

# TECHNICAL NOTE



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## Concrete encasement and grouting of plastics pressure pipes

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### Introduction

Two potential problems arise when encasing plastic pressure pipes in concrete: temperature and local strains. Designers and installers should be aware of these issues. Although they are generally covered by recommendations contained in AS 2032<sup>i</sup> and AS 2033<sup>ii</sup>, the reasons and consequences are somewhat obscure, and it is the purpose of this technical note to expand on this information.

This note applies to PVC and PE pressure pipes, but is generally applicable to other plastics as well. The new material efficient pipes, Supermain (PVC-O) and Hydro (PVC-M), and PE100, with thinner walls, are subject to the same limitations as PVC-U, but introduce somewhat more vulnerability to these factors.

For non-pressure pipes the technical factors are different, and are outside the scope of this discussion.

### Local strain development

Plastic pipes have a relatively low modulus and expand considerably under internal pressure for PVC-U about 0.5% long term, and for PVC-O and PVC-M around 0.8%. For PE strains up to 2% are possible.

When a pipe is surrounded by concrete or cement grout, transfer of a large proportion of the stress from the plastic pipe to the concrete occurs. This may or may not be of consequence, depending on whether the concrete surround is designed to accept such stresses.

Further, where the pipe emerges from the concrete, local axial bending stresses are set up that may contribute to long term rupture at that point.

The standards recommend the use of a compressible membrane around the pipe,

which then allows the pipe to strain naturally, and avoids the issue.

They also recommend that a joint be located at the exit from the concrete. This safeguards against longitudinal bending moments due to settlement of the structure, and protects the pipe from external damage at wall penetrations due to thermal expansion and contraction.

### Temperatures

Significant heat is evolved during the hydration of cement products. The amount of heat depends on numerous factors, including the type and composition<sup>1iii</sup> of cement, the proportions of the mix, and the ambient temperature<sup>2iii</sup>. The last factor is very important, since higher temperatures generate faster reactions with more rapid heat evolution, invoking a runaway effect.

The temperatures reached in turn depend on dissipation rates. In large dimension mass concrete, temperatures of 50°C are not uncommon. It should be noted that heat is evolved during the entire hydration process and it may be days before maximum temperature is reached.

In grouting applications, more dangerous temperatures can be developed, since not only is the grout generally composed of a very high proportion of cement, but also the applications by their nature tend to severely

<sup>1</sup> For example: Heat of hydration of major components of portland cement (Joules/gm):  
C<sub>3</sub>S=502, C<sub>2</sub>S=260, C<sub>3</sub>A=867, C<sub>4</sub>AF=419  
(C=CaO, S=SiO<sub>2</sub>, A=Al<sub>2</sub>O<sub>3</sub>, A=Fe<sub>2</sub>O<sub>3</sub>)

<sup>2</sup> For example: Heat of hydration of types of cement at various temperatures

Type of cement	Temperature °C			
	4	24	32	41
I	154	285	309	335
III	221	348	357	390
IV	108	195	192	214

restrict heat dissipation. Temperatures over 80°C are known to have occurred.

## Material response to elevated temperature.

Plastics lose about 2% of their tensile strength for each 1°C rise in temperature, rating zero for long term strength at 70°C. Elastic modulus likewise decreases, although non-linear. AS 2032 and AS 2033 put the maximum operational temperature for PVC-U and PE at 60°C. In fact, these plastics do have short-term strength beyond these temperatures, but the rate of viscoelastic creep is so high that to all intents and purposes it is not usable.

To the extent that mechanical strength is required during the setting of the concrete or grout, this may or may not be important. The temperature rise is generally slow enough for the initial set to occur before dangerous levels are reached, and in fact the pipe will be supported structurally by the cement. Ability to support grout pumping pressures against buckling collapse<sup>3</sup> will be reduced by early temperature rise.

A more significant problem relates to reversion. This refers to the memory effect with plastics, which is the tendency of any post formed material (material which is re-formed after extrusion or moulding) to revert to its initial formed state. This applies to any fabricated item, such as sockets on PVC pipes, or formed fittings. PVC-O pipes are oriented by post-stretching and will revert dramatically if subjected to high temperatures.

## Preferred practice and precautionary techniques

Concrete encasement or grouting serves no useful purpose as far as the pipe is concerned, and when additional protection or load support is deemed necessary, preferred practice would be to post-install pipes in protective or load-bearing conduits.

Where embedded directly in concrete, a joint should be sited at each exit from the concrete, and a length of one diameter into the concrete should be protected with a compressible material wrap.

If significant temperature rise is expected, and the pipe will be subjected to mechanical loads during installation, choose a higher

class of pipe, and/or apply internal water cooling. If it is suspected that temperatures of the grout may exceed 60°C, water cooling is mandatory<sup>4</sup>. Flow must be maintained over the hydration period – several days if necessary. It would be wise to monitor the temperature of the outflow.

Fast setting cements generate much higher temperatures – avoid if possible. The temperatures developed in grouts can be moderated using flyash, and up to 40% has little effect on flow or strength.

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## References

- <sup>i</sup> Australian Standard 2032 - 1977 "Installation of PVC pipeline systems"
- <sup>ii</sup> Australian Standard 2033 -1980 "Installation of Polyethylene pipeline systems"
- <sup>iii</sup> Neville A M, "Properties of Concrete", Longman

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<sup>3</sup> See Technical Note 4F "PVC Pipes Under External Pressure"

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<sup>4</sup> It is the average temperature over the wall of the pipe that is important. The outside temperature may exceed 60°C, provided the inside temperature is maintained below 60°C by the same margin.

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