

USING HOME-PRODUCED MATERIALS FOR THE IN-HOUSE PE INSULATION OF STEEL PIPES

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Currently, high level of corrosion protection of main oil and gas pipelines is achieved by the combined application of modern insulating coatings and electrochemical protection. In-house applied coatings based on extruded PE have been widely used within the last few years.

The transition from bitumen mastic and film in-situ coatings to factory applied PE coatings of pipes allowed to increase the pipelines construction rate, eliminate the dependence of insulation works on weather conditions. Most importantly, as a result of extensive application of pipes with factory applied coating in construction of oil and gas pipelines, the quality and efficiency of corrosion protection has grown. Modern polymeric coatings can provide corrosion protection of pipelines for 40–50 years. Quality corrosion protection allows to significantly reduce the risks and emergencies, as external corrosion causes the most of emergencies of main pipelines.

There are two types of factory applied external PE coatings used in Russian Federation: two-layer PE coating and three-layer PE coating.

The two-layer PE coatings, consisting of adhesion sublayer based on hot-melt polymeric compound of 250–400 microns and outer PE layer of no less than 2 mm, are used as external protective coating for field pipelines, inter-settlement low-pressure gas pipelines and utility networks. They are practically not used abroad and they have been replaced by modern three-layer PE pipe coatings.

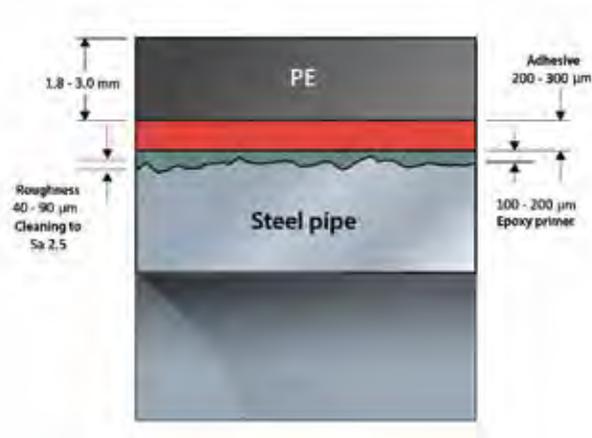
Three-layer PE coating is currently the most popular among all protective coatings applied in-situ or in-house. Unlike two-layer PE coatings, three-layer coating is not limited to pipe diameters and can be applied during construction of pipelines of any purpose.

The design of three-layer PE coating (pic. 1) is made of the following consequently applied PE layers:

- epoxy primer layer (100–200 micron thickness for powdered epoxy paints and 50–100 microns for liquid epoxy paints);
- adhesive sublayer based on hot-melt polymeric compound (thickness of 200–300 microns);
- external PE layer (thickness of PE layer and the total thickness of coating depends on the pipe diameter, type of coating and, as a rule, changes from 2.0 to 3.5 mm).

The epoxy primer ensures coating resistance to cathodic disbonding, increased adhesion with steel as well as adhesion stability in the course of long-term operation, providing the basis for corrosion protection.

Adhesive polymeric sublayer is an intermediate transition layer between epoxy primer and PE layer. Its main function is to provide adhesion between outer PE and inner epoxy layers. Specially developed hot-melt polymeric compounds based on graft PE are used as adhesives. Such compounds have increased softening and melting points, high durability that allow to widen the temperature range for in-house coatings (up to +80°C) and significantly increase their adhesive properties.



Pic. 1. Design of three-layer PE coating

External PE layer having low moisture permeability acts as diffusion barrier and simultaneously provides high mechanical strength, impact resistance, puncture resistance, excellent dielectric properties.

The signature feature of three-layer PE coatings is the application of high-density PE compound for external extruded layer, that enhances all mechanical properties of the coating including tensile strength, impact resistance (in wide range of temperatures), puncture and cuts resistance. Enhanced mechanical properties of in-house applied three-layer coating ease transportation, long-term storage of insulated pipes, and range of construction works and pipeline installation.

Combination of three layers makes three-layer PE coating solid and one of the most effective protection coatings of pipelines.

Until recently all Russian companies mainly used imported insulating materials for three-layer PE coatings. Powder epoxy paints were supplied by 3M, BS Coatings, Akzo Nobel, Jotun Paints. Borealis AG, Basell Polyolefins, Total Petrochemicals, Arkema and a number of South Korean companies supplied adhesive composites and PE.

Despite the ever growing need in plastic materials for in-house PE pipe insulation there is an obvious deficit of home produced high quality advanced insulating materials. Home produced materials used for two-layer PE pipe insulation do not meet the modern technical requirements (industry regulation of Gazprom, AK Transneft) by a number of properties. Hence development and deployment of new plastic materials for in-house pipe insulation is an important matter of practical significance. It should be noted that the development of home produced materials for in-house pipe insulation has been intensified lately. Deployment of epoxy primers of producers like Yaroslavl Plant of Powder Paints and Pigment LLC of St. Petersburg has been successful as

well as localisation of a number of foreign materials. Significant achievement has been reached in import substitution of adhesive and PE compounds for three-layer PE coatings by METACLAY CJSC, company of RUSNANO, which held about 20% share of PE coating market in 2014. POLYPLASTIC R&D Company has offered its own integral solution – Armobond composite adhesive and Torlen PEHD compound.

POLYPLASTIC together with Stavrolen started development of anticorrosion materials for pipelines in 2005. As a result of testing at production settings of Volzhskiy Pipe Plant, Moscow Pipe-Coating Plant and lab testing of VNIIST Institute, Lukoten F3802B pipe grade PEHD by Stavrolen was approved for use in three-layer PE coatings for pipes used in construction of main oil pipelines. Despite positive results of testing, the new PE composite found limited application in factory pipe coating. Deployment of the material was limited by its high viscosity, insufficient handling ability using transverse extrusion method and absence of home produced adhesive. Leading foreign companies offer complex solution to the pipe insulation industry – adhesive composite + PE composite.

Therefore, in 2012 POLYPLASTIC R&D Centre began research and development work to create own composite adhesive and PEHD for in-house PE pipe insulation similar to world's leading companies.

The following conditions were taken into consideration during materials development:

1. Technical characteristics and processability of materials must be competitive to their imported alternatives.
2. Basic insulating materials and PE coatings derived from them must comply with GOST R 52568-2006, Gazprom requirements (STO Gazprom 2-2.3-130-2007) and general specifications of Transneft (OTT.25.220.01-KTH-212-10).
3. Materials must be compatible with modern high-speed lines with the output of 3000 kg/hour.

The deployment of Armobond – Torlen anti-corrosion system started in 2013 [5]. The key feature of materials is the significant presence of home produced raw materials in composition.

To date, the following materials have been developed and passed technological and approval testing:

- Armobond PE-2K adhesive composite, TU 2243-122-11378612-2014;
- Torlen PE-2K-901 PE composite, TU 2243-123-11378612-2014.

Armobond PE-2K adhesive composite is a modified material based on LLDPE, has high processability, increased thermal stability and great mechanical properties.

Torlen PE-2K-901 PEHD composite has an optimal set of process and physical-mechanical properties as well as thermal stability. Armobond PE-2K system can be used for both two-layer and three-layer PE pipe coatings.

Technological tests of materials were carried out during batch production while coating application on big diameter pipes at Moscow Pipe-Coating Plant and Vyksa Steel Works. Coating application process was identical to the application of materials based on imported materials (application of Armobond at melt temperature range from 220 to 235°C, Torlen PE composite – from 230 to 245°C). This simplifies the transition between the coating systems and does not require readjustment of the equipment, which minimises possible additional costs.

Adhesion of the coating with steel in all cases was over 300 N/cm and cohesive peeling was observed during testing (pic. 2).

Currently there is a number of successfully passed testings



Pic. 2. Peel testing. Cohesive peeling of Armobond PE-2K

applied at MTKZ OJSC, VMZ OJSC and a number of other enterprises with a combination of Resicoat R-726LD (AkzoNobel), PEP-0305 (NPK PK Pigment), PEP-0130 (YaZPK) epoxy primers. The quality of coating is approved by certificates of conformance of Transnet AK on all types of coatings of VNIIST OJSC, VMZ OJSC and approval of Gazprom VNIIGAZ.

Composition of Armobond adhesive and Torlen PE can replace their imported analogues, which helps import substitution of produce for main pipelines in a very important energy sector.

From the beginning of 2015 POLYPLASTIC R & D began serial production of Armobond and Torlen compounds and can commit to 20 thousand tonnes of produce per year, which will satisfy 25% of total demand from home enterprises in this type of material.

References

1. S.G. Nizyev. Factory pipe insulation at home enterprises. – *Territoriya Neftegaz*, No. 11, 2004.
2. S.G. Nizyev. Modern materials and coatings for corrosion protection of main oil pipelines. – *Corrosion TNG*, No.2 (7), 2007
3. S.G. Nizyev. Features and prospects of factory pipe and fittings insulation. – *Territoriya Neftegaz*, No., 2008.
4. S.G. Nizyev. Corrosion protection of main and field pipelines using modern polymeric coatings. – *Territoriya Neftegaz*, No.9–10, 2009.
5. K.A. Evseeva, V.V. Bitt, D.A. Abrosimov, A.I. Ekimov, E.V. Kalugina, A.A. Ioffe. Polymeric compounds for corrosion protection of steel pipelines. – *Plastic Pipes*, No.1 (39), 2013.