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GLASS-FIBRE UV-CIPP LINERS FOR NO-DIG PIPE RENOVATION AND THE IMPORTANCE OF THE INNER TUBULAR FILM FOR THE INSTALLATION

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ABSTRACT: This is a joint paper from RELINEEUROPE GmbH and SÜDPACK Verpackungen GmbH & Co. KG. The paper is divided into two parts. SÜDPACK, as one of the leading film producers in Europe, will focus on the inner tubular film (manufacturing and characteristics) and RELINE will present the installation procedure of the Alphaliner using the SÜDPACK inner film. The paper also includes some case studies and reference projects. Due to the fact that inner tubular films are used for the installation of the final liner produced by RELINE this presentation covers a significant part of the value chain with focus on the material needed for the trenchless pipe refurbishment.

1. Inner tubular films provided by SÜDPACK

SÜDPACK is a leading producer of high-performance films & packaging solutions. The portfolio includes films for the food packaging, medical and technical applications. The company is family owned since inception in 1964 and with the state-of-the-art machinery the global markets will be served out of 9 different production plants with more than 1.800 employees.

In terms of technology SÜDPACK is fully integrated, having blown film extrusion, cast film extrusion and lamination capacities for the base film production and printing and bag production capacities for conversion. In addition, compounding capabilities are also available.

Südpack has been investing in processes and technologies for many years in order to keep existing plastics in the cycle and to recycle them in a meaningful way. Internal materials management with in-house regranulation and compounding as well as the commitment to Carboliq, a pioneering chemical recycling technology, are essential components of the sustainability strategy.

The inner tubular films for the pipe renovation are produced with the blown film extrusion technology in Ochsenhausen (state of Baden Wuerttemberg).

The blown film extrusion process is the most common process to produce continuous films made from polymer materials. The process starts with the feeding of granulates by the hopper into the extruder. The extruder has the function to melt the polymer by heating elements as well as friction by the rotating screw inside the extruder.

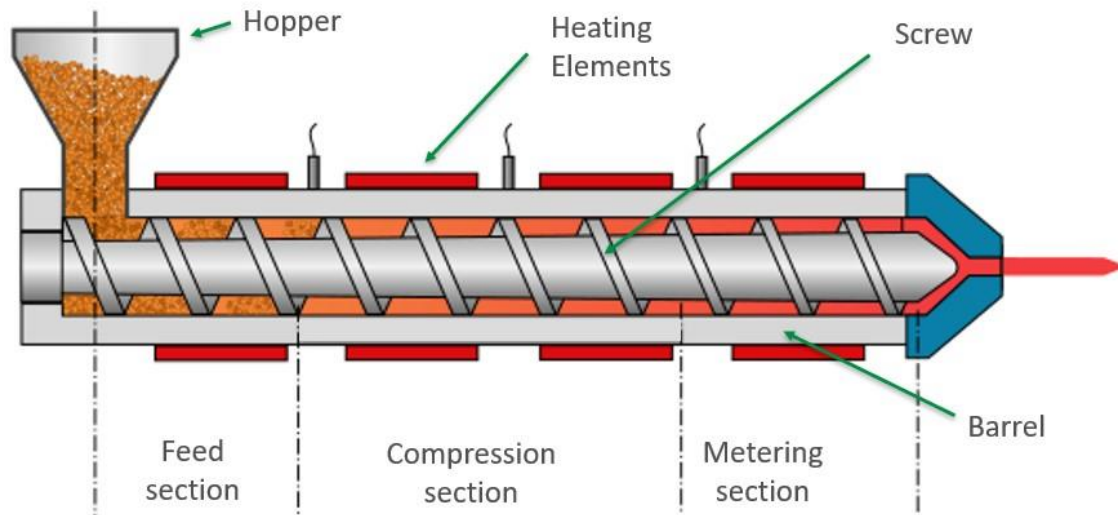


Figure 1: Illustration of an extruder

The extruder pushes the molten material into the film forming tool, called die head. With the die head the material will be formed into a tube of plastic material. After exiting the die head the material is still in a plastic state and will be pulled upwards by nip rollers and stabilized by a calibration system. At the same time compressed air is blown into the film tube to achieve the desired width while the total film thickness and thickness distribution is constantly measured and controlled. In parallel, chilled air is blown outside of the tube. Once cooled the film approaches the nip rollers and the bubble of film is gradually flattened into 'lay-flat' tubing. The nip rollers transport the film to the roll winders at the base of the line. It is also an option to slit the tube at the edges to achieve two stand-alone flat films.

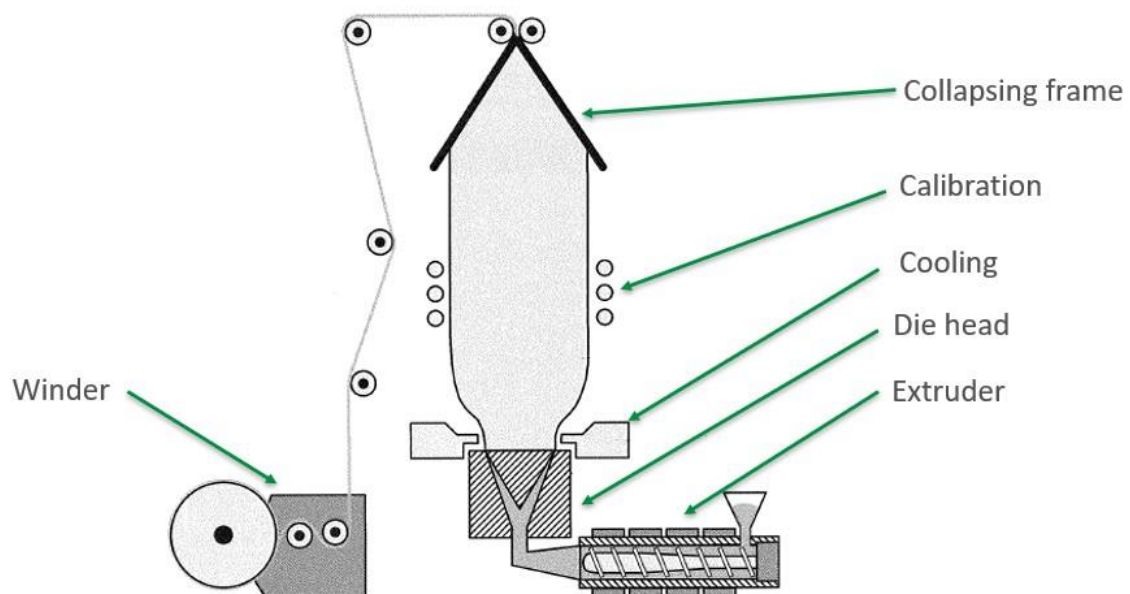


Figure 2: Illustration blown film extrusion process

Such a film can consist of one up to several layers. In terms of a multilayer structure more extruders are required.

The inner tubular film for the pipe renovation is a multi-layered film based on polyamide and polyethylene. In order to cover a required wide range of widths for certain pipe dimension SÜDPACK uses two different production lines. The main function of the film is to straighten up the liner to the appropriate position with air pressure during installation. The standard thicknesses of these films are 120µm, 150µm and 170µm. The films are extremely durable and sturdy. Due to the direct contact with epoxy resin the film needs a high chemical resistance and barrier function provided by the polyamide. The high mechanical impact on the film during installation requires an excellent consistent product quality without any deviations which may lead to weak points.

2. RELINEEUROPE UV-curing GRP liner – Alphaliner

2.1. Introduction

The success of a rehabilitation project with UV light-curing GRP hose liners depends to a large extent on the technologies used.

With its Alphaliner, RELINE is the global leader in the field of trenchless sewer rehabilitation with UV light curing. As the only manufacturer of GRP hose liners, RELINE also develops and produces complete systems and equipment from UV curing systems to turnkey complete conversion of rehabilitation and service vehicles.

With GRP technology, RELINE offers an optimal CIPP liner for trenchless pipeline rehabilitation that is tailored to the static requirements of the sewer, the quality of the wastewater or other media and the given safety requirements.

2.2. Built-up of Alphaliner

Materials of the highest quality - special ECR glass fiber and a resin adapted to UV light curing - form the basis for this successful GRP technology. This enables optimal curing with innovative UV light curing and long-lasting quality of the Alphaliner.

The innovative design of the Alphaliner stands for endless areas of application and stands out with properties that set high standards.

Liner build-up from the outside to the inside:

- UV light-proof, fabric-reinforced PVC outer protection, optionally as integrated sliding protection or integrated preliner.
- Polymer film (PA) with styrene barrier function.
- Load-bearing thickness of the composite structure consisting of ECR fiberglass for Alphaliner500G or for Alphaliner1800H. Formed out of wrapped pre-impregnated fiberglass layers.
- Abrasion protective layer against highest chemical and mechanical loads.
- **SÜDPACK** Inner film (PE/PA) as installation aid with styrene barrier (generally removed once curing is completed)



Figure 3: Built-up of Alphaliner

2.3. Inner film properties

The inner film defines the size of the liner, as the production of the Alphaliner is from inside to outside. This inner film must be capable of expansion without bursting in order of keeping the liner airtight during the whole installation process.

In our laboratory the quality assurance of incoming raw materials includes the test of expansion of the inner films.



Figure 4: Expansion test of inner film

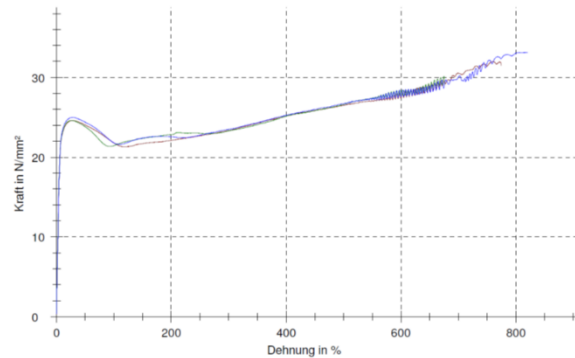


Figure 5: Expansion capacity of inner film

As already described above, the inner film consists of two important layers: the PA (polyamide) and the PE (polyethylene) layer.

In the Alphaliner the polyamide layer serves as styrene barrier as well as release film (installation aid), which facilitates the removal after curing. The PE layer serves as sliding partner, expansion material and as mechanical protection against damaging of the impregnated fiberglass composite during installation.

2.3. Production of Alphaliner

A key factor for a successful rehabilitation project is that the Alphaliner has been evenly impregnated along its entire length. To achieve this, the fibreglass complex is pre-impregnated with resin in a special process before the liner itself is produced.

As soon as the required resin viscosity has been reached, the resin impregnated fibreglass compound is wound into a seamless hose in an endless continuous production process. The fiberglass is applied directly to the inner film, which is only used as an installation aid. This winding process enables the production of hose liners in theoretically unlimited individual lengths. In practice, Alphaliners are manufactured with individual lengths of up to 500 metres.



Figure 6: Inner film for liner production

As there is no seam, the Alphaliner can expand far flexibly and homogenous when inflated with compressed air. Due to deliberate under sizing, the Alphaliner always expands close-fit to the host pipe wall. Its distinctive sandwich design enables the production of different types of liners, each with individual, precisely defined properties.

Alphaliner		Altrohr			
DN [mm]	Verbunddicke [mm]	von DN [mm]	bis DN [mm]	von Umfang [mm]	bis Umfang [mm]
150	3,0	146	154	459	484
	3,7	147	155	462	487
	4,4	146	150	459	471
200	3,0	195	205	613	644
	3,7	196	207	616	650
	4,4	197	208	619	653
	5,1	193	200	606	628
250	3,0	243	256	763	804
	3,7	244	257	767	807
	4,4	246	259	773	814
	5,1	247	260	776	817
300	3,0	293	308	920	968
	3,7	294	309	924	971
	4,4	295	310	927	974
	5,1	296	312	930	980
350	3,0	342	360	1074	1131
	3,7	343	361	1078	1134
	4,4	345	363	1084	1140
	5,1	346	364	1087	1144
	5,8	347	366	1090	1150
400	3,0	391	412	1228	1294
	3,7	392	413	1232	1297
	4,4	394	415	1238	1304
	5,1	395	416	1241	1307
	5,8	397	417	1247	1310
	6,5	398	419	1250	1316
	7,2	392	410	1232	1288

Figure 7: Range of application of Alphaliner in relation to the dimension of nominal width or circumference of CIRCULAR PROFILES to be rehabilitated.

To produce the Alphaliner, the inner film is pulled and pushed around the core cylinder. At the end of the cylinder are so-called vanes. These vanes expand to the desired diameter to produce the liner in the ordered dimension.

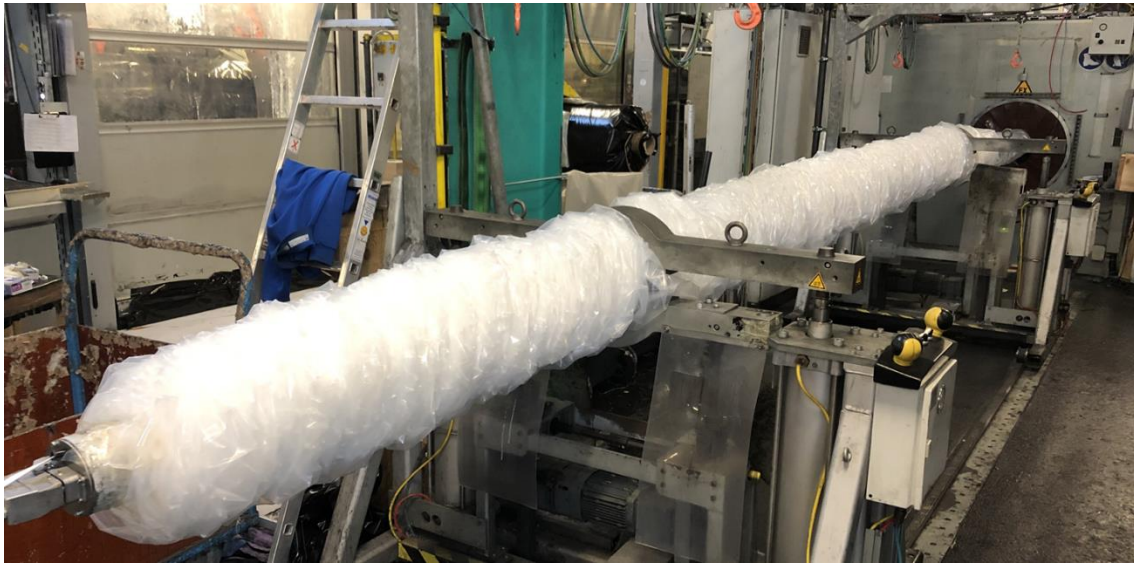


Figure 8: Inner film on the cylindrical production core

The production of the Alphaliner is a specific and unique system by wrapping the pre-impregnated fabrics around an expanded cylindrical core. This process is a continuous process and the Alphaliner is produced homogeneously along the requested length, with individual lengths available up to 350 meters as standard (can be extended to up to 600 meters).

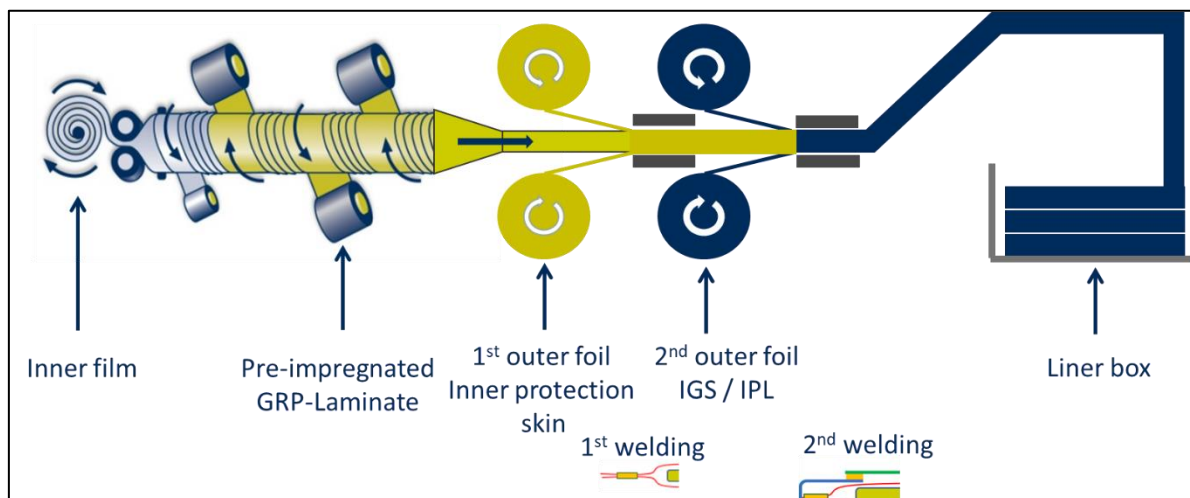


Figure 9: Schematic overview of Alphaliner production

2.4. Installation and curing

The installation process of the Alphaliner is a so-called pulling procedure. The liner is delivered ready to install in protective wooden crates, which are positioned nearby the entry manhole or open pit.

After drawing in the liner, both ends are blocked with appropriate end cans to maintain the compressed air inside. The liner is inflated with air with an inner pressure up to 500-750mbar for curing the liner.

When the liner is inflated up to the required inner pressure, the light chain with an amount of UV bulbs is pulled back with a predefined curing speed.

All installation parameter, e.g. inflation steps, inner pressure, inside and liner surface temperature, UV-light intensity of each bulb, curing speed and distance, are permanent monitored during all the process and protocolled for quality assurance.

After the curing process and a predefined time for cooling down, the end cans are removed, the liner ends cut back and, the inner film is removed from the liner.



Figure 10: Release of inner film after curing



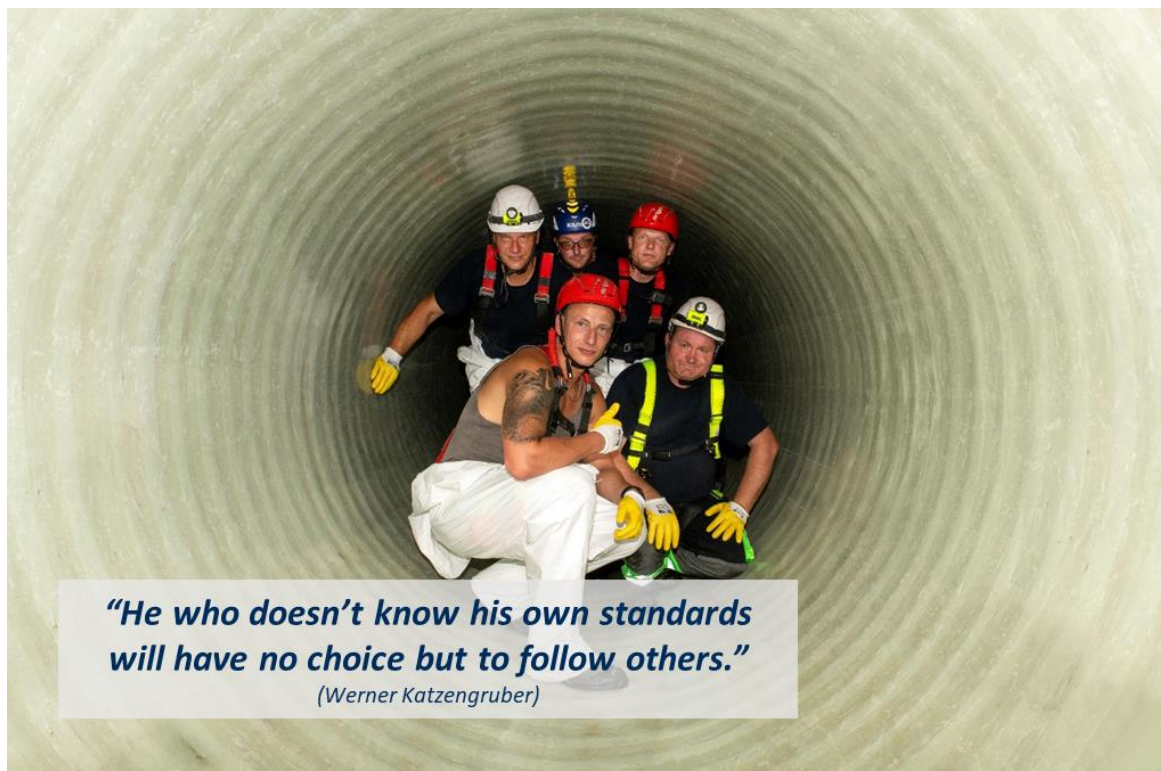
Figure 11: pulling of the inner film



Figure 12: Smooth liner surface after removal of inner film

After removal of the inner film the liner shows a very smooth and homogeneously tight surface.

The ends of the liner are sealed against the wall of the manholes or building chamber and the system can be returned to operation immediately.



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