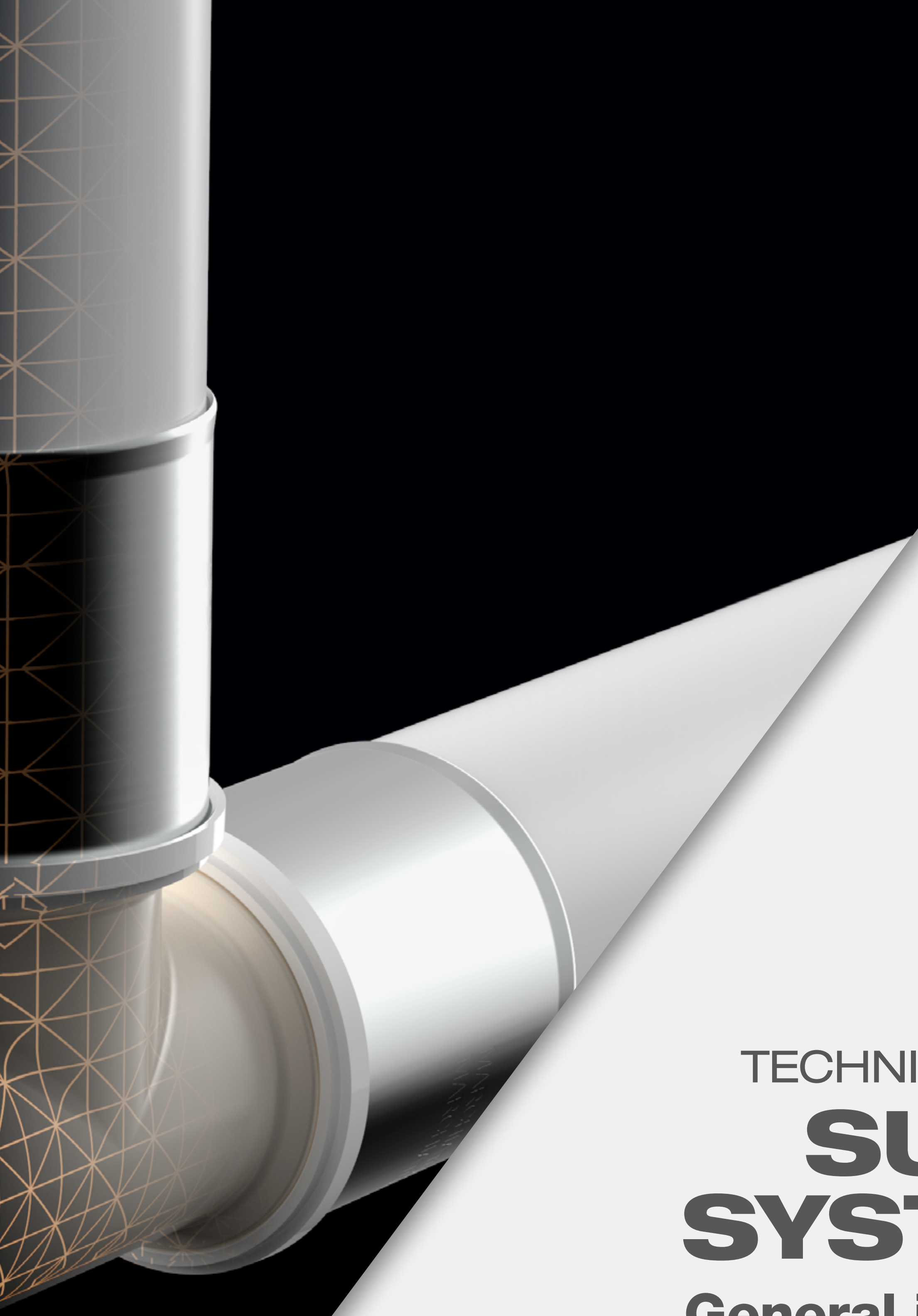

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TECHNICAL MANUAL

SUPPLY SYSTEMS

General information

MADE IN ITALY

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QUALITY FOR PLUMBING

This new edition of the technical manual for heating and plumbing systems is characterised by a thorough review of all the contents, especially following the publication of new international regulations.

The first chapter of this comprehensive manual deals with some interesting facts concerning the production process of multilayer systems, the characteristics of crosslinked polyethylene and of aluminium and the concept of oxygen barrier, an important aspect in closed circuit systems.

After an in-depth section that describes the characteristics, technical data, fields of use, certificates, markings of Pexal®, Mixal®, Thermoline® pipes and related Pexal® Brass press fittings, technopolymer Bravopress® press fittings, modular Pexal® XL fittings, full-bore Pexal® Easy fittings and compression Pexal® Twist fittings, the installation rules and techniques are described; minimum installation spaces and minimum distances between fittings, techniques for connection to utilities and distribution systems to utilities, as well as instructions for use of special fittings, such as repair joints are discussed.

A large section is dedicated to laying, including underground, in chase, exposed and seismic environment installation with the relevant types of clamping, manual and mechanical bending of the pipes, thermal insulation against condensation and energy losses, protection against UV rays and fire and commissioning (testing, flushing and disinfection).

The section about design covers cold and hot water and recirculation networks, explaining, with the use of practical examples, the calculation rules introduced by EN 806 and UNI 9182. In comparison with the previous edition, the design of heating and conditioning systems, the sizing of central heating systems and in particular of storage cylinders, expansion vessels, water hammer pressure surges, hydraulic separators, manifolds and mixing groups, are dealt with in detail.
In addition, considering the significant benefits of using Pexal® and Mixal® multilayer systems in the construction of compressed air distribution systems, a chapter describes the methods for calculation of the grids.

Finally, a technical appendix full of interesting and useful information completes this new edition of the technical manual for heating and plumbing distribution systems, underlining once more the commitment of Valsir to offering technical guides that are full of examples, rules and suggestions that can be used as a daily reference for the work of planners and plumbers.

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GENERAL INFORMATION

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GENERAL INFORMATION

1.1 Introduction

Pexal®, Mixal® and Thermoline® are pipes and fittings systems designed for hot and cold water distribution networks, heating and cooling circuits, air-conditioning, compressed air supply systems and industrial plants in general. The Pexal® and Mixal® systems are composed of multilayer pipes, which are produced by overlapping different materials, such as crosslinked polyethylene for the internal layer, aluminium for the intermediate layer and polyethylene (crosslinked for Pexal® only) for the external layer. The multilayer pipes combine the characteristics of plastic with those of ductile metal, thus offering many advantages in terms of use, performance and durability.

The Thermoline® system is composed of synthetic pipes and in particular the version with an oxygen barrier is created by covering the layer of crosslinked polyethylene with a particular polymer film (EVOH), thus giving the product a good gas impermeability, which is fundamental for heating, cooling and air-conditioning systems. Even though the Thermoline® pipe with an oxygen barrier is composed of several layers of material, generally speaking, the term “multilayer” is only used to describe products with an internal layer in aluminium, such as Pexal® and Mixal®.

1.2 The production process

The Pexal® and Mixal® production process can be divided into different phases.
The first phase is carried out by an extruder, which is a plant fed with polyethylene particles, additives and catalyzing agents which melt the mixture and push it through a mould in order to shape the internal pipe layer. The material, which has not yet solidified, passes through a vacuum-sealed calibration and cooling chamber, where it reaches the defined dimensions. In the following phase, a second extruder applies a layer of adhesive onto the surface of the pipe; this layer creates a strong permanent bond between the plastic pipe and the aluminium sheet, which will be added in the third phase. The edges of the aluminium sheet, which is supplied in coils, are cut and the sheet itself is calibrated in order to fit the circumference of the pipe onto which it has to be wrapped. After being calibrated, the sheet is progressively shaped around the pipe through a multistage process which leads to the butt-welding of the external edges by means of a TIG welding process.
Thanks to the TIG butt-welding process chosen by Valsir the thickness of the aluminium layer is the same around the whole pipe circumference, unlike the overlapping technology where the sheet edges are welded after being overlapped. Immediately after the welding phase, the pipe is warmed up in order to activate the adhesive layer and generate the bond between polyethylene and aluminium.
In the next stage a third extruder covers the aluminium with another adhesive layer, which is the fourth layer of the multilayer pipe. Finally a fourth extruder covers the pipe with a polyethylene layer (which, for Pexal® is crosslinked polyethylene and for Mixal® is high-density polyethylene) that is thick enough to obtain the final diameter of the finished pipe. During the final phases the pipe is cooled down, marked and cut into straight lengths or coils.
Product quality is verified throughout the entire production process, in particular the thickness and diameter of the plastic layers, the quality of the welding and the absence of holes in both the plastic and aluminium layers.

For Thermoline® pipes with an oxygen barrier (EVOH) three layers of plastic are extruded; if the pipe is without an EVOH barrier, there is only one layer to be extruded.
For Thermoline® pipes with an oxygen barrier three different materials are extruded simultaneously inside the same extrusion head, which produces a crosslinked polyethylene internal layer, an intermediate adhesive layer and an EVOH external layer which acts as an oxygen barrier.

For Pexal® and Mixal® multilayer pipes and for Thermoline®, the extrusion phase is followed by a crosslinking phase, which will be analyzed in the following chapter and which guarantees the thermal and mechanical characteristics that are typical of Valsir pipes.

The aluminium forming process
There are different methods to produce multilayer pipes; it is the technology used to form the aluminium layer that differentiates one from the other. The aluminium layer can be formed by overlapping, overlapping and then welding, butt jointing and welding. Valsir has chosen the TIG butt-welding process because it guarantees a uniform thickness on the whole circumference of the aluminium layer, greater pressure resistance, uniformity of the mechanical characteristics, improved bonding between the layers and a total oxygen barrier.

Figure 1.1 Welding by overlapping.

Figure 1.2 Butt-welding.

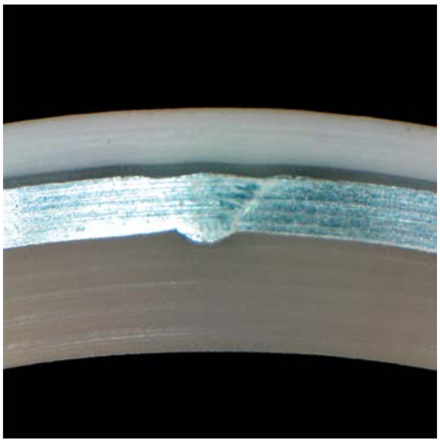
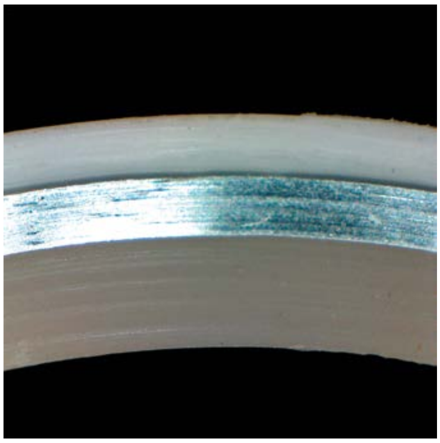


Figure 1.3 Valsir butt-welding.



1.3 Crosslinked polyethylene

Crosslinked polyethylene (commonly abbreviated PE-X, PEX or XLPE), is widely used to produce pipes for the construction of hot and cold water supply systems inside buildings, for the transportation of natural gas and industrial chemical compounds but also for the insulation of high tension electrical cables thanks to its excellent properties. In most cases PE-X is made from HDPE and contains bonds in the polymer structure that completely modify its characteristics changing the thermoplastic to a thermoset. The crosslinking process is accomplished during or after the extrusion and the required degree of crosslinking is imposed by the standards in force. Crosslinking improves the elevated-temperature properties of the material, chemical resistance is enhanced by resisting dissolution, low temperature mechanical properties, impact and tensile strength are improved.

The crosslinking process can be performed using different technologies that are recognized by international standards and identified by the methods A (peroxides), B (silanes), C (radiation), D (azo compounds); the method used is indicated after the material abbreviation, thus obtaining: PE-Xa, PE-Xb, PE-Xc, PE-Xd.

Figure 1.4 Non crosslinked polyethylene.

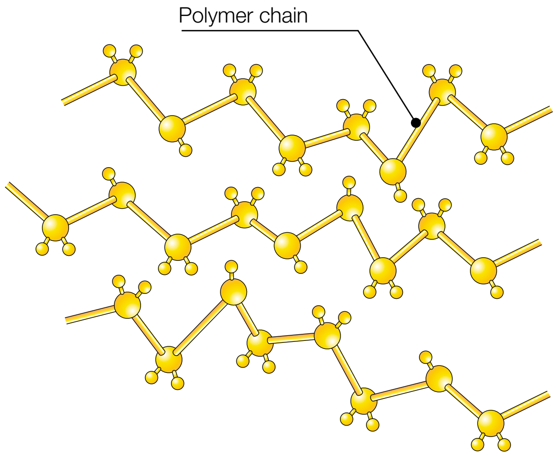
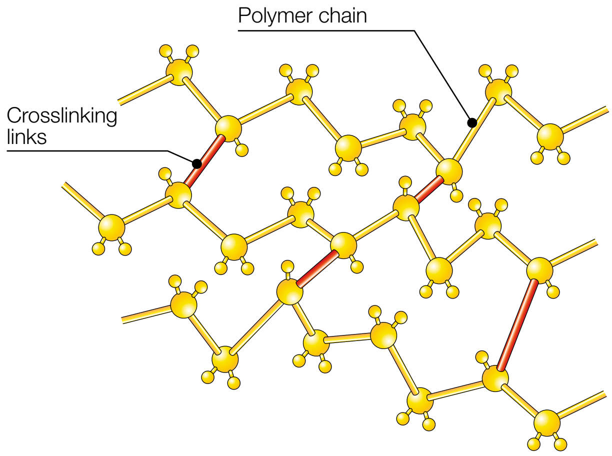


Figure 1.5 Crosslinked polyethylene.



PE-Xa is produced with the peroxide method (Engel, Pont à Mousson, Doaplast); this is the so-called “hot” cross-linking method because it is performed at a higher temperature than the melting point of the polyethylene. The material is extruded and, immediately after, for a certain period, it is kept at high temperatures and pressures inside long chambers. During this period, the peroxide decomposes into free radicals and reacts with the polymer creating bonds between the various polymer chains through the carbon atoms and creating methane as a by-product; that is the reason the high pressure chambers are used to avoid the leakage of methane that could cause pores or holes in the walls of the finished product. The structure that is created with the peroxide method is bi-dimensional and planar.

PE-Xb is produced with the silanes method (Sioplas, Monosil, Siloxal), which is performed in a secondary post-extrusion process. The crosslinking process is triggered in the presence of both heat and moisture; the water molecules, in fact, are dispersed inside the polyethylene, reacting and causing the polymer chains to bond together by groups of silanes that have higher flexibility compared to carbon atom bonds typical of the A and C methods. The bonding groups are composed of three silane chains next to each other, that are capable of forming a tri-dimensional crosslink and therefore a molecular structure with a high mechanical resistance.

PE-Xc is produced by electron irradiation (by Gamma or Beta radiations), which is performed below the crystal melting point. The energy of the electrons, which are accelerated by the pipe walls, splits the carbon-hydrogen bonds thus facilitating the creation of bonds between the polymeric chains. The generated structure is a planar one as with the Engel method. This type of crosslinking process is not usually carried out by the producer of the pipe but by specialized companies that receive reels composed of large quantities of pipe, which they unroll and place in special chambers. Once the pipe has been crosslinked, it is reeled in again and sent back to the pipe producer where it is once more unrolled and put onto smaller reels ready for sale.

This process therefore requires a lot of handling and manipulation if compared with the other crosslinking methods.

PE-Xd is produced using a process that is similar to the peroxide crosslinking method. The azo-compounds decompose at very high temperatures and form free radicals and create bonds between the polymer chains. When this manual was published this crosslinking method had apparently not yet been adopted by any of the producers of crosslinked pipes.

Table 1.1 Comparison of crosslinking processes.

Crosslinking process	PE-Xa	PE-Xb	PE-Xc
Method	Peroxides	Silanes	Radiation
Type of molecular bond	C-C	Si-O-Si	C-C
Molecular structure	Bi-dimensional	Tri-dimensional	Bi-dimensional
Type of molecular bond	Rigid	Flexible	Rigid
Minimum crosslinking percentage	70%	65%	60%
Crosslinking phase	During extrusion	After extrusion	After extrusion
Crosslinking outsourcing	No	No	Yes
Special tools and equipment	Yes	No	Yes
Production speed	Low	High	High
Range of diameters	Limited for big diameters due to low extrusion speed	No limits	Limited for pipes with big diameters and elevated thickness due to penetration difficulty of electrons
Use for drinking water supply systems	Yes	Yes	Yes

There is contradictory information on the market that labels certain materials as being of higher quality than others; however the quality of the product does not depend on the crosslinking process adopted but on the production capability of the manufacturer and the compliance of the product with the relevant standards that are valid for all four of the above-mentioned methods.
It is also important to mention that a higher level of crosslinking does not necessarily translate into higher product performance; on the contrary, exposing a product to too much crosslinking may make it fragile.

Valsir experience and technology
Thanks to years of experience and the technologies at its disposal, Valsir decided to implement an innovative crosslinking method for PE-Xb that leads to very important physical and mechanical performances.
The polyethylene used for producing Valsir Pexal®, Mixal® and Thermoline® pipes is crosslinked with steam at 100°C in sealed chambers.
In the chambers a level of vacuum is provided to ensure that the steam penetrates each roll completely, thus guaranteeing a uniform level of crosslinking regardless of the diameter or length of the pipe. Compared to traditional methods of PE-Xb crosslinking that use immersion or hot water circulation, this is an innovative crosslinking process that ensures extremely uniform mechanical characteristics of the finished product.

Cross-linked polyethylene offers significant advantages that, as we shall see, are amplified when combined with aluminium to form the multilayer Pexal® and Mixal® pipes.

Flexibility

PE-X is a widely used material for the production of piping for heating, water and sanitary applications and for the transport of gas also thanks to its flexibility. Compared to pipes made of PVC, CPVC, PP, copper, steel, etc., it can be bent and allows changes of direction in tight spaces. This feature allows pipes made of cross-linked polyethylene to be used to connect the gas supply point with the appliance without the need for intermediate fittings which are required in changes of direction for other systems.
This allows reducing costs, possible leakage points as well as pressure drops generated by the presence of fittings. Gas appliances can be supplied with higher supply pressures by reducing pressure drops.

Easy to install

The installation of PE-X pipes is less demanding and therefore more economical than any other type of metal pipe like copper or steel. Compared to copper, for example, no welding is required, and compared to other plastic materials it does not even require any glue.

Reliability

Compared to metallic materials PE-X does not corrode and does not develop any electrochemical processes leading to degradation or causing holes. Compared to copper pipes and fittings systems, its installation does not require the use of a flame that can cause fires, resulting in one of the safest systems available today (according to the U.S. Fire Prevention Agency, the copper pipes welding process is among the leading causes of fire).

Compatibility

PE-X is perfectly compatible with pipes made of other materials such as copper and PVC; there are many possibilities on the market today that allow you to connect a circuit made of crosslinked polyethylene to an existing system produced with different materials.

Durability

PE-X is a material with high thermo-mechanical properties and is characterized by a life expectancy of at least 50 years. The International Standards require that the producers of crosslinked polyethylene pipe systems perform tests that can verify and ensure the durability of the product.

Resistance

Crosslinking improves the mechanical, thermal and chemical properties of the finished products. PE-X is used for the production of pipes for cold and hot water supply, in fact, it offers a high resistance to high temperatures but also to very low temperatures. The crosslinked polyethylene can in fact be used in external ice melting systems by circulating a water and glycol solution in the pipes.
Compared to materials such as copper and PVC, PE-X has a higher resistance to freezing and bursting; when water freezes it expands in volume thereby increasing the internal pressure of the pipe to bursting levels.
PE-X changes shape thanks to its particular characteristics and can partly accommodate - more so than other materials - the increased water volume and thus offers a lower risk of burst pipes. In any case, when there is a risk of water freezing, it is always advisable to drain the system if it is not in use.

Table 1.2 Comparison of materials making up the main water supply systems.

Properties	PE-X	PP-R	PVC	Copper
Corrosion and pitting corrosion resistant	Yes	Yes	Yes	No
Incrustation resistant	Yes	Yes	Yes	No
Installation using flames	No	No	No	Yes
Installation using solvents or adhesives	No	No	Yes	No
Absorbs vibrations and reduces the risk of water hammering	Yes	Yes	No	No
Disperses heat and has a higher condensation risk	No	No	No	Yes
Flexible, reduced number of fittings needed	Yes	No	No	No
High cross-sectional area	Yes	No	Yes	Yes
Availability in coils	Yes	No	No	Yes

As well as the comparison table indicated above, there are also other differences between PE-X and other plastic materials that are worth remembering. With the same external diameter, PP-R (Polypropylene Random) pipes have cross-sectional areas that are on average lower than PE-X pipes, and this is due to the characteristics of the raw material. PE-X is a material with a lower ageing speed and its mechanical characteristics are more stable over time than those of PP-R, which, on the contrary, has a more rapid reduction of its mechanical resistance and therefore requires a greater wall thickness. For example, a PP-R pipe with an external diameter of 50 mm has a cross-sectional area that is 37% lower than that of a Pexal®/Mixal® pipe of the same external diameter; for more details, please refer to the comparison tables shown in the Appendix.
PP-R and PVC pipes are more rigid than PE-X based pipes, in fact, they are not supplied in coils but only in straight lengths and hence the number of fittings required is far greater during the installation process.
PE-X based pipes (whether they are multilayer or all-plastic pipes) are easily bent without having to use fittings, and the possibility of purchasing them in coils makes them suitable for a multitude of applications such as radiant heating and cooling systems.

Today on the market, PE-RT (Polyethylene of Raised Temperature Resistance) is fairly widespread as an alternative to PE-X for the production of multilayer pipes. PE-RT is a polymer with the properties of conventional polyethylene (non-crosslinked) with the addition of some extra features.

PE-RT has a higher temperature resistance than non-crosslinked polyethylene but has significantly lower properties compared to crosslinked polyethylene PE-X. PE-X can be used continuously up to 95°C while PE-RT has a 70°C limit and therefore, if it is not combined with a layer of aluminium that compensates the lower performance, it will have a limited field of use. PE-RT is not crosslinked and therefore the production process ends with the extrusion of the pipe. It can be stated that the use of PE-X for the production of multilayer pipes allows elevated safety factors, especially regarding high temperatures and high pressure applications, compared to those that can be guaranteed with the use of PE-RT.

1.4 The aluminium

The combination of crosslinked polyethylene and aluminium allows to obtain pipes (so-called "multi-layer") providing exceptional mechanical properties and to offer one single product with the advantages of both materials. The performances of multilayer pipes are highly dependent on many factors including the type of aluminium alloy, the relationship between the thickness of the aluminium and the total thickness of the pipe, the position of the aluminium layer, the technology used in the forming and welding of the aluminium, the adhesion of the same to the cross-linked polyethylene layers.

Obtaining a multilayer pipe that combines a high resistance to pressure and to high temperatures, flexibility and shape stability, is the result of a careful and accurate design phase that involves not only the most sensitive aspects of the product but also the processes and technologies used to produce it. The long-standing experience in the production of multilayer pipes has allowed Valsir to implement processes and technologies that make it a product that is recognized in the major international markets and it is precisely these factors that underpin the superiority of Valsir compared to most producers worldwide.

The intermediate metal layer of the Pexal® and Mixal® multilayer pipes is made from a foil made of a special aluminium alloy. The foil is formed around the layer of PE-X and the two edges, which run along the length of the pipe, are subsequently TIG butt-welded. With the TIG welding process aluminium thicknesses from 0.2 to 2.5 mm can be welded, this allowing the production of large diameter pipes with high aluminium thicknesses.

The main characteristics of the aluminium alloy used in the production of multilayer pipes are:
- Excellent forming and weldability properties.
- High mechanical strength at high temperatures.
- High yielding strength, which is the maximum stress applied to ensure that the material does not irreversibly deform.
- Excellent adhesion due to the special degreasing treatments applied on the surface.

1.5 Oxygen barrier

In so-called closed-circuit systems such as heating and cooling systems, the accumulation of oxygen can lead to incrustations and have corrosive effects on the ferrous metal components that it is made of. If in addition there is passage of sunlight when using semitransparent plastic tubes, oxygen facilitates the formation of algae. Plastics are partially permeable to gases and in particular to oxygen and it is for this reason that in these systems, pipes with oxygen barriers made up of EVOH (Ethylene Vinyl Alcohol) have become widespread. Originally developed for the food packaging industry, this material has the characteristics of being impermeable to gases more than any other polymer; however, although having about 57,000 times reduced oxygen permeability compared to polyethylene, it does not eliminate it. In addition, it should be noted that, as the working temperature increases, the permeability of EVOH tends to increase too, thus reducing the overall performance; passing from a temperature of 20°C to a temperature of 50°C increases the permeability by about 10 times.

That being stated, EVOH Thermoline® pipes can be one of the most effective and economical solutions for cooling and low temperature heating systems, however, the best choice is to use multilayer Pexal® and Mixal® pipes **as the butt-welded aluminium layer acts as a total barrier both to light and to gas**.

WASTE SYSTEMS

SUPPLY SYSTEMS

GAS SYSTEMS

FLUSHING SYSTEMS

BATHROOM SYSTEMS

TRAPS

RADIANT SYSTEMS

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ACADEMY

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L02-690/1 – Giugno 2022

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