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Study on the Behavior of the Cold-Applied Extruded Polyethylene Insulation under the Influence of Mechanical Actions – Part 1

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Abstract: ***This paper aims to research the mechanical phenomena leading to the advanced deterioration of insulation, considered to be the most important factor within a natural gas distribution system in terms of its protection, which is vital for supporting a good operation in exploatation.***

Keywords: insulation, polyethylene, mechanical action

1. Introduction

The deterioration of the underground natural gas pipeline insulation is generated by a multitude of factors, the most important of which being the application technology and the working conditions.

The modern passive protection against corrosion is achieved by coating the pipes with extruded polyethylene or by applying cold-rolled wrappings of self-adhesive tapes in one or more layers. [4]

Over time, the insulation is exposed to deterioration by the aggressive action of the trench bedding in which the pipe is laid-down. Accelerating damage is caused by failure to comply with the conditions specified by the insulating products manufacturer. Since application, the insulation should not show defects such as poor adhesion due to the incorrect application, insufficient or exaggerated stress, discontinuities, etc. During operation, the insulation defects can be the result of the water absorption or the presence of hard bodies in the soil cover that are imprinted in the insulation. [5]

2. The Current State of Research in the Field

Starting from the analysis of the defects found on the urban gas distribution networks, we can classify the deterioration factors as follows:

- Corrosion defects due to an improper laying of the pipe networks:
- Corrosive soils;
- Inappropriate depth;
- Non-existent or inadequate sand protection layer;
- Heavy traffic;
- Interventions of third parties in the area of the urban gas distribution networks:
- Modernization of other underground utilities or the extension of the existing ones;
- Conducting general excavations at a depth of more than 0.5 m in order to modernize the road infrastructure, which is by far the most likely to contribute to the deterioration of the natural gas distribution network;
- Unauthorized or unprepared repairs and maintenance to remedy defects. [3]

The following can be added:

- The lack of cathodic protection of the pipes;
- The existence of stray leak currents;
- The natural calamities such as landslides, floods, earthquakes. [2]

The present paper will approach the mechanical characteristics of the Xunda type self-adhesive tapes.

3. The Tensile Test

3.1. Building the specimens

Starting from the assumption that in many cases, due to excavations, the distribution pipes are damaged, hit or simply hooked, we tested polyethylene specimens made according to the model in Figure 1.1. [1]

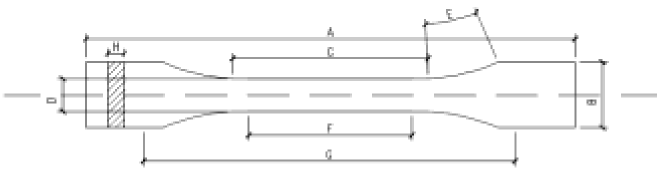

Figure 1: PE insulation specimen

The specimens were made by water jet cutting, the sets comprising:

- One defect-less layer

- Two defect-less layers
- Three defect-less layers
- One defect layer
- Two defect layers
- Three defect layers

As it shows in the figures below, a defect 3 mm in size was simulated on some of the specimens subjected to the tests.

Table 1. Size of specimens

Symbol	Description	Size [mm]
A	Total length of specimen	150
B	Width of the specimen in the clamp area	20 ± 0.2
C	The calibrated length of the specimen	60 ± 0.5
D	Width of the specimen in the calibrated area	10 ± 0.2
E	Radius	60
F	Length of the extensometer	50 ± 0.5
G	Initial distance between bars of the testing machine	115 ± 0.5
H	Thickness	depending on the no. of layers

Figure 8: Polyethylene specimens with three defectless layers

Figure 9: Polyethylene specimens with defect simulation

3.2. Material of the specimens

The material used for the specimens is the polyethylene and butyl rubber Xunda-type tape appropriate for insulating welded ends of steel pipes pre-insulated with extruded polyethylene, branches, bushings, transition fittings, etc.

The insulation materials subjected to this test are composed of single tape systems, which are cold-applied, recommended for:

- Insulating the butt welds, curves, branches (simple tees), bushings, the metal part of the steel-polyethylene transition fittings;
- The tapes are asymmetrically structured on three layers on polyethylene support and fitted with butyl rubber adhesive on both sides.

The catalogue characteristics of the tape material are listed in Table 2. [6]

Table 2. Characteristics of the polyethylene specimens

Structure and composition of the tape	-	Asymmetrically structured three-layer tape on polyethylene support and fitted with butyl rubber adhesive on both sides.	-
Nature of the supporting film	-	Stabilized polyethylene	-
Nature of the adhesive	-	Based on butyl rubber	-
Total thickness	mm	≥ 0.75	SR ISO 4593:1998; SR ISO 4591:1996
Thickness of the polyethylene supporting film	mm	≥ 0.25	SR ISO 4593:1998; SR ISO 4591:1996;
Thickness of the butyl rubber inner layer	mm	≥ 0.40	SR ISO 4593:1998; SR ISO 4591:1996;
Thickness of the butyl rubber outer layer	mm	≤ 0.10	SR ISO 4593:1998; SR ISO 4591:1996;
Elongation at break	%	≥ 500	SR EN 12068:2008
Fracture strength (23°C)	N/10mm	≥ 90	SR EN 12068:2008
Temperature of application on the pipe	°C	-10 ... +70	-
Pipeline's temperature of operation	°C	-40 ... +50	-
Strength class	-	C-50	SR EN 12068:2008
Steel adherence (23°C, 10 mm/min)	mm	≥ 20	SR EN 12068:2008
Tape-tape adherence (23°C, 100 mm/min)	N/cm	≥ 30	SR EN 12068:2008
Electrical resistance of the insulation	$\Omega \cdot m^2$	$\geq 10^8$	SR EN 12068:2008
Impact resistance	J	≥ 15	SR EN 12068:2008
Fracture strengths of the winding (50°C)	N/cm^2	≥ 12	SR EN 12068:2008
Width of tape	mm	30 (Ø < 3") 50 (3" ≤ Ø ≤ 8") 100 (Ø > 8")	-
Temperature of application on the pipe surface	°C	-10 ... +70	-
Pipeline's temperature of operation	°C	-40 ... +50	-
Water vapor transmission rate	-	£ 0.1gm/M2/24h	ASTM F1249
Water absorption rate	-	< 0.10%	ASTM D570

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Author Profile

Stefan Mihai Filip has had an extensive and important training in the natural gas field, studying at the Petroleum-Gas University of Ploieşti and "Lucian Blaga" University in Sibiu, being awarded the title of Bachelor of Science in Engineering in the

Petroleum and Gas Engineering Department. He has a rich practical experience in the natural gas distribution systems, occupying the position of project manager within the Eon Romania Distribuţie SA company, coordinating important works in the field, which allowed him to gain important knowledge and to detect certain problems the company has been dealing with, and, by performing such works, to try to find solutions for them.