Plastic Pipe Systems for District Heating, Handbook for Safe and Economic Application (1999: T6)

Introduction

Plastic medium pipes have in some countries, especially in Scandinavia, been used for many years in floor heating applications and in smaller local networks. In Denmark these pipes are also quite common for smaller district heating pipelines. In spite of years of experience, there still exist doubts about the possibilities of using plastic pipes in district heating applications, mostly because of the limitations in pressure and temperatures which must be observed when using plastic medium pipes. The use of plastic medium pipes is also limited to relatively small dimensions, i.e. below 100 mm diameter, which makes it necessary to mix steel pipes and plastic medium pipes in many applications, a combination for which experience so far was not systematically documented.

The aim of the project is to compile know-how and installation experience from various countries and to present the results about plastic medium pipe techniques in the shape of a handbook. The handbook describes the basic properties of plastic materials involved and the conditions for its applications, as well as recommended laying and installation techniques to be used for receiving both technically and economically favourable results

The handbook is divided into two main parts: An engineering part A describing the main aspects of using and applying plastic medium pipes, including also economical system aspects, and a material part B, giving more detailed background information about the specific material properties as an Appendix. Some field projects are documented in the Appendix part C.

A - Engineering aspects

The plastic medium pipe systems are described for all makes commercially available on the European market (i. e. in more than one country) for the last years. This implies that products under development or just pilot products are not included. This limits the make description to the following systems:

Bonded pipe systems with PEX:
ABB-PEX flex (ABB Isolrohr). Brugg-Calpex. Isoplus-Isopex. Lögstör LR-Pex.
Tarco PEX/FLEX.

Non bonded pipe systems with PEX:
Uponor Ecoflex.

Pipe systems with other material than PEX
Flexalen.

A complete list of properties of these systems mentioned above is included in Table 2.1. It gets evident from this list, that the PEX medium pipe is the prevailing pipe material and that practically all PEX-pipes to be used for district heating have a diffusion barrier of EVOH (ethylenvinylalcohol) which reduces the risk of oxygen diffusion to a great extent. Polybuthylene (PB) - with or without a diffusion barrier - is only offered by one manufacturer. PEX pipes are available in dimensions up to DN 100 mm whereas the PB pipes are offered also up to DN 125 mm. For pipe joints, a variety of joint systems are available, most of them are of type press or screw fittings. An exception is the PB pipe, which can be welded.

The advantage of plastic medium pipe systems is their flexibility. This holds not only for the plastic pipe but also for the total pipe system including insulation and jacket. Even for the largest diameter the minimum radius of curvature is given to 1.5 m. In all pipe systems, except the Uponor-Ecoflex and Tarco, the insulation is made by PU-foam, covered with an outer jacket of PE. The Ecoflex system uses PEX foam insulation with a PE jacket, and Tarco uses a PU-foam with a jacket of an elastomere ethylenic butylacrylate.

The most important difference between plastic pipe systems and preinsulated steel pipes is their simple and quick assembly. Whereas a typical time for the construction of a section of preinsulated pipes might be counted in weeks, plastic medium pipe systems can be installed within a few days.

In assembly, only simple tasks have to be carried out which can be completed quickly. For this reason it has been shown that the same contractor can manage all installation work. The pipe ditch is kept quite narrow with a minimum of excavated material since no welding work has to be made down in the ditch (except some large holes for joints or service Tees). The sand bed can be immediately filled up, the plastic pipe laid down in its full length and the ditch can be refilled within hours except may-be the excavation of larger holes made for joints or branches. By that way, roads are usually only blocked for some hours, bridges are not required and traffic interruption and other impact to the public is kept at a minimum.

Connections of PEX-pipes are best carried out as press connections. They can be mounted using a special tool far more quickly than a welded connection on a steel pipe. Visual control of the joints is sufficient. However, PB pipes are commonly connected by welding.

Whereas the pipe laying effort for the main pipe system is considerably lower for plastic pipe systems compared to preinsulated pipes, branches require about the same effort for both systems. In plastic medium pipe systems, branches are produced very often with prefabricated Tees and the joints have to be carefully insulated and tightened.

Comparing plastic medium pipe systems with preinsulated steel pipes it can be stated that - all work considered - the effort spent for laying plastic medium pipe systems is very much less than for preinsulated steel pipes. This results also in lower total pipe system costs in comparison with the preinsulated pipes. In studies made in Sweden, Germany and Denmark it was shown that the total system costs are well below those for preinsulated pipes up to DN 65, the difference being larger the smaller the dimensions are. That means that the main advantage of plastic medium pipe systems can be found in applications where the transported energy is below 500 kW.

B - Material aspects

The most dominant questions concerning the plastic medium pipes are the limitations in temperature and pressure at one hand and the oxygen diffusion at the other hand.

These questions have been investigated in different laboratories in Europe as well in the USA. Plastic pipe properties have been improved during the years and early measurements should be taken with caution. Reliable measurements for the lifetime expectancy of PEX and PB are nowadays available. These measurements are based on both real time laboratory measurements for more than 10 years and accelerated measurements at elevated temperatures and show that the time to failure is depending on both pressure and temperature. By taking mean values of the time to failure over different measurement series, lifetime diagrams as function of temperature and pressure can be constructed. Such diagrams are now proposed to be included in the new standard for plastic pipes.

For a district heating application with a temperature dependent supply temperature (i.e. 90 °C winter and 70°C summer) and an operating pressure of 5-6 bars, the expected life time can be calculated to be >100 years for PEX and > 60 years for PB pipes.

An important question is that of oxygen permeation through the plastic pipes. Untreated

PEX and PB material exhibit such a high rate of oxygen permeation that such pipes only can be used in special applications where all metallic materials in contact with the water must fulfil fresh water quality standards.

Therefore plastic pipes are covered with permeation barriers in order to reduce the oxygen permeation. For PEX as well as nowadays also for PB, all commercial makes for district heating use ethylenvenylalcohol, EVOH, as such a barrier.

Measurements of oxygen permeation through plastic pipes are very difficult to carry out and can easily be based by systematic errors. In recent times, such measurements have been performed on PEX pipes by laboratories in Sweden, Denmark and Germany. Usually such measurements are related to a given pipe dimension. Depending on the temperature and the test site, the permeation difference between systems with and without barriers is in the orders of 10 - 2000.

The most important question is which impact the remaining oxygen permeation has on the possibility of connecting plastic pipes to steel systems. Investigations have been performed at Fernwärmeverbund Saar in Germany. The expected corrosion impact from oxygen due to plastic pipes in two combined systems with twice as much plastic pipe volume as steel pipe volume, was calculated to be less than 0.03 - 0.1 mm loss of steel pipe thickness during 35 years. A study in Denmark resulted in still lower values. Hence from these and other measurements the conclusion can be drawn that the equilibrium contribution of plastic pipes to the oxygen leakage is negligible and plastic pipe systems can be mixed with steel pipe systems.

The influence of the diffusion of water vapour through the wall of PEX medium pipes on the pipe system is under investigation in Germany. In pipe systems consisting of media pipe, insulation and jacket, accumulation of moisture in the insulation of the pipe-system or also on the inner wall of the jacket can be expected, if the permeability of the jacket is less than that of the medium pipe. Moisture which accumulates in the insulation is expected to reduce the thermal resistance of the insulation. This on the other hand will increase the temperature of the jacket and hence increase its permeability until an equilibrium will be reached. Hence each pipe system is expected to have its own balance of humidity depending on operation temperature and materials involved in jacket and insulation. It is expected that the industry will use results of these measurements for further optimising the water diffusion properties of their plastic medium pipe systems.

C - Field demonstrations

Three examples from Sweden, Finland and Germany are presented in Appendix C of the report. In these projects, care was taken of using the advantages of plastic pipes as system size. Pipe dimensions and operating conditions were concerned. In two of these projects, the advantages of constructing the smallest pipe lines by means of Twin or even Quadruple pipe systems has been used. Although it is difficult to compare the costs of built systems and non-built calculated systems, the general conclusion was that a total cost advantage for small pipe systems (< DN 65) exists compared to conventional steel pipe techniques.
However, it has been found in parallel projects in the same countries (Sweden, Germany, Finland), that new installation techniques such as cold-laying and refill techniques for steel pipe systems and also the use of flexible steel and copper pipes, especially at operating conditions comparable to those of plastic pipe systems, also lead to reduced system costs.