper pipework, which was surprising if the concerns about copper are true.

The next part of the report has details of the riser inspection. Three risers were inspected from level 4 with a camera inserted into the pipe looking from level 5 to level 10. Results were that the straight sections of pipe had no problems, some of the ends of the riser pipe where they went into a tee branch socket showed cracking on the ends. (The number observed with cracking wasn't stated.) If I understand the location correctly, this is the end of the 32 mm pipe inside the tee socket, where it has the thickness of the socket outside the pipe, i.e. the pipe wall is double thickness at this point. The outer wall cannot of course been seen by the camera, but the photo in figure 8 of the report where a header pipe has been cut shows the cracking appears to be confined to the inner layer, with the outer layer intact. The photo below shows the depth and thickness of the socket suggesting that any cracking on the end of the inserted pipe may be only superficial and in any case is completely enclosed in the socket.

Allan Davidson was concerned that the cheaper welded on saddles with stab-ins had been used but the risers weren't opened up enough to see whether this was the case. The camera showed only tee fittings and I have sighted Plumbing World invoices for this job showing large numbers of tee fittings purchased. PPS advised they only used proper tee fittings because it gave a better more reliable joint.

Joining, fixing and...

...aligning

There have been no leaks reported in these areas and it is hard to see how a fracture from expansion or contraction could occur at that point, it would appear to be the piece of pipe least exposed to that stress.

The report refers to the use of non-specified pipe clips (standard Munzing rings) instead of approved "Aquatherm" Fusio pipe clamps, suggesting this is against manufacturer's instructions. The installation manual on page 55 however states "All pipes should be fastened with only Aquatherm's green rubber compound fasteners, with expansion spacers, or other as deemed equal or approved by Aquatherm and/or the project's Hydraulic Consultant." Clearly this does allow for other approved fasteners to be used. I will address the issue of pipe clipping later in this review.

The report describes findings at the heating plant. There is the same cracking on the ends of the internal welded pipe inside the socket, no damage noted anywhere else. Figure 12 shows Aquatherm clips, the one on the blue striped pipe (cold water) with a tight sleeve and the hot water (dark green stripe) with a clip around the insulation. The report said all clips were tight, preventing thermal expansion.

The report noted the two circulating pumps in the plantroom were not screwed down. These should have been, but they are held firmly in place by the connected pipework and there appears to be no damage to them after 10 years of continuous operation.

The inspection revealed that a non-return valve had failed, and was replaced. If the non-return valve is too close to the pump then it can be affected by turbulence from the pump. While these are often placed very close to the pump it is better to install them five pipe diameters or

more from the pump. Scaling from a photo, it appeared the valves were about 4 ½ pipe diameters from the pump. With one failure in 10 years and the other ok for 10 years it does not appear to be a significant problem, and the failure was not picked up in routine maintenance.

The report notes a hose tap has been installed above power points. I understand this was installed post contract by different plumbers. It is a safety issue and should be fixed. It is a cause of concern that apparently incompetent plumbers have been messing about with the pipework and plant in the plantroom.

The report notes that the pressure limiting valve has been set to 340 kPa and should be set to 300 kPa. It does not identify when this was changed but it can be set back to 300 kPa. Stating that it would lead to excessive water consumption and making tenants uncomfortable may be overstating the problem as most tenants couldn't tell the difference between 5.4 bar and 5.8 bar (about 7% higher) and the shower mixer can be set to a comfortable pressure regardless.

The report says the hot water return pump needs to be checked as it may not have sufficient flow. If this were the case there would be complaints of insufficient or delayed hot water, and I understand this has not been raised as a problem. The flow should not be increased if it is not necessary as excessive flow in conjunction with other factors is a known cause of scouring of Fusiotherm pipework.

Pipe Failure

The major conclusion of the Envirogroup report is that poor clipping practices has resulted in stress on fittings and this stress combined with water temperature above 60°C, chlorine content higher than in Germany and copper ions in the water has led to cracking of the ends of the pipes welded inside the sockets. The implication is this may have caused pipe leaks on level 11 and may cause leaks in the future.

Looking at each of these factors in turn:

Pipe Clipping

The report says that to allow linear thermal expansion of pipe and avoid stress on ends of fittings, sliding points must be used as pipe support. In the recommendations the report says that pipe clips in the riser were not the correct brand and in any case were too tight to allow the pipe to slide in the clip.

The report reproduces figures from the installation manual (page 57) showing how branches should be supported and arranged to allow for expansion.

I note that figures 22 and 23 in the report reproduced from the Aquatherm manual specifically reference Fusiotherm pipes manufactured without stabilizing components (aluminium or faser) and so do not apply to this installation. It is quite misleading to include them in the report or to say that the provision they make for expansion is applicable to this site.

Figure 21 correctly shows that the riser pipe should be clamped close to each branch and in fact says "All clamps in the riser must be installed as fixed points". And also says "The linear expansion of fusiotherm®-stabi-composite pipes and fusiotherm®-faser composite pipes in vertical risers up to 40 m high can be ignored".

This shows that the emphasis in the report on the way pipes are clipped is completely unwarranted. The Fusiotherm installation manual is very clear that the pipework in the riser should be firmly clamped at each clip and allowance for sliding is not required or desirable.

By installing the pipework in the risers to restrain the movement from thermal expansion the plumber was fully complying with the installation instructions.

The report talks of the clipping putting stress on fittings. The clips are on the pipework rather than the fittings, and because the pipework is constrained the fittings do not move so there is no sideways stress on the fittings from the branches.

As I mentioned at the start of the review, Allan Davidson was understandably concerned about the risk of leaks in the risers similar to other jobs he had experienced. This job is different in that the pipework movement that caused failures in the other jobs is not present, and secondly the plumber used the move expensive tee fittings for the branches rather than stab-ins which can weaken the pipe.

Water temperature above 60°C

This is listed as a potential contribution to failure despite the fact that the report is clear that Fusiotherm literature says 65°C is satisfactory for a 50 year life.

Chlorine content higher than Germany

Fusiotherm are still selling the product in Wellington and elsewhere around the country without derating it for known chlorine concentrations. It is hard to see how it could be a factor.

Copper ions

There is very little copper pipe in the system (apart from that put in by Envirogroup to fix the first leak), again a factor unlikely to cause problems.

Cracking of the end of the pipe inside the welded fittings

There is no evidence to suggest that this is caused by stresses on the fitting from thermal expansion of the pipe, or caused by any poor installation practice, and more importantly that this cracking is any cause for concern. This cracking is occurring on the end of a pipe deep inside a welded fitting. There is no evidence that this has affected the integrity of the fitting or that it is anything other than a superficial side effect of the welding process. There is no evidence it has caused any leaks.

Review of Recommendations

No.1

Lowering temperature using a Jrgumat valve is not necessary based on Fusiotherm published data but if there are concerns about the Fusiotherm product then it can be done.

No.2

The report states that a calculation shows that the velocity in the headers exceeds 2 m/s. My calculation indicates it is less than this. Usually if the velocity is high and the temperature is quite high (Allan Davidson said he found the boilers set to 70°C when he went to site) then

there will be evidence of scouring. When the pipes were cut open they showed no scouring at all.

I note though that the Rinnai Infinity headers are subjected to much greater thermal cycling that other parts of the system and to higher temperatures particularly when people lacking knowledge have adjusted them at various times, and experience over many installations over the years has shown that Fusiotherm is not particularly robust under these conditions. The body corporate may wish to upgrade to a more robust pipe material to reduce the chance of failure some time in the future.

No.3

The pipework was installed as per Aquatherm's published instructions as addressed above. If Aquatherm are now changing their recommendations then a change may be warranted, otherwise the risers should be left as they are.

No.4

I assume fire compliance was generally checked during construction by the Council.

No.5

Pumps can be checked however if they are operating satisfactorily for the tenants then increasing the flow will add operating costs, increase scouring on pipes and be costly to carry out for no advantage.

No.6

Relocating pumps is an unnecessary expense as they can be accessed. Adding a bracket to further support them is recommended.

No.7

Not necessary. Thermal expansion in the plantroom is only 3 – 4 mm maximum, generally less. It has operated satisfactorily for 10 years.

No.8

Actually there is no evidence that all the branch tees and clips must be redone.

No.9

When the system was installed there was no requirement for structural engineer sign-off. The buffer tank is secured with steel straps inside a Unistrut frame. Not clear why this is raising a red flag.

No.10

An enclosure for the boilers is not recommended. The boilers are designed for outside mounting and in fact there is a manufacturer's label on the appliance saying DO NOT ENCLOSE THIS APPLIANCE. There is however a large slatted timber screen already installed as a windbreak to minimise any wind effects on the combustion.

No.11

As noted in the report level 3 construction is likely to be similar to the risers, and if the risers are not causing problems, and there have been no leaks in the pipework on level 3, then without further information coming to light this pipework can be assumed to be satisfactory.

No.12

Any missing insulation can be replaced.

No.13

NR valves can be relocated, although one failure in 10 years is not a major problem.

No.14

Hose tap in that location is a safety risk and should be relocated.

Review of Enthalpy Report

The start of the report confirms that pipework is operating within the design parameters of temperature, pressure and velocity and repeats the discussion about copper ions affecting PP-R although there is very little copper in the system.

It says that incorrect installation methods and elevated hot water temperature has caused internal radial cracking of branch tees. It justifies this by saying that clips are incorrectly installed. In particular it says "Supports at riser branches are wrongly located. Mid-riser supports are restricting free movement." This conclusion conflicts with the manual saying all the clamps in the riser must stop free movement.

It says the manufacturer recommends 60°C as the circulating temperature for hot water. While the present 65°C circulation temperature complies with published data for a 50-year life, as noted before if there are doubts about the product then there is merit in providing a greater safety factor.

The report repeats concerns about the Level 3 pipework and says it is unknown if an expansion loop is included. From page 58 of the manual, allowance for expansion must be included (in the clips) but an expansion loop is not needed for less than 40 m of straight pipe.

Generally the peer review repeats the same things as the report and those points are addressed above.

Leaks on Level 11

It is not stated in the reports what caused the initial leak on level 11, nor any subsequent leaks so it is difficult to say whether the same factors could be present in other parts of the system. There was a suggestion that the original installation used a different, incorrect pipe type from the one stated, viz MF SDR9 RP instead of the Faser SDR7.4 MF pipe which have the same dark green identification stripes. I note that the MF SDR9 RP pipe is a new product in the last couple of years so could not have been used originally.

My Conclusions

The conclusion by Envirogroup that the radial cracking observed on the inside of the riser pipes at the end of the pipes (deep within the sockets) was caused by stretching or compressing the pipe as a result of poor clipping practices is not supported by the evidence.

The Fusiotherm installation manual is very clear that compression forces created by the hot water heating of the pipe after installation can and should be managed by firmly clamping the pipe. The usual problem with riser pipes is that they are installed with sliding clips allowing expansion over several floors and if the branch pipes are clamped too close to the pipe they are torn away when the riser pipe expands. There is no evidence this is happening here. The radial cracking appears to be right inside the fitting where it would have least physical strain on it. None of the fittings with that cracking on the ends of pipes have exhibited leaking.

My major conclusions are first that the cause of the leaks on level 11 have not been identified in the report so it cannot be said that leaks there point to the likelihood of leaks elsewhere. The leaks could be caused by poor installation but just as easily by product failure or through causes completely outside the plumbing installation such as nail guns or seismic events.

Secondly, that the Fusiotherm hot water pipework in the risers was installed in accordance with the manufacturer's recommendations and that no leaks have occurred.

Other conclusions are contained within the report.