
WHITE PAPER CABLE PROTECTION FOR RAIL APPLICATIONS

45 years PMA Cable Protection in Rail Vehicle and Railway Infrastructure Applications

Cable protection and wiring in the Rail Industry



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Like the Jungfrau Rail Company in Switzerland, PMA has been providing rail companies with cable protection solutions for 45 years

PMA has provided cable protection solutions to many of the world's leading rail manufacturers including Alstom, Ansaldo Breda, BEML, Bombardier, CAF, CRRC, Downer Rail, ERA, Hitachi, ICF, Faiveley, Kawasaki, Koncar, Mitsubishi, PESA, RCF, Siemens, Solaris, Stadler, Talgo, Voith, Wabtec and many others. Through proven product and service performance, PMA has gained a reputation as a reliable business partner supplying components of the highest quality.

Today's challenges in the rail industry

Product performance and quality are influenced by many factors including design, materials, production equipment and processes. Our team of designers continuously improves component design, evolving a product range tailored to the requirements of rail applications. New designs have required the introduction of new production processes such as the two-component injection

Since the start of the PMA product line in 1975, a strong focus upon the railway industry exists, providing cable protection solutions for almost all types of rail vehicle and for railway infrastructure applications. During this period, the team has gained knowledge and experience from countless projects and applications around the globe.

molding process required for the PMAFIX Pro fitting and the multilayer extrusion process required to manufacture the new rail conduits. Throughout its history, the PMA team has worked continuously on the formulation of ideal raw material mixtures. PMA proprietary material mixtures include basic polyamide 6 or polyamide 12 in combination with characteristic modifying additives. Flame retardants, plasticizers, lubricants, UV and heat stabilizers, impact modifiers and color batches. Because the interaction of the various additives is difficult to predict in advance, the development of new material mixtures requires time consuming iterations of sampling and testing. Close relationships have been established with major raw material suppliers, ensuring PMA remains up to date with new material developments. During times of material shortages, PMA still receives raw material when other manufacturers are receiving reduced supplies. The task of optimizing raw material mixtures is particularly difficult for the railway industry because of the stringent fire safety requirements applied.



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01 PMA can develop system solutions and special products that are designed to meet specific customer requirements

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02 PMA has developed novel, innovative, EN 45545-3 compliant fire barrier solutions for combination with its proven cable protection systems.

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03 The PMAFIX Pro has two components, an outer body and an inner sealing element. The sealing element functions both as a seal and as a locking mechanism providing all ingress protection grades up to IP68 and IP69 even in applications where there is long term continuous movement.

Passenger safety is of paramount importance so only plastic materials complying with the limits for flammability, smoke emission and toxicity set by the international standards may be used. Since there is an inherent tradeoff between fire safety characteristics and mechanical performance criteria, the material formulation becomes even more critical. A conduit with the necessary fire safety certification but fails in the application after a short period of service may require trains to be taken out of service for expensive repair procedures. This underscores the need for superior materials and the extensive testing that the PMA team provides.

Providing complete cable protection systems for rail applications

For flexible polyamide cable protection systems for rail vehicle and railway infrastructure applications, PMA is a technology leader in the market. The PMA product portfolio has continuously evolved to meet the new challenges of the applications. The PMAFIX Pro fitting series, for example, is a technologically advanced fitting for a corrugated conduit. It combines ultimate simplicity for the user, push fit installation with an audible “click” confirmation of correct assembly, and produced through state-of-the-art construction. The key element, the PMAFIX Pro locking and sealing

element, is produced in a two-component injection molding process. The structural core provides mechanical stability, as the locking function positions the conduit perfectly centralized within the fitting. The softer sealing component provides the longest sealing area of any fitting available on the market. Sealing material on the inside of the core provides a seal to the conduit, sealing material on the outside of the core provides a seal to the fitting body. The design and development of the



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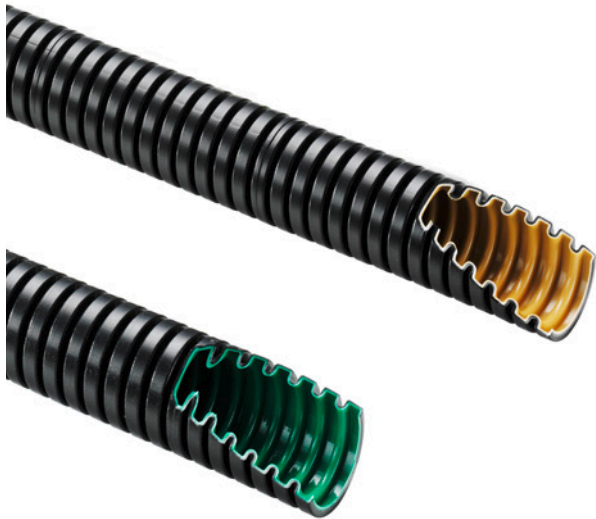
— BGPM modular multiple conduit and cable clamping system provides total modular configuration flexibility to clamp any combination of conduits and/or cables

PMAFIX Pro fitting required the introduction of two component injection molding technologies in the PMA manufacturing facility.

New multilayer conduit technology for improved performance characteristics

PMA multilayer conduit technology is designed for optimal performance characteristics for the various applications on trains and in rail infrastructure applications. A differentiator in the market, the technology allows the best features of different materials to be combined to create conduits with the ideal characteristics for specific applications. In order to produce multilayer conduits, new extrusion equipment was required with multiple extruders feeding a single corrugating tool. A further demonstration of the PMA technology leadership in the cable protection market is the newly launched BGPM modular multiple conduit and cable clamping system. This provides total modular configuration flexibility to clamp any combination of conduits and/or cables. It provides ease and flexibility for installation. It can be pre-installed as

— The new multilayer conduit product line for the rail industry provides optimized performance in rail applications.



part of a cable loom before attachment to the train or it may be attached to the train first before the conduit and cables are introduced. It is the lightest, most compact clamping system of its kind available on the market and it is manufactured from a material which is certified by the major international fire safety standards.

In-house PMA testing facilities

Testing plays an essential part in the attainment and maintenance of quality levels. It is critical as a means of assessing possible new materials, processes and designs, it is necessary for design verification in new product development and must be performed to ensure quality control of series production components. With extensive testing facilities available for PMA both in house at the production facility in Uster, Switzerland and at other ABB sites around the world, products are tested to internationally recognized standards. For cable protection products designed and manufactured by PMA, IEC 61386 and UL1696 are the most commonly applied general product standards that include a wide range of tests for mechanical strength characteristics, flexibility, operating temperature range, system ingress protection and resistance to aging under temperature and UV exposure. The international standards test to specific performance levels. PMA performs tests beyond these levels according to internal procedures to find the performance limits of each product. A state-of-the-art-robot is installed in the laboratory able to simulate complex movements which may occur in a specific application, such as the cable connection between two railway carriages. PMA has invested in equipment to measure the limited oxygen index (LOI) of materials. This enables PMA to test possible new materials and if the fire safety certification of our competitors is genuine according our test results. PMA has also invested in a Fourier Transform Infrared Spectroscope (FTIR). When plastic materials are exposed to infrared radiation over a



— Extensive testing is critical for research and development of new cable protection products

range of different frequencies, some frequencies are absorbed more than others. The frequencies which are absorbed correspond to the frequencies which cause the molecular structure of the material to vibrate. (Resonant frequencies). The FTIR machine records the profile of absorbed frequencies, which is unique for each different material and used in categorizing the materials. Additives such as flame retardants show up as a peak on the characteristic curve of a material. This technology allows us to identify with very high probability the materials used in the market. PMA has focused on offering a complete cable protection system, not just individual components. For external rail applications, the state of the art PMAFIX Pro fitting series offers customers a performance level ahead of the competition.

Fulfilling IP68 and IP69 according to EN60529

— Fourier Transform Infrared Spectroscopy (FTIR), allows PMA to identify with very high probability the materials used in cable protection products.



standard and fulfilling the PMA DO 9.21-4440 sealing test under dynamic conditions that simulates real applications where the conduit moves relative to the fitting helps ensure consistent performance. The unique construction offers the longest sealing area available and the conduit is mechanically fixed within the fitting so that if the conduit moves, bending cannot occur within the fitting sealing area. Please refer to the new Test Methods section of the PMA website.

Focused on serving the customer with customer specific solutions

Serving the customer has remained a strong focus for ABB. The PMA team provides information and guidance on application specific challenges, and develops products to meet the needs of the rail industry. PMA maintains the highest level of customer support throughout all phases of a project from design through the project build phase and to the operation phase with a fast, efficient response. PMA has local representation worldwide able to support customers with product knowledge specialists in local language and provide local stock for fast delivery.

Application and customer specific developments have been an important factor in serving our rail customers. If PMA does not have a suitable product in its standard range to solve a customer design problem, the team is able to design a customer-specific element to provide the necessary function. From its beginnings, PMA adopted a systems approach to cable protection, designing conduits,



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40 years' experience in material technology is a key factor for developing new cable protection products with increased product performance.

fittings and accessories for optimal function together as a system. Tolerances of all components within the system are aligned for correct function. Conduit and fitting dimensions must be aligned for correct sealing performance, conduit and accessory dimensions must be aligned to ensure correct function. For example, PMA conduit clamps are designed to provide axial fixation but with rotational freedom to prevent torsion forces building up in conduits. Consequently, PMA declines all product liability claims for installations where PMA products have been used in combination with components from other cable protection manufacturers.

Over 40 years experience in material technology

PMA has over 40 years' experience in the development of polyamide conduits for the rail industry. The research and development for creating the new rail multilayer conduits has been some of the most challenging work performed by our research and development team. The combination of fire safety, mechanical performance and the retention of performance throughout the conduit's service life remain the leading attributes for the PMA products.

An in-depth excursion about extrusion processes for conduits

There are two processes used for the manufacture of corrugated nylon conduit: pressure and vacuum

extrusion. PMA uses both processes in the production of PMA cable protection conduits.

Pressure Extrusion

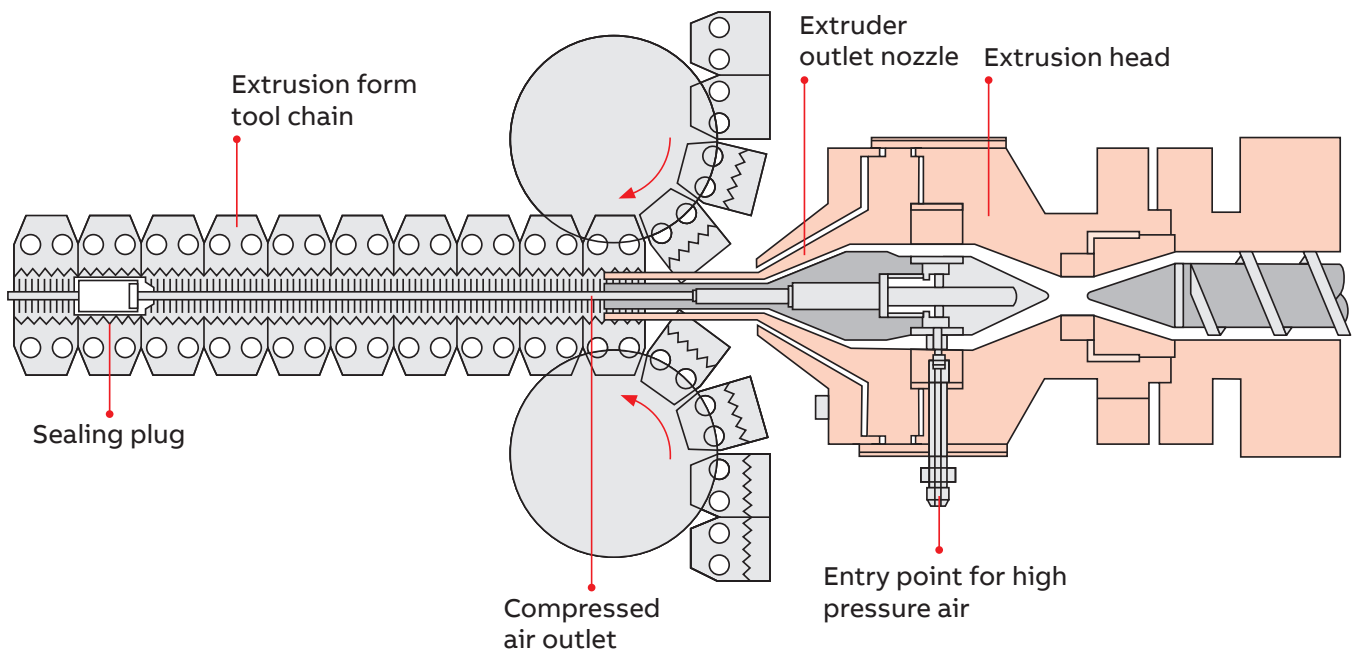
For corrugated conduit production, the pressure extrusion process consists of a tube of molten plastic exiting the extruder jet and is blown outwards into the corrugator mold. The mold defines the outer contour of the conduit. A sealing plug is used within the conduit in order to maintain the air pressure within the conduit. The manufacture of corrugated conduits by the pressure process method is a combination of two processes, extrusion and pressure molding.

Vacuum Extrusion

For corrugated conduit production by the vacuum extrusion process, a tube of molten plastic exits the extruder jet and is then sucked into the corrugator mold by a vacuum pump. The two processes can be combined to process very difficult materials.

Characteristics of Pressure Extrusion

- Applicable to many different types of material with a broad range of viscosities, also materials with high additive content such as flame retardant or plasticizer.
- Broader scope for mold extraction of different materials with varying viscosity than vacuum extrusion.
- Constant conduit quality over prolonged periods of time, long production runs due to practically no buildup of deposits.
- Outer surface of conduit always smooth (No vacuum slit) can be important for sealing systems



- Process begin difficult to control due to sealing plug
- Sealing plug must be adjusted for different weights of conduit with different wall thickness and ID .
- For large thick wall conduits and highly viscous materials it is difficult to achieve an even wall thickness throughout the corrugation.

Characteristics of Vacuum Extrusion

- Easier process start-up particularly for low viscosity and fast crystallizing materials.
- Higher production speeds achievable through faster and cleaner mold extraction.
- Quicker adaptation to a new conduit weight (No tooling change required)
- More suitable for large conduit sizes. Constant conduit profile and easier tool extraction
- Visible signs of the vacuum slit on the conduit surface particularly when processing low viscosity materials. Can negatively affect sealing performance in combination with fittings.
- Additives may be drawn out of the raw material

- by the vacuum. Additive migration to the surface can cause deposits in the mold/vacuum slits. Periodical cleaning necessary to prevent quality reduction over time due to deposits
- Maintenance of a good vacuum seal essential for product quality, requires extensive cleaning and maintenance routines.
- Higher investment costs due to complex mold geometry with vacuum slits and vacuum pump.

Summary of extrusion process technology

In general, the vacuum extrusion process is advantageous for large production batches with standard materials and for large diameter conduits. The pressure extrusion process is advantageous for flexible production of small batches of different materials with high additive content and where constant high-quality production is the highest priority.

Both processes have advantages and disadvantages but can be used for most applications without major difficulties or differences in the product quality. For the PMA conduit range and production practices





Smart Sensors are wireless, self-charging devices that easily attach to equipment, monitor crucial functions and report data through the ABB Ability™ system. .

with many different materials and frequent changes, the pressure extrusion process is mostly preferred.

For the production of multilayer conduits in large diameters the possibility exists to choose either process depending upon the material. The processes can even be combined.

Smart Cable Protection System enables users to cut downtime, reduce sudden failures and pinpoint needed repairs rather than performing expensive change outs based on generic schedules. A patent is pending on this groundbreaking new technology.

Links to topics mentioned in this white paper:

[PMA Rail portfolio](#)
[PMA Testing facilities](#)
[PMA Fire barrier solutions](#)
[PMA Multilayer conduits](#)
[PMA Smart sensor solutions](#)

The future: Intelligent cable protection

One of the key issues in many industrial applications is the penetration of water into electric systems, caused by damaged components or condensation. Smart Sensors are wireless, self-charging devices that easily attach to equipment, monitor crucial functions and report data through the ABB Ability™ system. With ABB Smart Sensors already available to monitor electric motors, pumps and mounted bearings, PMA supports integration of ABB Ability™ to Smart Cable Protection System. Through integrated sensors, the PMA cable protection products can detect this kind of water penetration early on.

With the ability to pinpoint important indications of problems in cable protection systems such as condensation, leakage, fractures and high heat,

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