# REQUIREMENTS FOR CABLE LINE PIPES

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*Almost a year ago, an article was published on the pages of the CABLE-news magazine [1], in which the question was raised about the priority requirements that should be imposed on pipes for laying 6-500 kV cable lines. In the new material, I would like to continue the topic raised in the article.*

**Keywords:** cable line, cross-linked polyethylene, polymer pipe, polyethylene pipe, HDPE pipe, corrugated pipe, cable laying in pipe, pipe heat resistance.

## Introduction

In the article [1] it was noted that recently cables are placed in cold-water pipes made of low-pressure high-density polyethylene (HDPE), designed to operate in the temperature range up to 40°C [2]. The admissibility of such a technical solution has not been checked by anyone, no relevant tests have been conducted, and the operational experience has not been analyzed.

At the same time, there are reasons to believe that laying cable lines (CL) in HDPE pipes is undesirable. The fact is that modern cables with cross-linked polyethylene insulation (XLPE) normally have a temperature of up to 90°C, and taking into account possible overloads and short circuits – even more. Such a significant difference in the operating temperatures of cables (90°C) and pipes (up to 40°C) in which they are laid can lead to undesirable consequences, for example, to sticking of the cable and pipe or to deformation of the pipe, as a result of which the cable cannot be removed from the pipe if necessary.

The discrepancy between the characteristics of HDPE pipes of cold-water supply to the conditions of joint work with 6-500 kV CL was also confirmed by the participants of the meeting of the Association of Power Supply of Russian Cities "PROGRESSELECTRO", which took place in early June 2014 in Nizhny Novgorod. At the same time, one of the experts drew attention to the fact that, for example, in the Moscow cable network, so-called double-walled corrugated pipes are used for laying cables, which, in his opinion, are more suitable for these purposes than HDPE.

What characteristics should polymer pipes still have for laying CL? Let's try to figure out why manufacturers of water supply systems and drainage systems (sewerage) trying to "adjust" all those pipes for the needs of the electric power industry. We will consistently consider: drainage (corrugated), cold-water and hot-water supply.

## Drainage pipes

Modern drainage pipes are known to all those who have summer cottages (Fig.1). They are designed to collect and divert water from sites into drainage wells, ponds and ditches. Drainage pipes with a diameter of 50÷200 mm can be found in any hardware store. Such pipes are made corrugated, which gives them the flexibility necessary for installation and allows them to be sold in bays convenient for buyers. Pipes of a higher diameter are more difficult to wind into a bay, and they are sold in straight pieces of a certain length.

Drainage pipes mostly have perforations – small holes or incisions, thanks to which water from the ground gets inside the pipe and then into the drainage system. In order to prevent the ingress of small soil particles into the pipe, it is wrapped with geotextile from the outside (in Fig.1, this is a light gray fabric).

Most often, drainage pipes are made in black, but you can make any others. Also on the market in the assortment are various connectors for pipes, tees and adapters, plugs and funnels, inspection wells.

**Fig.1.** Drainage corrugated pipe with perforation, wrapped with geotextile.

The simplicity of production led to high competition in the market of drainage and sewer pipes, and over time entrepreneurs began to look for new opportunities for the sale of corrugated pipes. For example, corrugated pipes turned out to be convenient for performing hidden electrical wiring in 0.4 kV low voltage networks (Fig.2). So, at present, almost any electrical goods store has a gray corrugated pipe with a diameter of one to several centimeters, packed in coils of 50 or 100 meters. Of course, such a pipe no longer has a perforation and is not wrapped with geotextile, and for the convenience of pulling the cable inside the pipe, a special inside thin steel wire is provided, which is called "conductor".

The idea of using corrugated pipes in the installation of cable and wire products, successfully implemented in 0.4 kV networks, led to the fact that there were firms offering such pipes not only for 0.4 kV networks, but also for 6 kV and higher. Of course, before entering the market of 6-500 kV CL, conventional corrugated pipes required "refinement". Its necessity was due to the fact that, unlike 0.4 kV networks, in 6-500 kV networks, the operating temperature of cables is significant: for paper-impregnated insulation – 70°C, for cross-linked polyethylene insulation – 90°C. Thus, the "refinement" of corrugated pipes should have consisted in giving them heat-resistant properties. The result of the work was the entry into the cable market of double-walled corrugated pipes (Fig.3).

**Fig.2.** Electrical wiring 0.4 kV made of corrugated pipes.

**Fig.3.** Double-walled corrugated pipe offered for power cables.

On the Internet and in factory catalogs for a similar double-walled corrugated pipe, it is indicated that it has two layers:

– external, made of HDPE (low-pressure high-density polyethylene);
– internal, made of LDPE (high-pressure low-density polyethylene).

It is also indicated that this pipe is designed to operate in the temperature range up to 90°C. It is the direct indication in the catalogs of the operating temperature up to 90°C that seems to allow the pipe to be used for laying cables with XLPE insulation, if not for one important "but".

As is known, the melting point of HDPE according to GOST 16338 is 135°C. The melting point of LDPE according to GOST 16337 is only 103°C, i.e. LDPE is even less suitable for working together with CL than HDPE, which is the subject of the article [1].

In fact, the appearance of an inner layer of LDPE in a corrugated pipe has nothing to do with solving the problem of giving the pipe the heat resistance necessary to use the pipe together with 6-500 kV CL.

The inner layer of LDPE is just a kind of base on which the outer layer of HDPE is glued, that allows you to increase the annular stiffness of the pipe without losing its flexibility. However, the use of a soft and viscous LDPE layer creates additional resistance when pulling the cable inside the pipe, which can lead to undesirable consequences. Therefore, an attempt by a number of companies to pass off the presence of a LDPE layer as a special advantage of double-walled pipes, which is important when laying XLPE cables, is actually dishonest, and the indication in the catalogs of the operating temperature of 90°C is an outright misleading.

The double-walled corrugated pipe offered on the market, the material of which melts already at 103°C, cannot be used in conjunction with XLPE-insulated high voltage cables that have a long-term permissible temperature of 90°C (with overloads and short circuits, the temperature is even higher). Therefore, the use of double-walled corrugated pipes for laying 6-500 kV CL is an erroneous technical solution, the reason for which – lies in the operating temperature of 90°C incorrectly indicated in the factory catalogs.

The only technically justified field of application of corrugated double-walled pipes in the electric power industry is the implementation of electrical wiring in networks up to 1 kV (Fig.4, 5). Only in networks up to 1 kV, the temperature regime of cables meets the real characteristics of HDPE/LDPE pipes.

Even if we imagine that manufacturers of double-walled corrugated HDPE/LDPE pipes would really be able to bring the operating temperature of the pipes to the advertised values of 90°C (this is impossible with the use of a LDPE layer), then in this case such pipes still could not be used in 6-500 kV cable networks.

The reason is very simple – these corrugated pipes cannot be laid by horizontal directional drilling (HDD), which has become indispensable for laying 6-500 kV cables, because to use HDD, the pipe must be resistant to stretching (it is important when tightening the pipe into the ground) and have sufficient ring stiffness (so that it is not compressed by the ground).

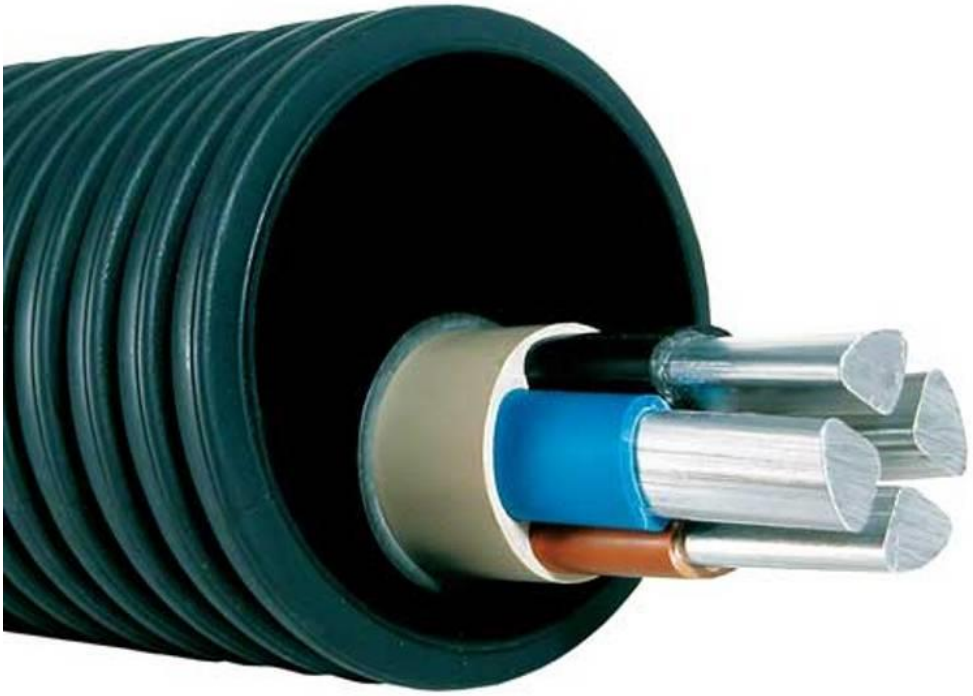

**Fig.4.** A 0.4 kV cable line laid in a double-walled corrugated pipe.

**Fig.5.** 0.4 kV cable lines laid in a double-walled corrugated pipe and located in a trench.

## Cold-water and hot-water pipes

Unfortunately, according to clause 6.11.4 of the standard [3] when laying cables in pipes, it is recommended to use HDPE pipes based on GOST 18599-2001 "Pressure pipes made of polyethylene" [2]. Currently, the use of such pipes is widespread.

In accordance with this GOST, low-pressure polyethylene pipes (HDPE) are designed for long-term operation in the temperature range up to 40°C, since they are cold-water pipes. At the same time, cables with XLPE insulation have an operating temperature of up to 90°C, and even higher taking into account overloads. Why are HDPE pipes actively used despite the obvious discrepancy between their characteristics and the operating conditions of CL?

HDPE pipes (fig.6) have a number of properties that have proved to be in demand in cable network construction: they are relatively inexpensive, have good ring stiffness (with the right choice of wall thickness), can be easily soldered together to form an extended section. Of all the pipes that were on the market at the time of the development of the standard [3], according to the set of characteristics only HDPE pipes could be used for laying CL by horizontal directional drilling (HDD).

It should also be noted that when creating the standard [3], laying cables in pipes was meant in relatively small areas, such as punctures under roads, railways, reservoirs. The developers [3] could hardly have imagined that laying cables in pipes up to 1000 meters long and even more would become so popular, where the cable cooling conditions are not at all as favorable as in small sections.

In conditions of expensive long pipe sections, the discrepancy between the operating temperature of the HDPE pipe and the CL cannot be ignored. Therefore, the development and implementation of special heat-resistant cable pipes in networks is an urgent task, having solved which it will be possible to complete the period of forced use of HDPE water supply pipes, which for many years had no alternative in power grid construction.

**Fig.6.** HDPE cold-water pipes.

If the cold-water pipe is not heat-resistant, then the hot-water pipe is already devoid of such a disadvantage. For example, Korean and Chinese companies offer pipes made of polyvinyl chloride (PVC), chlorinated polyvinyl chloride (X-PVC) or polypropylene (PP) for laying high voltage cables, naming them in catalogs like "Power Cable Protection Pipe" (Fig.7), where operating temperatures up to 90°C are fairly indicated. Another example: the largest manufacturer of plastic pipes – the American company Eagle – produces pipes for CL only from heat-resistant polymers with an operating temperature of 90°C, calling them "Electrical conduit" (Fig.8).

**Fig.7.** Chinese pipes "Power Cable Protection Pipe" for the protection of power cables.

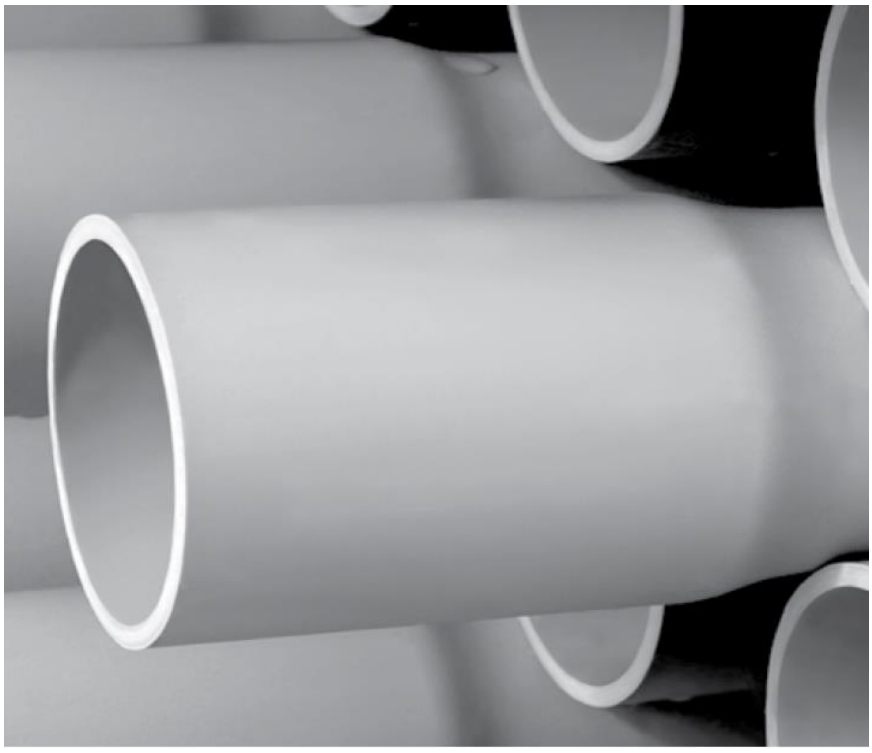

**Fig.8.** American pipes "Electrical conduit" for the protection of power cables.

Unfortunately, the mentioned foreign pipes are not flexible and are more difficult to weld with each other in comparison with HDPE, which, unlike HDPE, does not allow them to be used for the needs of horizontally directed drilling HDD. For example, for connecting "Electrical conduit pipes", they have a funnel at one end. Despite the above advantages and disadvantages of foreign heat-resistant pipes, another thing is quite clear – abroad they recognize the need to lay XLPE high voltage cables in heat-resistant pipes, and there is no question of using HDPE for these purposes!

## Conclusions. Pipe requirements

To date, for the laying of 6-500 kV CL in our country and abroad, they have tried to use almost the entire range of pipes produced for the needs of water supply and sewerage. These were corrugated drainage pipes, cold-water pipes made of low-pressure polyethylene HDPE, and hot-water pipes made of polyvinyl chloride PVC. However, it did not work out to fully meet the requirements of laying 6-500 kV cables, and in fact these requirements are clear to any cable operator:

- heat-resistance for temperatures up to 90°C and even above;
- the possibility of laying by horizontal directional drilling HDD (the pipe must be flexible, durable, subjected to butt welding);
- the possibility of removing the cable from the pipe in order to repair or replace it.

Maybe engineers on power energy need to finally clearly formulate these three simple requirements and give the industry a task to develop pipes that would fully satisfy them?

After all, it is impossible to call a normal situation when for laying expensive CL (the cost of each kilometer of which, taking into account the installation, reaches 1 million-euro), drainage pipes or pipes of water supply systems are used that are obviously not suitable for these purposes and have nothing general with electrical engineering either by characteristics or by origin!

## References

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