

PVC Recycling into Sandwich Construction Pipe

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Abstract

Sandwich construction PVC-U (SC PVC-U) has been successfully used in Australia for more than two decades in non-pressure drain, waste, vent (DWV), stormwater and electrical conduit applications. It has a number of advantages in environmental, economic and social aspects compared to single layer solid wall PVC pipe and alternative materials. In particular, the ability of SC PVC-U to use manufacturers rework, post-industrial and post-consumer PVC waste in the sandwich layer is directly responsible for the annual diversion of thousands of tonnes from landfill in Australia^{1,2}. The sandwich layer is commonly foamed, further enhancing its benefits by reducing the quantity of raw material required, the weight of the pipe and thus its embodied energy. This paper will discuss the issues that arise when using recycle into SC PVC-U pipe and what has been learnt by the Australian PVC pipe industry in the twenty plus years of successful manufacture of this product.

1. Introduction

SC PVC-U pipe was developed in Europe in the 1980's by Alphacan, primarily to improve the environmental performance of PVC as the product provided a ready outlet for the recycling of waste and end of life PVC-U products³. However, it also had significant benefits of enabling production of lighter weight and cheaper pipes compared to single layer pipes⁴.

Sandwich construction pipe technology was introduced into Australia by Key Plastics in 1996 under a licence from Alphacan. Key Plastics launched SC PVC-U pipe into the Australian market under the brand name 'Bipex', the pipe being used in the non-pressure DWV and stormwater applications. Key's main driver was to reduce the cost of their pipe and gain an advantage over their competitors.

The core or sandwich layer in SC PVC-U pipe can either be a solid or foamed layer, depending on the end requirements of the application and the asset owner. Whether the pipe contains recycle or not is also dependent on these factors but also the availability and quality of the recycle. Key immediately began foaming the sandwich layer to produce a lighter weight pipe and also sought sources of suitable PVC-U material to recycle into this layer.

By the time Key launched their products into the Australian market, other SC PVC-U manufacturing technologies had been developed. The other major local PVC pipe producers

invested in these technologies over the next few years and launched their alternatives to Bipex.

SC PVC-U pipe was quickly widely accepted by the Australian water industry, particularly for DWV applications. Today, SC PVC-U pipe is by far the most commonly produced plastic pipe in Australia. It is produced in sizes ranging from 100 to 300mm diameter.

2. Recyclate Quality

The three standard sources of recyclate PVC material - internal rework, post-industrial and post-consumer - are all used in Australia for the production of SC PVC-U pipe. However, as the quality of the recyclate will vary depending on its source, this will affect how and where the recyclate can be used. The type of pipe being produced will also determine what quality of recyclate is required and if the available recyclate can be used.

The first step in the usage of any PVC recyclate will normally be to reduce its size so that it can be reprocessed. From a processing perspective, the smaller the particle size that the recyclate is reduced to the better. Ideally, the recyclate would be micronized to sub 500 μ m particle size to allow better handling and processing. However, achieving this size is not practical, mostly due to the energy required for micronizing equipment to reduce to this size. The pipe producers typically will aim to grind down to <1mm particle size. The micronized material will be passed over a screen to filter out contamination.

If the recyclate is clean and of known quality and formulation, for example internal rework, it can be reused without micronizing through simply regrinding down to <10mm particle size.

Whenever possible, the PVC pipe producers will foam the core or sandwich layer of SC PVC-U pipe to minimise the raw material content of the pipe, even when using recyclate in this layer. Foreign contamination is a problem here as it can provide nucleation points for the foaming process, which can lead to blow outs in the wall of the pipe. Even if not foaming, larger pieces of contamination will cause ruptures in the wall of smaller diameter thinner wall pipes.

3. Formulation

Ideally, the SC PVC-U pipe producer will have some knowledge of history and type of PVC-U recyclate to be used. The important considerations from a formulation perspective are the molecular weight of the PVC and what thermal stabilisation system has been used to prevent degradation of the material. Properly formulated PVC-U can be recycled several times before having insufficient residual thermal stability to allow reprocessing. Given the

overwhelming majority of PVC-U products are used in long life applications such as pipes, window profiles and wall cladding, the material will have a potential working life of hundreds of years or more. However, provided the recycle is PVC-U, it is not essential for the pipe producer to know exactly what its formulation is. Recyclate of unknown origin and history can still be used by micronizing and blending with virgin PVC blend or known quality recycled material in thicker walled, less critical products such as stormwater pipe.

The production process for making SC PVC-U pipe copes reasonably well with variations in molecular weight of PVC recyclate. It also is capable of handling material comprising different stabilisation systems, though some reformulating may be required when using Tin stabilised recyclate. Lead stabilised pipe produced prior to 2010, when the Australian PVC pipe industry voluntarily ceased the use of Lead based stabilisers in all PVC pipe products, can be recycled without issues. As the recyclate is encapsulated in the wall of the pipe between virgin layers of material, there is no risk of any legacy additives in the recyclate coming into contact with the contents of the pipe or its surrounding environment.

Clearly if using internal rework, the pipe producer will know the material's formulation and history. This material can readily be used in all SC PVC-U products.

4. Usage

When possible, the pipe producers will use 100% recyclate in the sandwich layer of SC PVC-U pipe. However as previously mentioned, this will be dictated by the availability and quality of the recyclate material, and also the type of pipe being produced. Also when possible, the pipe producers will foam the recyclate material through the addition of blowing agents.

A significant advantage of using SC PVC-U pipe to consume recyclate in the sandwich layer is that the colour of the recyclate is irrelevant, allowing the pipes to meet the colour requirements in the relevant product standard without any colour adjustments.

The ability to use recyclate is somewhat dictated by the quality requirements of the pipe being produced. DWV pipe has the highest quality requirement of all SC PVC-U pipe types and the pipe producers will restrict the usage of recyclate in this product. In fact, 100mm DWV pipe, the most commonly produced and installed plastic pipe in Australia by length, is made without recyclate. The thicker walled, larger size DWV pipes will normally contain recyclate, typically foamed up to 225mm diameter and as a solid layer in larger sizes. To ensure the quality of the pipe, DWV pipe will normally use micronized recyclate.

Stormwater pipe, having fewer quality requirements is a major consumer of recyclate. Interestingly, as the recyclate being used will often be internal rework of higher quality requirement pipe such as pressure pipe, stormwater pipe containing recyclate can have

better physical properties than that made with no recyclate. Stormwater pipe will normally use regrind rather than micronized recyclate.

Electrical conduit generally has a thicker wall than DWV and stormwater pipe. Its sandwich layer will contain up to 100% recyclate, which will normally be foamed.

Foamed SC PVC-U pipe is typically 25 – 30% lighter than its solid wall alternative, hence there is significant benefit to the pipe producer to be able to foam the sandwich layer whenever possible.

5. Benefits

SC PVC-U pipe has many benefits compared to monolayer solid wall PVC and other alternative pipes from performance, economic, environmental and social perspectives. These include:

Performance:

- Meet all relevant product standards
- No loss in properties compared to monolayer solid wall alternatives – in fact properties may be enhanced with recyclate use in some cases
- Reduced weight when the sandwich layer is foamed

Economic:

- Avoiding waste disposal costs of material than can be recycled
- Avoiding the storage and handling costs of rework material by pipe manufacturers
- Reducing material costs in foamed SC PVC-U pipe
- Reducing freight, handling and installation costs of lower weight foamed SC PVC-U pipe
- Avoiding landfill levies

Environmental:

- Diversion of recyclable material away from landfill into products that benefit society
- Lower Carbon footprint, particularly when foamed
- Lower embodied energy compared to alternative products
- Compliant with Green Building Council of Australia Best Environmental Practice PVC requirements
- Lowest environmental impact⁵

Social:

- Light weight reduces risk of injuries to manufacturers and installers
- Reduced pipe cost
- Ease of usage

6. Summary

SC PVC-U pipe gives many benefits to the plastic pipes industry, not only in its ability to incorporate significant volumes of recyclable material but also to society as a whole. It has successfully been used in Australia for more than two decades. The ability to foam the sandwich layer whether using recycle or not makes it the most material efficient of all pipe types for non-pressure applications.

It is little wonder why the vast majority of DWV and stormwater pipe installed in Australia is SC PVC-U.

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