PROSPECTS AND OPPORTUNITIES FOR INCREASING THE EFFICACY AND SAFETY OF DOMESTIC NATURAL GAS INSTALLATIONS BY USING NEW UP-TO-DATE GAS PIPES AND FITTINGS

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ABSTRACT: The article analyses the prospects and opportunities for using new up-to-date gas fittings and pipes for domestic natural gas, which are produced from cross-linked polyethylene/overlapped welded aluminum/cross-linked polyethylene – for short called PEX-AL-GAS.
These pipes are well known in all over the world. They have been used for a long time for building domestic natural gas installations in Europe, Australia, North and South America. The use of PEX-AL-GAS is analysed: it leads to decreasing the domestic gas installation price, the time for building installations is down, and their efficacy and safety increase. The regulatory possibilities for and obstacles to the introduction of this material are discussed. The necessary administrative measures and regulatory changes for the widespread use of PEX-AL-GAS on the territory of the Republic of Bulgaria are proposed, which will accelerate domestic gasification. The result will be a further improvement in the well-being of the population and a significant reduction in the carbon emissions generated.

Key words: natural gas, government regulations, standards, gas pipelines and fittings

ПЕРСПЕКТИВИ И ВЪЗМОЖНОСТИ ЗА ПОВИШАВАНЕ НА ЕФЕКТИВНОСТТА И НАДЕЖДНОСТТА НА БИТОВИТЕ ГАЗОВИ ИНСТАЛАЦИИ ЗА ПРИРОДЕН ГАЗ ЧРЕЗ ИЗПОЛЗВАНЕ НА НОВИ СЪВРЕМЕННИ ГАЗОВИ ТРЪБИ И ФИТИНГИ

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РЕЗЮМЕ. В статията са анализирани перспективите и възможностите за използване на нови и съвременни фитинги и тръби за битови газопроводни инсталации за природен газ, произведени от омрежен полиетилен с висока плътност и алуминиева вложка, с техническо наименование PEX-AL-GAS. Тези тръби са добре познати в световен мащаб. От години се използват за изграждане на битови газопроводни инсталации в Европа, Австралия, Северна и Южна Америка. Анализирано е използването на PEX-AL-GAS, което види до понижаване на цената на битовите газови инсталации, съкращава времето за изграждането им и значително повишава тяхната ефективност и безопасност. Разгледани са нормативните възможности и пречки за въвеждането на този материал. Предложени са необходимите административни мерки и нормативни промени за широкото използване на PEX-AL-GAS на територията на Р България, което ще ускори битовата газификация. Резултатът ще бъде повишаване на благосъстоянието на населението и значително понижаване на генерираните въглеродни емисии.

Ключови думи: природен газ, нормативна уредба, стандарти, газопроводни тръби и фитинги

INTRODUCTION

The activities to ensure the possibility of using natural gas for household needs on the territory of the Republic of Bulgaria are united by the widespread civil use - the word "Gasification".

For the realisation of gasification of a household, it is necessary to meet several requirements:

The first and main thing is to have a built-in urban gas distribution network to which the respective household can join in order to receive natural gas (there is also a way to supply natural gas by high pressure bottle installations, which is not a subject of this material).

In a number of countries with developed gasification, when natural gas started to be used, the gas pipes were produced from cast iron. Subsequently, they were replaced by steel pipes.

The use of steel pipes is associated with a number of difficulties, the main being the expensive and laborious welding and control process, and corrosion protection. For this reason, new materials for the production of gas pipes are sought.

As a result of this, nearly 20-25 years ago, gas pipes of PEHD 80 high-density polyethylene were manufactured, with a maximum working pressure of 4 barg. At the same time, the gasification process began in several Bulgarian cities.

Delayed domestic gasification (construction of urban gas distribution networks (GDN) in Bulgaria actually gave a wonderful opportunity to Bulgarian gas distribution companies – to use the most modern materials and technologies. The use of the new PEHD80 allows fast, secure, and efficient construction of GDN.

The construction of gas pipeline diversions to new households (consumers) is also easily and safely executed. At the same time, in countries with developed domestic gasification

(e.g. Italy), a larger part of GDN is realised with steel pipes with a large diameter and low operating pressure, which generally makes it more expensive to build, maintain, and include new users.

After PEHD80, PEHD100 was created, which allows the construction of gas pipelines up to Pmax = 10 barg. As a result and thanks to the use of high-density polyethylene pipes, which do not need corrosion protection, and their connection is performed quickly and securely by automated devices, over 5500 km of GDN have been built in over 35 towns in Bulgaria in the past 20 years only.

Today, no one is asking what type of pipe to use when you need to build a pipeline with working pressures up to 10 barg – the logical choice is PEHD. But the beginning of gasification was marked by the usual distrust and resistance from the institutions against the use of these new materials. Why? Because technology is usually ahead of lawmakers.

In Bulgaria, in addition, there is no specialised institution (such as DVGW in Germany) that ~~is~~ constantly works to synchronise technologies with regulations, in this case specifically in the field of gasification.

Despite the above mentioned obstacles and as a result of the adoption of the Energy Act at the end of 2003, in the accompanying secondary legislation, and in particular in "ORDINANCE on the Structure and Safe Operation of Transmission and Distribution Gas Pipelines and Facilities, Installations and Appliances for Natural Gas" and "ORDINANCE No 6 of 25.11.2004 on Technical Rules and Regulations for Design, Construction and Use of Sites and Facilities for Transmission, Storage, Distribution and Supply of Natural Gas", high density polyethylene pipes and fittings were listed as one of the options for materials for the construction of GDN.

Thanks to the foresight of the experts in the working group creating these regulations, so that it does not have to be constantly updated when creating new materials for the manufacture of pipes and fittings for natural gas, in the part what pipes and fittings are permissible in the construction of gas installations, it is written: "Gas pipelines of gas installations can be made of seamless or electro-welded steel pipes, copper pipes, high-density polyethylene pipes … and other pipes, specified for natural gas" and "The building gas installation /BGI/ shall be designed in compliance with the requirements of BDS EN 1775." Annex D of this standard deals with copper press joints and the PEX AL GAS system.

Possibilities for using PEX-AL-GAS high-density cross-linked polyethylene pipes

The choice of material for gasification construction is a multifactorial task that can be easily solved by applying criteria such as price, compatibility with cathodic protection, safety, chemical activity, durability, and others (Hristova, 2013).

The second condition for a household to be gasified is for the owner to invest the necessary amount of financial resources in his gasification investment project, which includes design, construction, and commissioning.

Currently, copper pipes are mainly used for the construction of internal gas systems (for domestic needs) in Bulgaria. These pipes and fittings are the most expensive possible material.

The implementation of gas installations with copper pipes is an expensive process, but it is also associated with the need to use highly qualified and responsible personnel. What we mean is that the process of joining the copper pipes is "brazing" with a solid solder by using a gas-oxygen high-temperature burner. The dangers, on the one hand, are from the use of explosive gases (oxygen and propane-bute), and on the other hand is the need for accurate and precise execution of the soldered joints by the staff to ensure durability and tightness of the gas installations. Unfortunately, the executive staff basically ignores the danger of working with explosive gases and the required safety measures are not observed. The main problem is the failure of the executive staff to comply with the technology of preliminary preparation of joints for brazing, as a result of which the soldered joints are compromised and exposed to the risk of cold cracks and gas release. In combination with the method of installation of copper pipes, namely tightly covered with putty, they become stationary and subject to the movement of the building, which also contributes to plastic deformations.

The latter, combined with a non-technologically executed brazed joint, is a prerequisite for future gas leakages.

Another dangerous approach is the use of a cold-press non-detachable copper compounds in hidden installations (under plaster or putty).

And the last but not least, the high cost of labor for the performance of soldered copper joints disadvantage is yet another disadvantage.

In order to avoid the shortcomings described in the construction of building gas installations with copper pipes and fittings, leading companies, such as *HENCO*, *VALSIR*, *REHAU* and others, have been producing high-density cross-linked polyethylene pipes with an aluminum insert for natural gas, designated as PEX AL GAS, for more than ten years.

Features of the PEX AL GAS system:

The PEX AL GAS system consists of multilayer cross-linked polyethylene pipes with an aluminum layer and brass press fittings. They are intended for use in installations for natural gas, propane-butane, and naphtha and other petroleum products. The PEX AL GAS system of multilayer polyethylene combines the positive characteristics of typical crosslinked polyethylene and those of aluminium.

Crosslinked high-density polyethylene HDPE, PE-X (a, b, c, d) guarantees excellent mechanical, physical, and chemical properties. The butt welded aluminum layer provides mechanical strength that provides flexibility and malleability to the pipe. Together, these characteristics of polyethylene and aluminum provide quick and simple operations when installing the system.

As a final result, the obtained product is composed of different composite layers connected to each other, allowing the achievement of excellent characteristics that can not be achieved with a pipe made of only one type of material.

The PEX AL GAS system is manufactured in accordance with the European norm BDS EN ISO 21003 [4] and the international standard for the production of multilayer system ISO 17484-1. Its reliability and quality are guaranteed by constant meticulous inspection of the production by various authorised bodies in accordance with BDS EN ISO 21003-1, (Fig. 1):

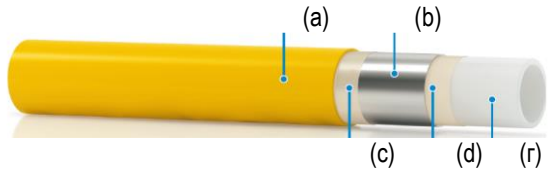

Fig. 1. Structure of a PEX Al GAS pipe

(a) outer layer – made of crosslinked polyethylene HDPE, PE-X... and acts as a mechanical, electrical, and chemical protection for the aluminum layer, protecting it from impact, scratching, and the electrochemical effects of water, cement, and other substances present in the soil;

(b) inner layer - it is made of aluminum alloy, butt welded along the length of the pipe providing a barrier to penetration of oxygen, gas, and light, providing the pipe with excellent mechanical strength and flexibility;

(c) bonding layers - they are made of strong glue, which provides excellent bonding of the layer of aluminum with the outer and inner layers;

(d) inner layer – made of crosslinked polyethylene high density HDPE, PE-X..., characterised by an extremely smooth surface that minimises pressure losses.

Working pressure: up to 500 mbar
Maximum working pressure: 5 bar;
Application: natural gas;
Operating pressure for gas installations: up to 500 mbar;
Temperature range of the fluid: - 60°C to + 100°C;
Softening temperature: +130°C;
Color: yellow RAL 1023;
Roughness: 0,007 mm;
Temperature expansion: 0,026 mm/mK;
Temperature conductivity: 0.42 ÷ 0.52 W/mK

Characteristics of the protective corrugated pipe for the PEX AL GAS system – (Fig.2):

Provides protection from UV rays;
Combustible material that slows down combustion;
Provides crush protection.

Fig. 2. Protective corrugated pipe

Section of a press fitting for the PEX AL GAS system (Fig.3):

Fig. 3. Section of a press fitting for the PEX AL GAS system

The PEX AL GAS system is the result of many years of experience in the production and use of multilayer pipes and the ability to use them in installations for combustible gases in buildings.

The fittings are manufactured from a special brass alloy with built-in rubber gas seals. The rubber gasket (O-rings) themselves are yellow type HNBR according to BDS EN 682. The pressing joint is made of AISI 304 stainless steel, fixed to the body of the fitting. It has two or four holes to control the press joint.

The end of each fitting, which enters the pipe, is covered with a teflon layer, which guarantees easy installation and non-dismantling of the joint. To increase the security of the joint, there are also metal cuts, which, when pressed additionally, provide mechanical and hermetic strength.

The pressed fittings of the PEX AL GAS system are non-detachable, durable, and with spatial strength connecting elements. The press fittings of the PEX AL GAS system for gas installations are marked on both sides with yellow color.

Installation of the PEX AL GAS system

For the installation of the PEX AL GAS system, each manufacturer provides installation instructions according to the BDS EN 1775 standard. Only original press fittings with an original HNBR sealing ring corresponding to the pipe – from one manufacturer – should be used.

Fixing of pipes

Gas pipelines must not be attached to other pipelines or used to carry other pipelines.

Gas pipelines should be fastened to the building structure with non-combustible fasteners – for example, metal clamps – and ordinary dowels – those can also be plastic.

Gas pipelines filled with PEX AL GAS pipes and fittings can be mounted:

i) In ventilation channels (Fig.4 - a and b):

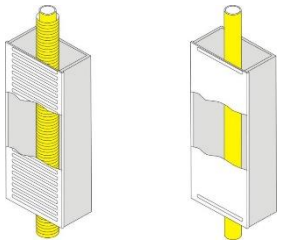

Fig. 4. PEX AL GAS pipes and fittings mounted:
a) outdoors (b) indoors

ii) In plaster (Fig.5) and/or putty (Fig.6) without cavity.

Thus, with gas gaps, the gas is safely taken out at both ends of the gas installation.

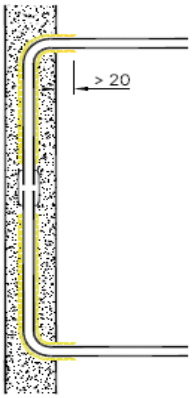

Fig. 5. PEX AL GAS pipes and fittings mounted in plaster

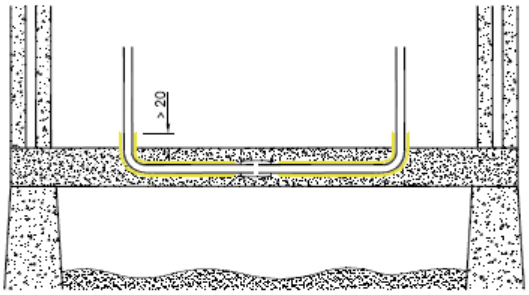

Fig. 6. PEX AL GAS pipes and fittings mounted in putty

iii) Underground installation (Fig.7)

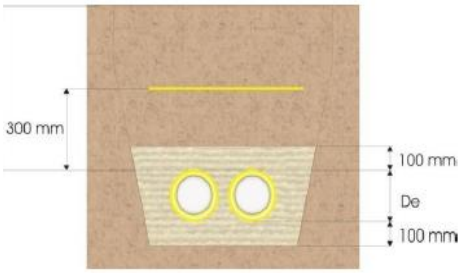

Fig. 7. Underground installation of PEX Al GAS pipes

iv) Installation in a channel (Fig.8)

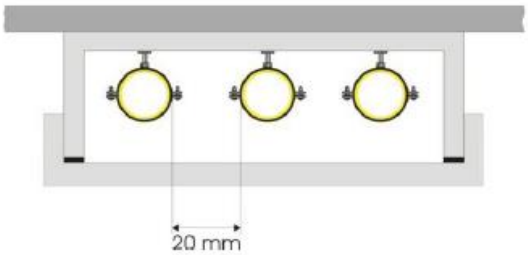

Fig. 8. Installation of PEX Al GAS pipes in a channel

Sample scheme for the construction of a domestic gas installation /DGI/ (Fig.9):

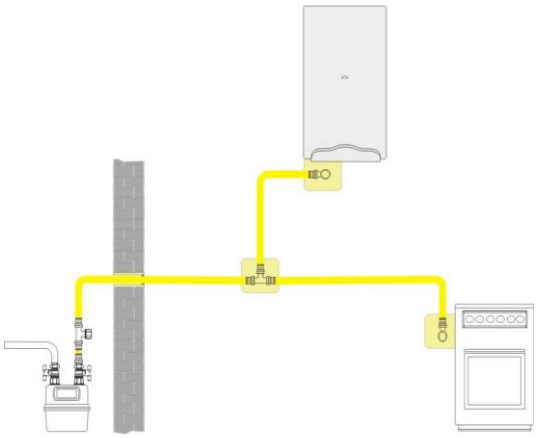

Fig.9. The PEX AL GAS pipe is necessarily laid in a corrugated pipe, which is brought out into protective boxes installed in the places with fittings

Outlet for gas appliance (Fig.10 - a, b):

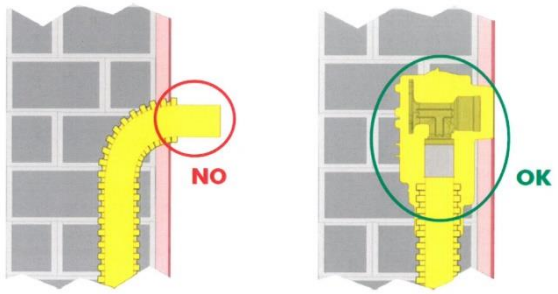

Fig. 10. a) incorrect b) correct

It is forbidden to open an installation by PEX AL GAS in a room with gas appliances.

The outlets for gas appliances are installed indoors in a box built into the wall.

Press tools and pressing profiles (jaws).

The press system has different press tools with the corresponding pressing profiles, most widely used in the market.

The plumbers can use press tools, which they possess. It is important to use pipes and fittings which are from the same manufacturer.The systems of press tools have press automation and equal pressing effort, guaranteeing quality connections.

Before the pressing process is completed, it is not possible to open the press jaws and remove the fitting.This ensures that pressing is always finished and that the pressed connection is of high quality. Some companies also offer tools for the control of pressed joints, (Fig. 11):

Fig.11. A tool for the control of pressed joints

Strength and density testing of gas pipelines of DGI, performed with PEX AL GAS system

After the construction of building gas installations, performed with a PEX AL GAS system, brass plugs are installed on all terminals and the mechanical strength of the pipeline is carefully checked.

Gas appliances, regulating, and safety fittings shall not be included in the test.

The strength and density test shall be carried out with air or inert gas in accordance with the requirements of the Ordinance on the Structure and Safe Operation of Transmission and Distribution Pipelines, Facilities, Installations and Appliances for Natural Gas.

The strength test pressure is recommended to be 5 bar;

The test pressure of density is equal to the operating pressure of the gas installation.

Advantages of the PEX AL GAS system from HDPE multilayer cross-linked polyethylene pipes, PE-X… with aluminum layer

The characteristics of the PEXAL GAS system make this product extremely reliable and easy to install;

The PEX AL GAS system has a guaranteed life expectancy of 50 years. Its mechanical characteristics are such that at room temperature, the tube ruptures at pressures above 100 bar;

The exceptional smoothness of the inner surface of the pipe minimises pressure losses.

Crosslinked polyethylene is extremely resistant to the abrasive action of fluids, so this system is not affected by the abrasive action of the gas and possible contaminants in it;

The PEX AL GAS system is extremely resistant to the corrosion action of the environment in which it is laid. For this reason, no additional measures need to be taken for its passive or active corrosion protection;

Flexibility and resistance of shape – the combination of cross-linked polyethylene and aluminum layer guarantees excellent bending properties. In addition, once bent, the tube retains its shape. For this reason, it does not need many fastening brackets, which significantly cheapens the cost of installation. Due to these qualities, this system is most reliable for use in earthquake areas;

The thermal expansion of the pipe is 8 times less than the other polyethylene pipes and approaches that of metal pipes;

The weight of PE XAL GAS pipes is 1/3 of the weight of copper pipes and 1/10 of the weight of metal pipes at the same DN;

Crosslinked polyethylene is three times more elastic than copper pipes and absorbs vibration;

The butt welded aluminum layer serves as an oxygen and light barrier, which is the cause of corrosion in other polyethylene pipes;

The tools used to build the PEX AL GAS system are standard, making it easy to install and operate. Reduced to zero errors or non-compliance with technology by the executive staff;

The system has fittings for the transition from a PEX AL GAS pipe to a copper pipe (Fig.12.), for cases where local norms require open gas pipelines to be performed only with metal pipes.

Fig.12. Fitting for transition from PEX AL GAS to copper pipe

Conclusion

So far, despite the statutory prerequisites for trouble-free use of the PEX AL GAS system in Bulgaria, for unclear reasons, its use has been tacitly stopped.

Unlike Bulgaria, where the implementation of new technologies is extremely difficult due to the lack of responsible institutions and streamlined norms, in a number of developed countries, such as Italy, Austria, Germany, Ukraine, China, South America, and others, this issue has long been resolved by the adoption of ISO 17484 and, on its basis, the issuance of local instructions for installation and operation.

A serious reference for the security and reliability of this system is the fact that all gas installations in the buildings of the artificial island PALM JUMEIRAH – DUBAI are built with *HENCO* PEX GAS.

Recommendation: It is necessary for the gas specialists in the industry in Bulgaria to unite and, together with the State Technical Supervision, to decide on the use of the PEX AL GAS system in building gas installations in compliance with the current regulatory requirements and prescriptions of the manufacturers.

The implementation of the PEX AL GAS system will provide the following opportunities for domestic gasification in Bulgaria:

- will ensure greater reliability and security of the built and commissioned gas building systems;
- will decrease the price of building gas installations, which will provide a larger range of the population with the opportunity to use ecological fuel natural gas (Boyadjiev and Georgiev, 2020);

The implementation of the previous two main advantages of the PEX AL GAS system will provide a significant reduction in carbon emissions generated by households.

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