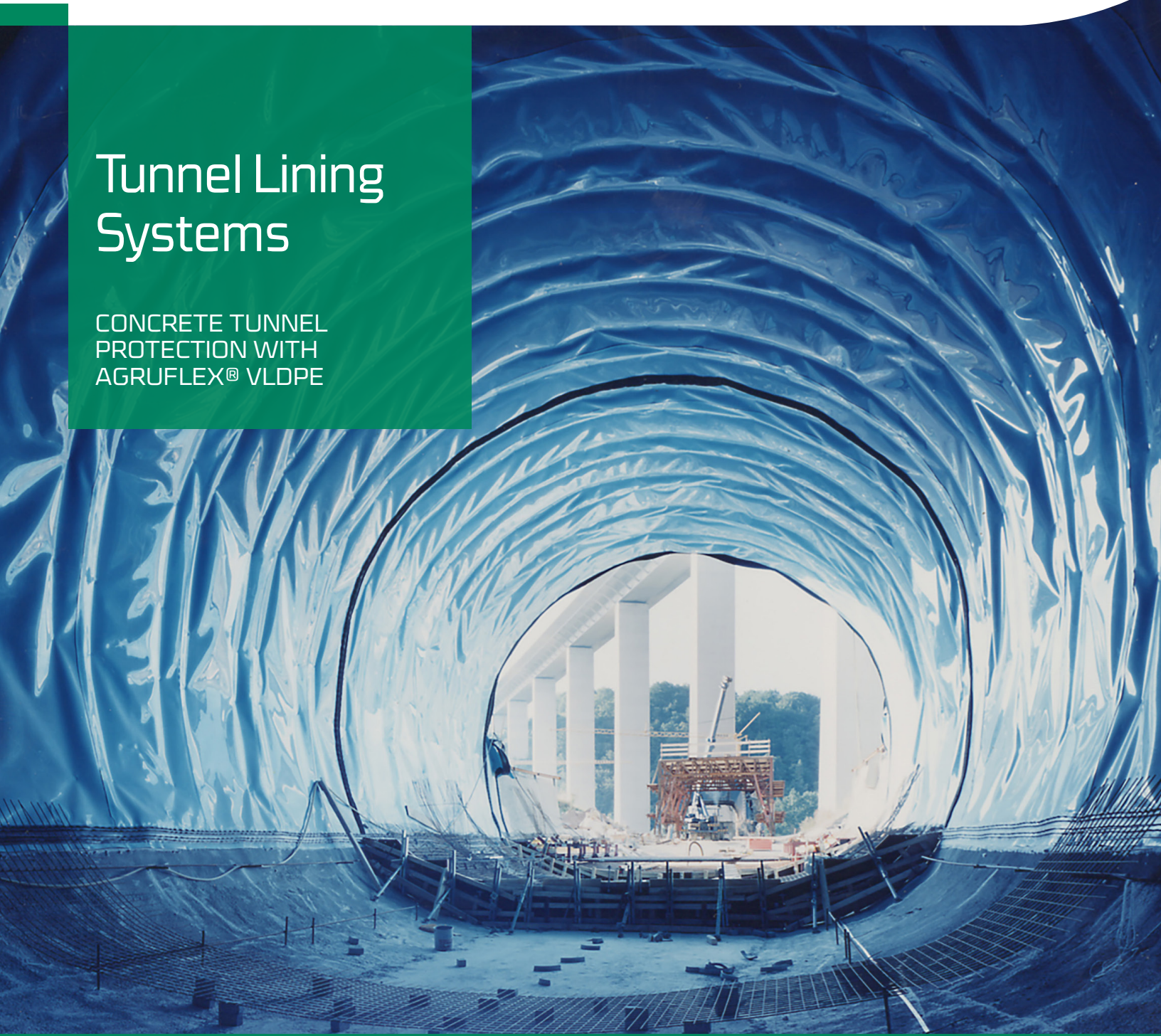


Tunnel Lining Systems

CONCRETE TUNNEL
PROTECTION WITH
AGRUFLEX® VLDPE





The Plastics Experts.

Our tunnel lining product group offers a complete, top-quality range of waterproofing and concrete protective liners that have a special focus on protecting tunnels from leakage as well as aggressive and abrasive media. These liners along with their ancillary components are specifically designed to meet the stringent demands and extended life requirements mandated for tunnels.

The AGRU success story has been unfolding for seven decades. Founded in 1948 by Alois Gruber, who set the company on the course for plastic manufacturing, AGRU has become one of the world's most important single-source suppliers for piping systems, semi-finished products, concrete protection liners, and lining systems made from engineered plastics. We use only top-grade thermoplastic polymers as our raw materials. When it comes to application-technical consulting, we are your best partner in the field.



Quality

Customer satisfaction comes first at AGRU. Technical consultations are an essential part of our customer service. The AGRU quality assurance system is compliant with multiple international standards and AGRU's procedures help ensure that products meet or exceed international standards, on an ongoing basis.

The start-to-finish attention to quality ensures that the products meet and beat the strictest technical specifications, giving safe and dependable operation within transportation, water, and wastewater infrastructures.

Overview

Water does not have to be a major obstacle during tunnel construction. With AGRU's complete set of tunnel lining systems, you can expect superior water resistance that virtually removes the maintenance cost to repair water spots, dripstones from lime diffusion, and external corrosion. AGRUFlex, an integral part of our lining system, is the perfect partner in SEM/NATM or conventional bored tunnel constructions. Its primary purpose is to protect concrete tunnel structures against the infiltration of water and/or gases, and aggressive soils and groundwater.

AGRUFlex is made with an advanced polyolefin called Very-Low-Density Polyethylene (VLDPE) (read more on page 4), which is non-toxic, flexible, and light.

- Non-Toxic: AGRUFlex does not produce toxic fumes which could cause health and safety concerns in the confined space of tunnels.
- Flexible: AGRUFlex flexibility and elongation properties allows it to easily conform to the irregular shapes and surfaces that are typically encountered in tunnels.
- Lightweight: AGRUFlex has a relatively low density of 0.89 g/cc, making it about 25–30% lighter in weight than competing PVC liners. Working with lighter materials reduces the burden and fatigue on installation crews and equipment.

Efficient corrosion protection in tunnels

AGRUFlex, produced from VLDPE, protects the inner concrete shell and supports:

- SEM/NATM, bored, and cut-and-cover tunnels
- Protection against aggressive mountain water
- Improved tunnel shaping thanks to its high flexibility.

Multiple layer choices

AGRU coextrudes AGRUFlex with a white or colored signal layer.

- Exposed white surface reflects light to enhance tunnel visibility.
- The colored signal layer improves damage detection.
- Leakage white or brightly colored surface layer enhances lighting in tunnel construction areas.

Economic installation methods

AGRUFlex supports simple and permanent welding technologies, with benefits such as:

- Physiologically safe welding
- Innovative installation methods (e.g., induction welding)
- An easy installation thanks to the product's high elongation and flexibility ratings.

One-stop shopping

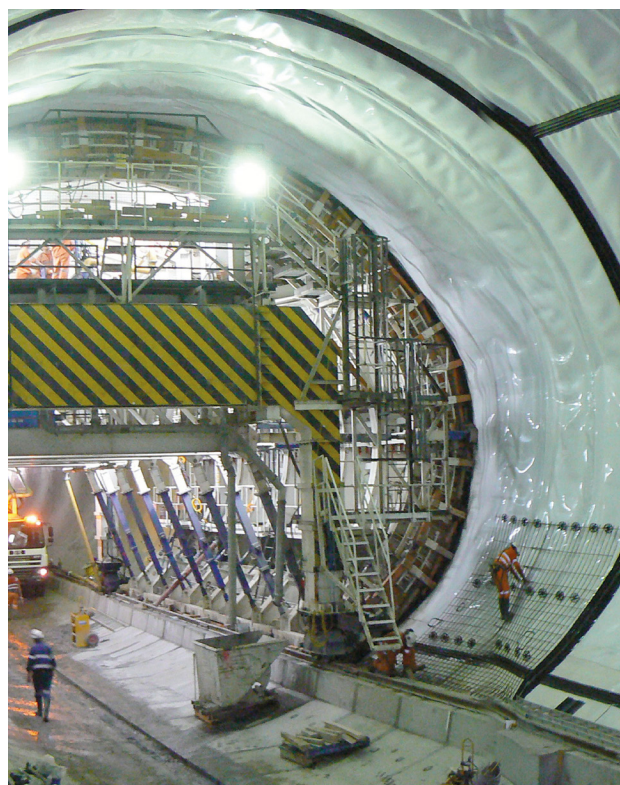
Purchase liners, water stop profiles, discs, and drainage pipes from under one roof.

- A complete product catalogue for the perfect watertight system
- Including welding rods, water stop profiles, and cleaners
- Drainage systems using polyethylene (PE) and polypropylene (PP) for area and strip drainage.

VLDPE

VLDPE is an acronym for Very-Low-Density PolyEthylene. Polyethylene (PE) is the most common and versatile thermoplastic material and is part of the family of polyolefins that also includes polypropylene. Polyethylene is used in numerous everyday items from packaging containers for milk, detergent, and bleach to applications such as bread trays, milk crates, totes, bins, waste receptacles, and stadium seating. Polyethylene is also used for many items that support infrastructure such as pipes and fittings, concrete protective liners, and geosynthetic materials including geomembranes. In fact, polyethylene is by far the most common material used in containment systems for hazardous and municipal landfills where the protection of our environment is of the utmost importance. Polyethylene has become the workhorse for these industries and many more due to a long list of benefits, including, but not limited to, its cost effectiveness, durability, chemical resistance, waterproofing capabilities, reparability, and longevity.

All polyethylene types are characterized by long molecular strings of hydrogen and carbon atoms, however slight variations of these polymer chains by molecular branching can affect properties such as density and crystallization. While material performance properties are also influenced by the variations of polyethylene, they are typically differentiated by a reference to their relative. As the amount of polymer branching increases with the variations of polyethylene, the density and crystallinity of the material are lowered. Therefore, a very-low-density polyethylene liner material is lighter and much more flexible than a high-density polyethylene liner of the same thickness.



Applications

AGRU's tunnel waterproofing liners are perfectly suited for any type of tunnel construction including cut-and-cover, drill-and-blast (SEM/ NATM), and TBM bored methods. AGRUFlex is the preferred waterproofing liner system for all types of tunnel applications including highway, rail, light rail, hydro, and more. Underground rail/light rail stations need many of the same waterproofing and concrete protection as the connecting tunnels. AGRUFlex serves as the primary liner against corrosion and water penetration.

Compartmentalization and Redundancy Systems

Water stop profiles and specialized drainage techniques give the necessary redundancy in waterproofing tunnels throughout the lifetime of the structure. Modern tunnel lining is designed to support discrete repairs of hollow or leaky areas through the use of injection resins. Water stop profiles are installed between the liner and concrete to create separate compartments. Integrated injection hoses can then be used to inject resins at repair sections.



AGRUFlex Installation Features

Visibility and Quality Control

AGRUFlex is offered with a coextruded signal layer consisting of a white liner face with a black reverse side. The thin white surface reflects light to brighten the work area for efficient and safe installation. The white signal layer also doubles as an additional means to perform quality control. Damage to the liner can quickly be detected when the white layer is compromised and exposes the black base layer.

Weldability

As a VLDPE liner, AGRUFlex can be welded by thermal methods which provide for secure and watertight seams. The majority of the seam welds can be accomplished using the proven method of fusion welding with a double wedge welder. This technology provides for fast and efficient welds that can be air tested to ensure quality and performance. AGRUFlex can also be welded using other techniques such as hot air and extrusion welding. No harmful fumes are emitted during welding.

Innovative Fixation Methods

Traditional fixation methods require workers to awkwardly reach behind the liner and attach it to the pre-attached fixation discs using a handheld heating gun often producing poor welds which can potentially damage the liner. With the extent of an average worker's reach limited to 1 m, this traditional fixation approach limits the width of liner rolls to 2 m. AGRU's EasyFix and Induktofix fixation systems provide innovative methods which do not require access to the back of the liner. Therefore, these technologies support wider liner widths resulting in significantly fewer seams. Fewer seams result in minimized installation/welding efforts and an overall increased security for waterproofing.

- The EasyFix® system utilizes a nonwoven geotextile felt which is bonded to the back of the liner. The liner is simply pressed onto discs with a VELCRO® hook and loop design that secures the liner in place.
- Similarly, the Induktofix® system provides for secure induction welding from the face of the liner to special discs with an embedded wire mesh supporting the induction welding process.

Complementary Products

In addition to waterproofing liners, AGRU also offers a full line of complementing accessories.

AGRU Water Stop Profiles

The perfect solution for attaching concrete protective liners and other liners to large concrete constructions and for compartmentalizing areas for future, low-intrusive repairs. Benefits include:

- Integrated injection hose clamp for OD 9–12 mm
- Defined outlets for even distribution
- Flexible VLDPE resin
- Optimized compatibility with polyolefin-based tunnel liners
- Available in a variety of configurations and dimensions.

AGRUTEX Nonwoven Geotextile

Geotextile for cushioning tunnel constructions that are currently undrained, partially drained, or fully drained. AGRU manufactures a range of nonwoven geotextiles, composite drainage materials, and piping systems at various dimensions to support the construction of even the most complex drainage system. AGRUTEX benefits include:

- Provides for enhanced drainage
- Gives cushioning/protection for the waterproofing membrane.
- Highly customizable to fit project requirements.

Liner affixation discs/systems

Linear affixation discs/systems offer a means of temporary attachment of the liner to the tunnel substrate and also support the geotextile cushion/drainage layer. Benefits include:

- Available with traditional, EasyFix, and Induktofix technologies
- Chemical and corrosion resistant
- Manufactured using VLDPE
- Incorporates failsafe breakaway technology.

GeoClay Geosynthetic clay liners

AGRU GeoClay geosynthetic Clay Lines (GCL) prevents the penetration of liquids to support the integrity of a structure. Often used in conjunction with a waterproofing membrane liner, GeoClay adds additional waterproofing protection and provides self-sealing properties). Benefits include:

- Available as single liners or composite liners when used in conjunction with a waterproofing membrane
- Available in a variety of configurations with AGRUTEX needle-punched nonwoven geotextiles
- Provides the self-sealing benefits of a composite liner system.



Subject to errors of typesetting, misprints and modifications.
Illustrations are generic and for reference only.

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