

Plastic pipes with recycled content

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Summary

Pipelife Norway, a plastic pipe manufacturer, together with SINTEF and Norner, research institutes, carried out a project in 2024 and 2025 with the aim to explore the possibilities, challenges and limitations regarding non-pressure plastic pipe products with external recycled content. The project was supported by the Norwegian Retailers' Environment Fund ([About the Norwegian Retailers' Environment Fund - HMF](#)).

Sustainability is a keyword. The use of recycled materials in non-pressure plastic pipe applications contributes to a circular economy, reduces the consumption of fossil resources and reduces the greenhouse gas emissions. Plastic pipes constitute large volumes and are well suited for adding large quantities of recycled material – potentially several thousand tons per year in the Norwegian market.

Quality, lifetime expectations and economy are important issues. The products must be trusted to do the job, and the price cannot be considerably higher than for products made of fossil raw materials.

The work done by SINTEF and Norner point at issues to be dealt with in order to establish requirements for the raw materials in the “agreed specifications” together with suppliers of recirculates, do a proper reception control and introduce other measures before and during production. The requirements for the products, according to the product standards, must be met. Know-how about recycled materials is crucial in order to produce products meeting all requirements.

Plastics are well suited for mechanical recycling. This project show it is possible to produce plastic pipes fulfilling all requirements. Product standards and trustworthy certification schemes must be in place ensuring the actors in the value chain that products with recycled content are deemed safe to use.

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Introduction

Pipelife Norway, a plastic pipe manufacturer, together with SINTEF and Norner, research institutes, carried out a project in 2024 and 2025 with the aim to explore the possibilities, challenges and limitations regarding non-pressure plastic pipe products with external recycled content. The project was supported by the Norwegian Retailers' Environment Fund ([About the Norwegian Retailers' Environment Fund - HMF](#)).

The reports from SINTEF and Norner are in separate documents – available upon request. SINTEF focused on unplasticized polyvinylchloride (PVC-U) and Norner on polyethylene (PE) and polypropylene (PP).

Interviews with players in the public market, mainly end-users, were conducted to map their requirement and concerns for such products. Based on this feedback we intended to find the key measures – ensuring the end-users that such products are deemed safe to use.

We also planned to test the products in real life. But we did not manage to produce pipes fulfilling all requirements in the relevant standards within the timeframe. Such trials were done in a Danish project earlier – with no major findings affecting properties of products with recycled content. After all, plastic pipes with recycled content shall fulfil all the requirements as similar products made of virgin materials. The installer should not notice any difference. We concluded that such installations would give little added value and did not initiate such trials.

We used more resources on production trials – which gave a lot of learnings. We produced multilayer smooth non-pressure pipe systems with recycled PVC-U in the middle layer. We also produced doublewalled pipes from recycled PE and PP. During this period, we did a lot of test-runs with recirculates from several suppliers. Materials and pipes were extensively tested internally and by SINTEF and Norner.

Market survey

26 persons, representing municipalities, power utilities, consultants and road authorities, were interviewed by a neutral consultant with a broad professional background. In this way the interviewees could get a good explanation of the questions asked – ensuring good quality of the answers.

Basic issues to be covered during the interviews

1. Are there experiences with recycled plastic materials for this kind of infrastructure – and what are they?
2. What are the most important expectations and requirements to pressure-less pipe systems made from recycled materials?
3. What are the main advantages regarding recycled content in pipe products?
4. What are the main challenges allowing recycled content in pipe products?
5. Are there suggestions to concrete issues that should be investigated in this project?
6. What kind of documentation is needed to give confidence in installing pipe products with recycled content?
7. What kind of environmental requirements will be applied for pipes – now or in the future?
8. What happens to cut off pipes, other remains from construction sites and dug up pipes today – and is it a lot of this?

More often the interviewees gave almost the same replies.

Findings from the survey

- In principle, pipes with recycled content are seen as positive, due to environmental aspects and a more circular economy. The greenhouse gas emissions are more and more often considered in public procurements.
- The expected lifetime must be the same as for pipes of virgin materials.
- The strength and the quality must be on the same level as for pipes of virgin materials.
- Traceability and that we have control over the substances the materials contain are important issues.

- Some have some experience with products with recycled content. These products are more often not according to any product standard – and the quality varies.
- The products shall be covered by a certificate issued in a trustworthy certification scheme (e.g. the INSTA-CERT scheme).
- Some will accept a slightly higher price, to be considered together with the environmental performance (greenhouse gas emissions). Some expresses doubt due to tight budgets. All understand that the cost for a recycled material of high quality is not low, but many expresses that the will to pay is low.
- Cut off, remains and dug up pipe products are collected by companies taking care of the waste management for the municipalities, utilities, contractors etc. Pipeline products go into the waste stream together with the residual waste – and more often sent to energy recovery at incineration plants. If a collection scheme is established for plastic piping products, most interviewees would strongly consider using it – at least those having some volumes of such scrap.

Our overall impression is that there is a scepticism at all levels of the organisations that needs to be addressed. The regime with product standards and certification schemes is generally trusted. It must be proved that this regime also functions for pipe products with recycled content. Bad experiences at an early stage will create obstacles to a more sustainable future. Tight budgets and little willingness to pay are clearly obstacles that have to be dealt with.

How we, as a manufacturer, interprets the market and the situation

The knowledge about real lifetime is the main issue for the end-users. The costs connected to replacement and rehabilitation of pipelines are high – the overall lifetime cost should be as low as possible. Frequent replacements/rehabilitations also affect the climate performance as construction works is known as the most demanding part when it comes to greenhouse gas emissions.

Therefore, we understand and accept the demand for certification with stricter requirements than for pipes made of virgin materials. The key factors for manufacturers are knowledge about the properties of the recirculates, about how we can even out the variations within each batch and about how production processes and recirculate properties play together. In the beginning even more extensive testing than foreseen in the coming requirements for certification is needed – e.g. frequent impact tests etc. We also have to perform indirect tests that gives immediate results – e.g. one hour pressure tests with higher pressures etc. The research institutes recommend to start with small dosages of recirculates and increase the amounts as the knowledge about recirculates and production processes improve.

In 2024 our trade organisation, NPG Norway, conducted a pilot project on collection of pipes cut off, remains and dug up pipes together with contractors and a waste collector. This project was also sponsored by the Norwegian Retailers' Environment Fund. Containers were placed on four construction sites and 11,2 tons of plastic piping products were collected. The collected products were sorted and sent to recyclers for treatment. The pipe manufacturers buy the treated recycled materials from the recyclers.

As a result of this project, several collectors offer this solution in the Norwegian market today. Hopefully this will give us more valuable high quality recirculates needed for the manufacture of pipes with high quality and a long lifetime.



Container for collection of plastic piping scrap on a construction site

Manufacture of PVC-U pipes with recycled content

This chapter describes the manufacturing process of pipes with recycled content with respect to raw material, processing and product quality. Within this project period, the main focus was on the development of PVC cable protection pipes with recycled content. Hence, the experience described below is first of all related to the use of external recycled PVC (rPVC).

The product standard, EN 50626-2, allow recycled content. The requirements in this standard are strict – on the level for PVC-pipes for other non-pressure applications.

External recycled PVC raw material

The sources of rPVC used in pipe production are mainly from the pipe and window profile industry. Both pre-consumer ('new' products as cut-offs in the profile industry) and post-consumer (old pipes and window profiles) material is available on the market. The recycling process is based on washing and mechanical milling. The end product is typically a micronized powder with a particle size of about 500-700µm, as shown in the picture below.



This magnified picture shows micronized recycled PVC

PVC-U molecules are as long threads without branches – not very complex. The properties and process parameters are connected to the length of the molecules – classified by K-values. Furthermore, the “U” in PVC-U implies that the material is unplasticized. The sources for the recycled materials used in pipe products must be rigid PVC-U products within a spectre of K-values.

With respect to the mechanical recycling process, a 100 % purity of the raw material cannot be guaranteed by the suppliers. Contaminations may be found in the rPVC, both non-PVC plastic particles as well as non-plastic particles are common. As rPVC can be sourced from products with widely varying age, the raw material may contain lead as this was used as additive for the PVC production before year 2003 (depending on country). Today, rPVC is available in different grades on the market depending on its source, both as lead-free (<0,1 %) and lead-containing (<1,5 %) quality.

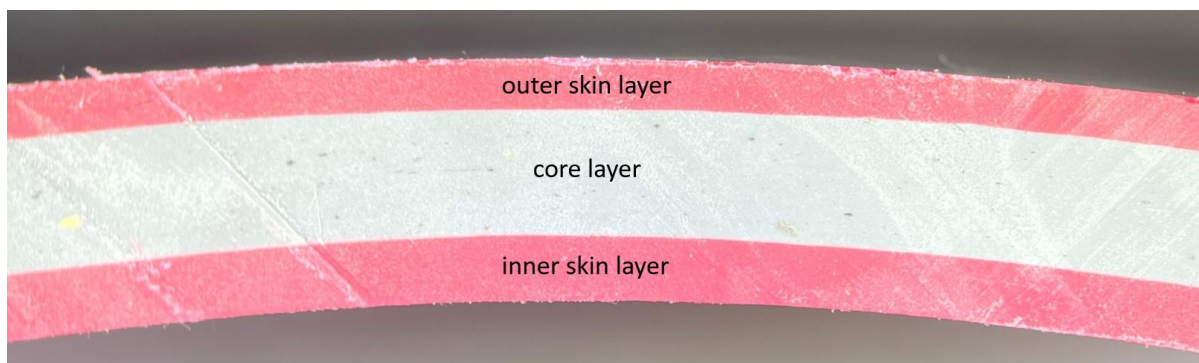
The handling of rPVC raw material is comparable to virgin PVC and it can be transported and stored in silos in the same way. Free-flowing properties are slightly reduced for rPVC due to its particle size and shape, however, standard equipment for material transport can be used without problems.

Extrusion process

As the original source of rPVC is often unknown, a detailed description of the formulation is missing. This includes unknown factors as remaining content of heat stabilizer and/or filler as calcium carbonate. To compensate for this, some heat stabilizer and/or filler might be added to the rPVC as preparation for the extrusion process. The extrusion itself can be done with standard extruder equipment as used for virgin PVC.

Multilayer pipe construction

A common approach for manufacturing pipes with rPVC is a 3-layer pipe wall construction (see picture below). This can be achieved by a special die head that welds together melted material from different extruder sources. A 3-layer pipe can be produced by the use of in total two extruders. One extruder processes the rPVC and provides the core layer, while another extruder processes virgin PVC that is used as both outer and inner skin layer (melt flow split in the die head). As alternative, separate extruders can be used for the two different skin layers. This alternative requires in total three extruders.



Build-up of multilayer pipe wall construction

The use of a multilayer pipe construction has several advantages:

- Thin skin layers made of virgin PVC can be used to colour the pipe for different product applications.
- A multilayer pipe fulfils the requirement of the REACH-regulation¹: '...recovered rigid PVC in derogated articles should be entirely enclosed within a layer of newly produced PVC...'
- The possibility to adjust layer thicknesses (core vs. skin) enables the manufacturer to ensure product quality for a wide range of rPVC qualities.

- The visual impression and smoothness of the pipe outer layer is maintained. Potential contaminations of the rPVC raw material are kept in the core layer, covered by skin layers on both outside and inside.

¹ COMMISSION REGULATION (EU) 2023/923 of 3 May 2023, amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council as regards lead and its compounds in PVC

Product quality

With respect to sustainability, the motivation is to produce pipes with a high recycled content. However, to ensure product quality is the overall guideline in the product development when adding recycled content. The development must be based on a target product quality to be achieved, leading to a recycled content that can be used to still fulfil this target. It should be in the interest of both industry and customers to not turn around this fact, and not base developments on a certain recycled content expected.

Within this project, the focus was on the development of a cable protection pipe that fulfils the requirement given in EN 50626-2:2023. Comparing the requirements listed in the standard with material (lifetime), general, geometrical, mechanical and physical characteristics, the most challenging requirement to achieve turned out to be the documented lifetime. This lifetime test is based on a resistance to internal pressure, even if the product itself is made for a non-pressure application. In addition, Vicat properties (VST - Vicat softening temperature) need to be achieved.

A challenging fact with respect to the internal pressure test is the purity of the rPVC material used in the core layer. If contaminations of a certain size are processed and placed in the melt flow close to the layer transition between core and inner skin layer, a defect may be initiated from the inside pipe wall during pressure testing. By increasing the skin layer thickness, this risk is significantly reduced, and lifetime tests can be passed successfully. This action ensures at the same time sufficient mechanical characteristics such as impact or stiffness properties.

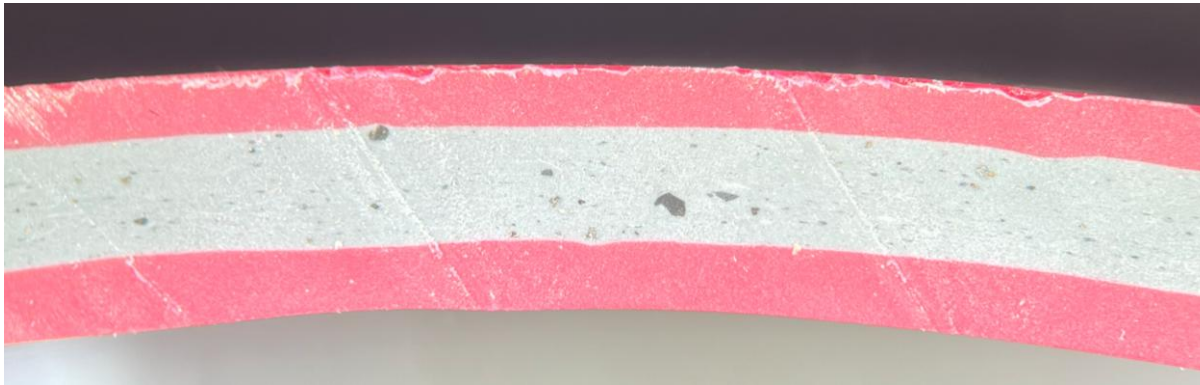


Image showing contamination that might be found in the core layer with rPVC

The second lifetime requirement by Vicat (VST) testing is another challenge, depending on the raw material used. The Vicat requirement in the pipe industry is generally higher compared to the window profile industry. Hence, if rPVC window profile material is used for the production of pipes with recycled content, a lower Vicat property may be the result.

Lessons learned

- The general experience with the production of PVC pipes with recycled content is that such pipes can be produced fulfilling the same requirements as virgin pipes. For the customer and end user, there shall be no difference in handling pipes with and without recycled content. In addition, also the expected service lifetime of these products can be fulfilled.
- The possible amount of recycled content used is closely related to the requirement that shall be fulfilled. As an example, sufficient impact and stiffness properties can be achieved with a rPVC content of about 50 %. However, such a pipe fails the lifetime test. To also ensure this requirement, the rPVC content must be reduced to about 40%. In general, while maintaining the product quality known from virgin PVC pipes, the possibility to add recycled content will be limited at a certain level.
- A multilayer pipe is a more technical product than a monolayer pipe. The separation in layers not only allows for the addition of recycled material, it also allows to control mechanical characteristics (such as impact properties) and general characteristics (such as colouring) more precise. By using the layer distribution of the multilayer pipe in an efficient way, product quality can be ensured for different material qualities. At the same time, the environmental impact of such pipes can be reduced compared to pipes produced with virgin material only.

Manufacture of PP and PE pipes with recycled content

We have produced corrugated pipes for land drainage from recycled PE, according to the Norwegian product standard NS 3065, used for agriculture for decades. The properties of the recycled PE is, of course, important. But the process window is wide and in this product standard there are no special material requirements. The time these products function is normally shorter as the filter materials around the pipes are normally clogged with fine soil within 30 – 50 years. There have been very few quality issues with these pipes during the years.

Other piping products of PP and PE for non-pressure applications have stricter requirements. The products first in line, allowing recycled content, are land drainage pipes used to control the ground water table in connection with buildings and infrastructure. There is no European product standard for such pipes yet. But a Nordic industry standard has been published, NPG/PS 116, based on EN 13476-3. EN 13476-3 cover structured wall plastics piping systems for non-pressure underground drains and sewers with smooth internal and profiled external surface.

Production trials have been rather successful. Virgin PP is used today. As the access to good quality PP recirculate is limited, we would also explore how recycled PE behaved using the same production equipment as for pipes of PP.

Lessons learned

The production with recycled PP gave products fulfilling all requirements. The only issue is the colour. The PP recirculate was from pipe products with different colours. We added black pigment, as black drowns out other colours and these land drainage pipes normally are black. We cannot add a lot of pigments as this compromises product quality. The result was black pipes with shades of brown – as the dominant colour of the recirculate was red-brown (from sewer pipes and fittings). Reactions on this are expected as colour is important in order to distinguish pipelines for different applications. And variations in colour may be interpreted as if something is wrong.

The production of pipes from recycled PE, with the same production equipment, went well. Due to the lower E-modulus of PE, we need to take some actions in order to meet all requirements for the finished products – especially regarding ring stiffness. It was not possible to implement all needed actions within the timeframe for this project. But all investigations, done by Norner and us, indicates it is no challenge to produce such a pipe meeting all requirements.