

Necessary Study on the Behavior of Polyethylene Pipes under the Action of Accidental External Mechanical Factors

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ABSTRACT: The paper is intended to be a study on the use of the polyethylene pipes, which will reveal the problems encountered when using them in the field of natural gas distribution caused by the action of accidental mechanical factors occurring during their operation.

Keywords: insulation, polyethylene, mechanical action.

I. INTRODUCTION

Based on the bibliographic studies, we notice that the basic materials for the production of plastics are natural materials such as cellulose, resins, oil and natural gas. Oil and natural gas are the most important raw materials. Crude oil is separated by distillation in several fractions. Depending on the range of boiling temperatures, different phases of distillation are obtained - gas, gasoline, kerosene, fuel oil and bitumen as residues. All these constituents consist of hydrocarbons that differ only by the size and configuration of the molecules. The most important fraction for the production of plastic materials is straight-run gasoline. This gasoline is further fractionated and transformed by a thermal cracking process (vapor cracking) into ethylene, propylene, butylene and other specific hydrocarbons. [1]

Thus, plastic materials are materials obtained by chemical transformation of natural products, or synthetically, based on organic compounds having carbon (C) and hydrogen (H) as their main constituents. At the base of most plastic materials are the *hydrocarbons* from which the individual combinations of plastics are derived, which are called *monomers*, namely monomer molecules of the same kind. [1]

Some of the advantages of using polyethylene in the field of natural gas distribution networks are:

- the possibility of welding at low temperatures (relative to the required temperatures for welding steel), by simple technology, and by mechanically assembled fittings, as the case may be;
- the possibility of combining polyethylene networks with the already existing steel networks or with the existing casings;
- the increased speed of installing the networks implies lower execution costs;
- the variety of dyes allows a precise marking and identification;
- the variety of pipe fittings dimensions of approximately 32,000 units;
- high resistance to corrosion, which eliminates the need for cathodic protection, a very important advantage for the gas distribution networks because the aggression of the soil in the urban environment is significantly higher than outside the localities;
- the possibility of using long pipes by delivering them in coils;
- good chemical resistance to the gas components;
- the natural environment protection due to the feature of recyclable material.

The Necessity of the Study

The market study on the use of polyethylene and the problems encountered by using it was carried out in collaboration with the National Regulatory Authority for Energy (ANRE), Eon Gaz Romania, Fusion Romania and Proconfort, covering the following objectives:

- to collect information on the structure and the volume of activities of the current recipients of polyethylene fittings and pipes;
- to identify the current requirements, disagreements and future needs of the current beneficiaries in order to improve the activity of the companies and to anticipate the future trend in their production;
- to identify new beneficiaries;
- to test the reaction of the industrial consumers to such actions, which are usually seen in a structured market economy.

The inquiry was carried out on by means of a questionnaire, which was filled in by a total of 164 people, representing engineers, project managers overseeing gas works, certified welders, engineers, authorized NRAE

technicians responsible for welding techniques, etc. Contracts have been signed with ANRE, Eon Gaz Romania, Fusion Romania and PROCONFORT in order to support the proposed activities. The companies that participated in this study belong to the following areas (see Figure 1):

- Legislation on the use of natural gas pipes and fittings - National Regulatory Authority for Energy (NRAE) - 8;
- The largest network developer in the country - Del GazGrid SA - 85;
- Manufacturers and distributors of materials: Fusion Romania, Romstal Valrom CIA Trade, Sibtub - 27;
- Network developers and maintainers: PROCONFORT, Eurowagen, Sinecon, Instal Grup, ConsPro, Standard Sanitare, etc. - 44.

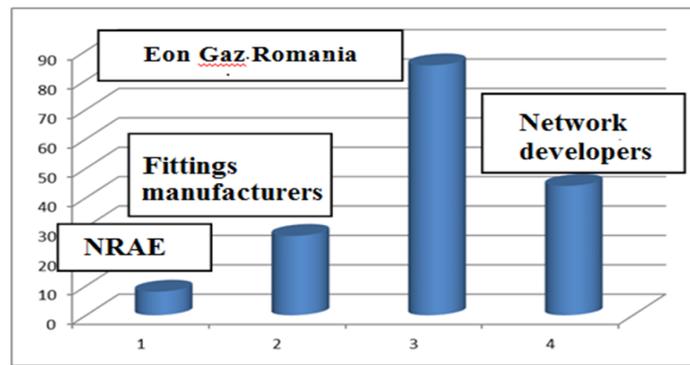


Fig.1. Distribution of the individuals participating in the inquiry

The results were analyzed by using MS Excel and SPSS, and they are presented as follows. The interviews on the use of polyethylene pipes and fittings are mostly used for the development of new gas distribution networks, followed by the distribution of spare parts and the repairs on the gas network, as shown in Figure 2.

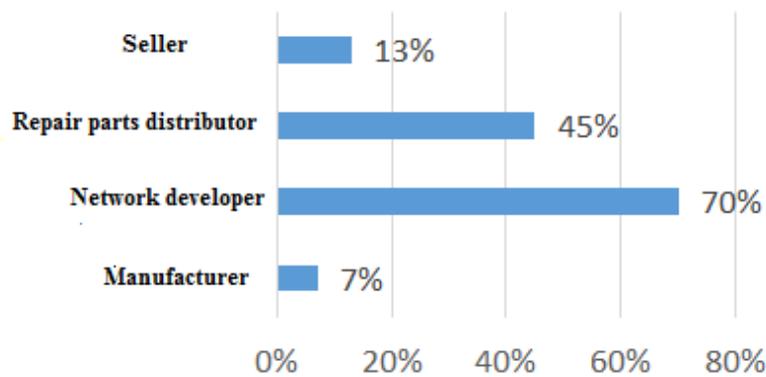


Fig.2. The use of polyethylene pipes and fittings

The respondents use the polyethylene pipes and fittings mostly for developing new gas distribution networks, followed by the distribution of spare parts and repairs of the gas network, as shown in figure 2.

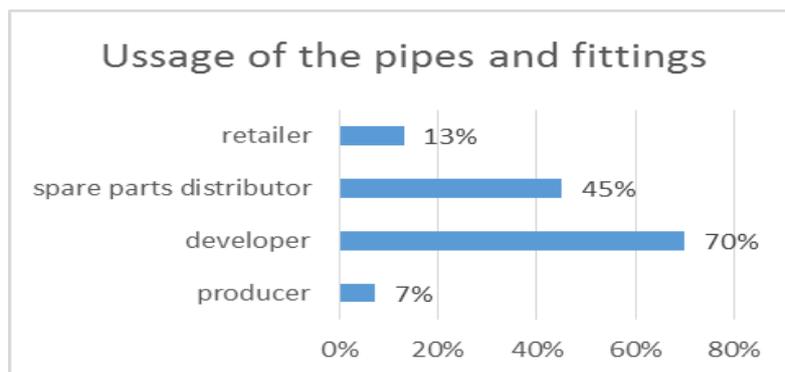


Figure 3. The profile of the respondents

The preferred type of welding for polyethylene pipes and fittings is electrofusion welding. 35% of the respondents declare that they use exclusively this procedure and another 41% say that 75% of the welding that they do is made through electrofusion. This shows that the respondents are using modern techniques and this information is completed by the next question, regarding the age of the equipment that they use. Over 65% of the equipment of the respondents is between 2 and 5 years old and very few of the respondents say that their tools and equipment are older than 6 years. Figure 3 shows that the origin of the welding equipment is mostly foreign. More than 81% of the respondents declare that they use mostly foreign tools while only 9% use Romanian equipment.

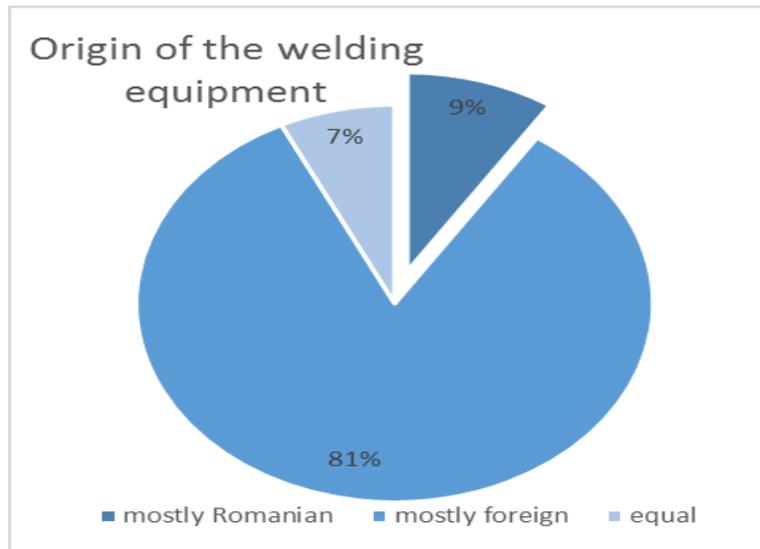


Figure 4. Type of welding equipment used

The research showed the percentage of polyethylene pipes and fittings provided by the main distributors in this field. Thus, 59% of the respondents said that more than half of their products are provided by Fusion Romania, followed by Techoworld with 12% and Palplast. This question reveals behaviors in the market that can be used by decision makers of companies that activate in the field of gas distribution networks. One reason why Fusion Romania is the preferred producer might be the customer satisfaction. 56.67% of the respondents say that the quality of the products purchased from Fusion Romania is very good, 41.67% consider that the products are good, while only 1.67% say the quality is satisfactory. It is interesting to observe that there is no customer who is totally disappointed by the quality of the polyethylene pipes and fittings produced by this company (see figure 5).

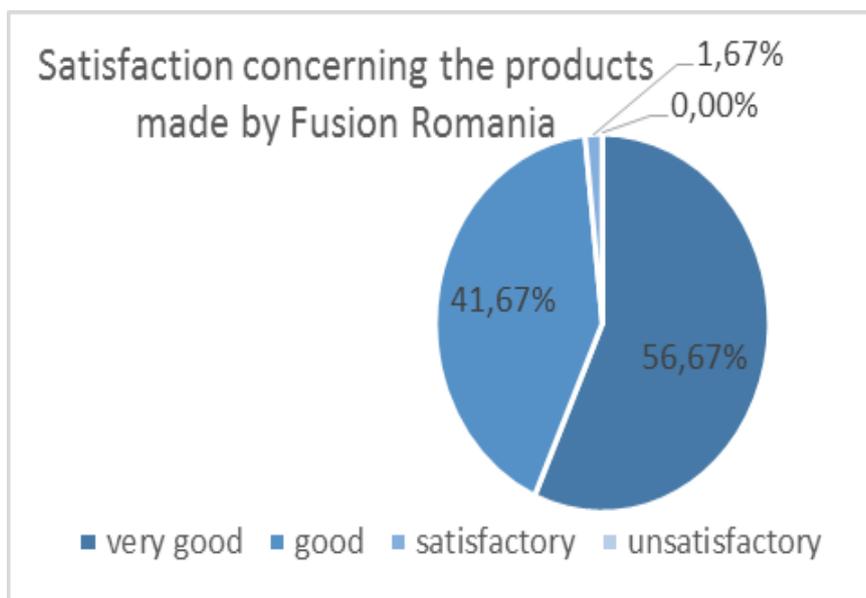


Figure 5. Customer satisfaction for the products offered by the market leader

Customer satisfaction is also on very high levels, concerning the services offered by this company. More than 93% of the customers consider that the services offered by Fusion Romania are good and very good, while only 1.72% think that the services offered are unsatisfactory (see figure 6).

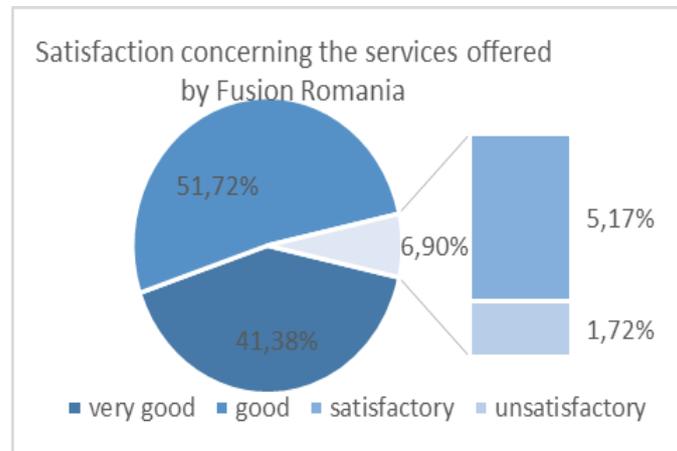


Figure 6. Customer satisfaction for the services offered by Fusion Romania

The market leader scores very high also in terms of the customer perception of the price for quality ratio. 91.38% think that the ratio is good or very good and only 8.62% consider this ratio to be satisfactory. The respondents, who operate in the field of gas distribution network field are optimistic concerning their future activities. Figure 6 shows that more than 36% think that their business will grow in the near future and about 56% think that they will maintain the current amount of work.

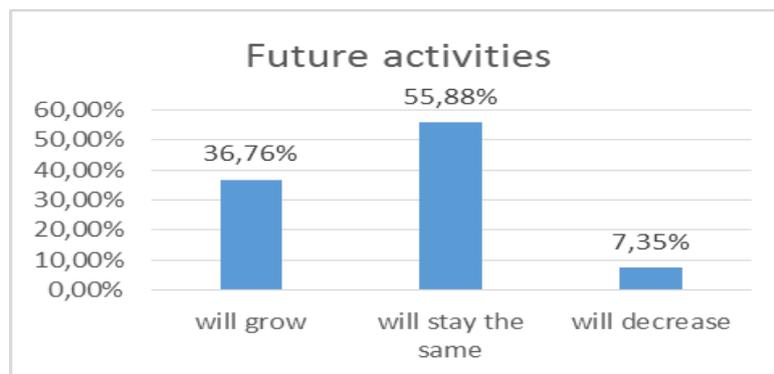


Figure 7. Estimation of future activities

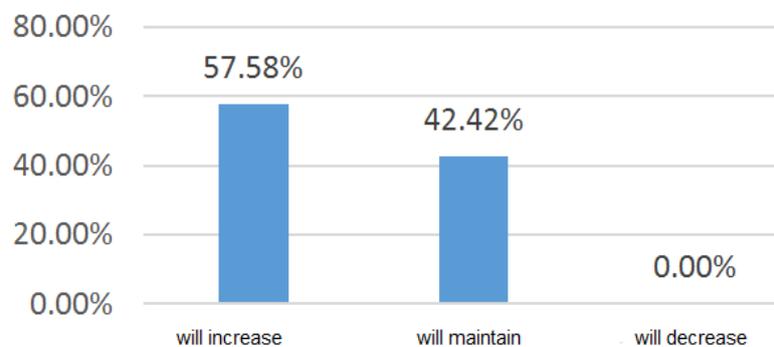


Figure 8. Opinions on the use of polyethylene pipes and fittings in the future

The last section of the questionnaire attempted to identify the most common defects and the flaws that arise in the use of the polyethylene pipes and fittings. As shown in Figure 8, the most common defect is the ovality

of the pipe, being reported by more than 87% of the respondents.

The last section of the questionnaire sought to identify which are the most common flaws and defects that occur in the usage of polyethylene pipes and fittings. As shown in figure 9, the most common defect is the ovality of the pipe, being signaled by more than 87% of the respondents.

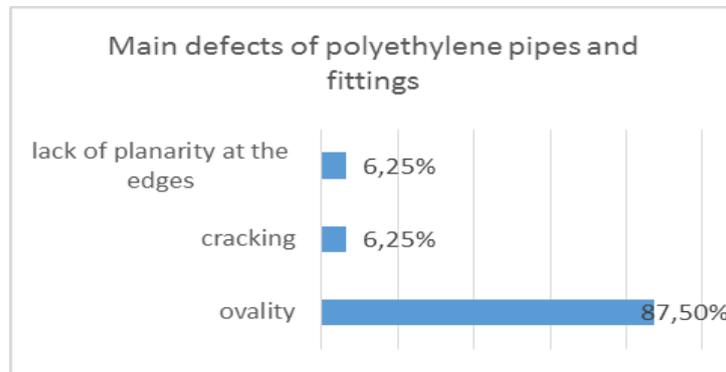


Figure 9. Main defects of polyethylene pipes and fittings

Other problems were identified in the welding process. The most common issue is ovality as well, being signaled by more than 56% of the respondents. Other 36% say that the most frequent issue that appears in the welding process is the inequality of the burrs, while 7.27% consider that the lack of planarity at the edges is the biggest problem that they face when welding (see figure 9).

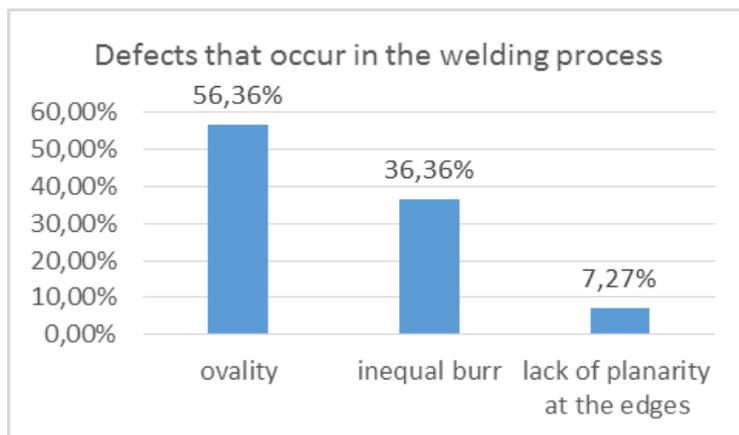


Figure 10. Defects that occur in the welding process

The errors that appear in the electrofusion welding of polyethylene pipes using clutches were investigated with an open question. Thus the specialists could write their experiences without being constrained by some given options. The most common issue that has been signaled by the respondents is the interrupted spiral. Other problems were incomplete welding, material leaks or unequal melting, depending on the density of the material. The issues encountered in the welding of electrofusion knuckles (see figure 10) were similar to the ones mentioned above, but some problems regarding coaxiality, collinearity or tension variations were also mentioned.



Figure 10. Knuckle

The questionnaire also identified the most common problems encountered in the welding process of the T-squares and in addition to the ones already presented the specialists identified issues with the bar codes, interruptions of the metal insertion during the welding process and leaks due to incomplete welding.

II. CONCLUSIONS

Polyethylene pipe systems have a significant and growing market share for low pressure (<16 bar gauge) pipe systems, particularly for the transportation of fuel gas and potable water. For sizes at 8 inches (219 mm) and below, EF fittings are widely and successfully used for joining pipes and constructing pipe networks (Bowman, 1997).

Buyers require a good quality of the products and reasonable prices; they want a good brand, a rich variety of products, useful and pleasant things, honest sellers and a lot of services. Vendors ask lots of questions, such as: to what group of consumers should they turn their attention, which are the requirements of these customers and what products should be designed, what prices should these products have in order to meet their desires, what kind of sale should they practice "wholesale" or "retail", which kind of advertisements should they promote or what type of sales personnel should they use and what salary should they be paid?

The main defects identified in the weld pipe assemblies - fitting are:

- nonlinearity of the assembly;
- incomplete Fusion; the welding witness didn't appear;
- the expulsion of molten material outward or inward;
- broken or shorted spirals;
- oval heads;
- failure to complete the welding cycle (device error);
- lack of sealing of the gasket of the branching T-square fitting for self-threading.
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Fig.11. Actual situation of accidentally applying stress on the PE 100 polyethylene pipe by the excavator bucket

This research showed that the market of polyethylene pipes and fittings for gas networks in Romania is expecting a growing trend and pointed out the behaviors of the specialists who activate in this niche, highlighting also the most common problems that appear in electrofusion welding of pipes and fittings. This study proved that some of the problems encountered in the operation of the distribution networks are due to the external mechanical

factors that lead to major expenses in their repair; therefore it was concluded that it is required to conduct a study on the behavior of the polyethylene pipes accidentally subjected to external factors, in our case an excavator bucket (of different widths: 300 mm, 400 mm, 500 mm and 600 mm) which stresses pipes of three commonly encountered diameters (Dn 32, 63 and 90 mm).

REFERENCES

- [1]. AVRIGEAN, E. Studii teoretice si experimentale asupra comportarii mecanice a ansamblurilor sudate de tevi si fittinguri din polietilena de inalta densitate. "Lucian Blaga" University Publishing House, Sibiu, 2015.
- [2]. Balan, M. L. Contributii la utilizarea procedeeului de sudare cap la cap a tevilor de polietilena destinate transportului si distributiei gazelor naturale. Doctoral thesis. Sibiu, 2009.
- [3]. DUSE, D. M. , BONDREA, I. Fabricatia integrata de calculator CIM a transmisiilor cardanice. "Lucian Blaga" University Publishing House, Sibiu, 2003 - chapter 3 - Model of a market study on cardan shafts.
- [4]. LUPU, N.I. Conducte din polietilena in sistemele de distributie. "Lucian Blaga" University Publishing House, Sibiu, 2000.
- [5]. MURARIU, C. Influenta imperfectiunilor imbinarilor sudate ale structurilor din polietilena de inalta densitate asupra comportarilor mecanice. – Doctoral thesis. Timisoara. 2008
- [6]. OLEKSIK, V., PASCU, A.M. Proiectarea optima a masinilor si utilajelor, "Lucian Blaga" University Publishing House, Sibiu, 2007.

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