**What is PE-X?**

PE-X is the term used by pipe manufacturers for cross-linked Polyethylene. In heating installations, PE-X pipe is additionally equipped with a diffusion barrier (EVOH or Aluminium) layer according to DIN 4726 which functions as an oxygen barrier. The pipe measurements correspond to DIN 16892/16893. A major advantage concerning their installation is the flexibility of these pipes. The minimum bend radius is in accordance with 5 x d. Therefore, PE-X pipes are well suited for the use in floor-heating and radiant systems. Cross-linked Polyethylene is highly temperature and pressure resistant (in-service temp of 95° C / at 10 bars).

*In the European standard, PE-X material is currently listed under draft ISO/FDIS 15875-1, edition 2002-11, “Plastic Pipe Systems for Hot and Cold Water Installation – Cross-linked Polyethylene (PE-X)” - Part 1, 2, 3, 5 and 7. Each European country accepts this European norm or has corresponding working papers for this material available allowing the application of PE-X for various applications.*

**The Molecule Structure of Polyethylene and Crosslinked Polyethylene**

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**What about standards and regulations?**

Despite their strong growth in Europe over the past ten years, PE-X pipes have mainly been regulated via national standards, such as BS EN 1055 (test method measuring resistance to elevated temperature), DIN 16892 and DIN 16893 (pipes made from cross-linked PE (PE-X)), ISO 13479 (resistance to crack propagation) and ISO/TR 9080. Especially the requirements for materials used in contact with drinking water and their respective performance on taste and odour, have been regulated under national acceptance schemes (NAS).

PE-X drinking water systems are under permanent control and therefore are in line with the latest KTW-recommendations of the German Department of Public Health for all ingredients which are used in the sense of the Food and Implement Regulation for drinking water applications.

Example: As a basis for the entire drinking water installation within buildings, DIN 1988, part 1 to 8, the TwVO as well as the accepted technical regulations have to be observed in Germany. The pipe insulation for cold and hot drinking water application is to be carried out according to DIN 1988, to the Energy Saving Regulation (EnEV) and to the accepted technical regulations. PE-X systems which have already been certified are permanently dense?? pipe joints in accordance
with DIN 1988. This will be confirmed by the examination performed corresponding to the DVGW-working paper W 534, and by the DVGW-registration.

**Pressure testing according to DIN 1988, part 2**

All pipes are subject to a special pressure test during installation. The completed but not yet covered pipes are to be filled with filtered tap water (protection against frost). The pressure measurement instrument is to be connected to the lowest part of the installation which has to be tested. Please note that only pressure measurement instruments are to be applied which allow a secure reading of pressure change of 0.1 bar. Valves are to be closed upstream and downstream of the heating unit (e.g. boiler) to enable the test pressure to be isolated from the rest of the plant. Afterwards the pipe system is to be subject to the test pressure and finally to be reduced to the operating pressure. The pressure for such an installation is the permitted operating pressure plus 5 bars. With pressure increasing systems, the maximum operating over-pressure is to be tested.

**Test pressure: maximum operating over-pressure plus 5 bars**

**Test period: after temperature conditioning between pipe and test medium, 2 hours**

- Test difference pressure: > 0.2 bar
- After the pressure test according to DIN 1988, part 2, an additional pressure test with 0.5 bar over a period of one hour is requested.
- Finally, all pipe joints are subject to visual examination.

In future, European legislators are looking at harmonizing these under a European Approval Scheme (EAS) with the objective to ensure that such products do not risk consumers' health, or cause unacceptable effects on drinking water quality.

**Rinsing of PEX-drinking water pipe systems**

For the removal of coarse pollution, the system has to be rinsed with water after the pressure test.

1) **What are the advantages of PE-X?**

- No corrosion
- Increased maximum operating temperature
- Reduced deformation under load (creep)
- Improved ageing resistance
- Improved chemical resistance
- Increased abrasion resistance
- Improved impact strength
- Reduced raid crack propagation (RCP) even at low temperatures
- Outstanding resistance to slow-crack growth

2) **What kind of cross-linking techniques are available?**

The following cross-linking techniques are available:

**Peroxide cross-linking (PE-Xa)**

- Cross-linking achieved by using peroxides
- Cross-linking in an amorphous state (\( \phi > 136 \) degrees Celsius)
- Homogeneous cross-linking over the entire wall thickness
- Highest degree of cross-linking \( k > = 70 \) %

**Silane cross-linking (PE-Xb)**

- Cross-linking by sil-oxane cross-linking groups
- Cross-linking in a semi-crystalline state
- Degree of cross-linking \( k > = 65 \) %

**Irradiation cross-linking (PE-Xc)**

- Cross-linking achieved by high-energy radiation
- Cross-linking in a semi-crystalline state
- Only wall thicknesses \( s < 4 \) mm are economically cross-linkable
Degree of cross-linking \( k \geq 60\% \)

**Azo cross-linking (PE-Xd) (nearly no more used today)**
Cross-linking achieved by use of AIBN initiators \( (2,2' - \text{Azobisisobutyronitrile}) \)
Cross-linking in an amorphous state \( (\Delta > 136 \text{ degrees Celsius}) \)
Homogeneous cross-linking over the entire wall thickness
Highest degree of cross-linking \( k \geq 70\% \)

**Remark:** Please note that all of the above-mentioned cross-linking techniques are referenced in one standard only.

3) **What is the application temperature?**
The maximum application temperature is 95 degrees Celsius.
The permanent operating pressure is 10 bars at 70 degrees Celsius.

**Maximum temperature**
The highest temperature of the water in the piping system during operation (up to 120 degrees Celsius), that occurs during a certain part of the lifetime of the piping system (the highest occurring temperature during a short time).

**Peak temperature**
The highest temperature of the water in the piping system under abnormal circumstances, for example due to malfunctioning, during a short time (maximum 100 hours per 50 years).

4) **What about the situation regarding the processing ability of such a system?**
Due to the notch impact strength according to DIN 53453 tests can also be carried out at a temperature of minus 20 degrees Celsius. Naturally, pipes are less ductile in these low temperatures which means that the manufacturer has to advise on handling when selling the pipes.

5) **For what kind of application is PEX used?**
PEX is used in the following applications:
- District heating
- Domestic hot and cold water
- Air-conditioning systems
- Underfloor heating
- Central heating
- Automotive and ship-building
- Transport of industrial gases, compressed air and fluids (including fuel oil, gases, acids and alkalis)
- Process engineering and other specialised applications
- District heating
- Natural gas supply in extreme ambient conditions

6) **Is PEX resistant to SCG?**
Use of standard PE pipes requires the adoption of cares in the installation of the pipe to avoid excessive external point loads and notches, which may reduce the lifetime of PE pipes. PEX is absolutely stress-crack-resistant
The lifetime of PEX pipes is not influenced by stones or scratches/notches.
Pipes made out of PEX can be used without sand-embedding-without risk.

7) **Can PEX-material be welded?**
Yes, it can be welded with electrofusion fittings. PEXb pipes can also be butt-welded.
8) **What kind of joint techniques are available for PEX-pipes?**

   The following joint techniques are available for PEX-pipes:
   - Press technique
   - Welding technique

**Electrofusion welding**

**Quick&Easy**

**Buttfusion welding**
9) **How long does PEX-material exist on the market?**

PEX-material has been applied in the field since approx. 40 years.

10) **Can PEX be used for potable water?**

Yes, PEX can be used for potable water conforming to the latest drinking water regulations.

Naturally, PE-X material is also part in the prevailing national drinking water regulations. This material corresponds to the European Acceptance Scheme’s (EAS) positive lists which are currently valid and which shall later on serve as a basis for a CE-marking when it comes to a European merging.

11) **What are the differences between PE and PE-X?**

- the molecule chains are connected together ‘non-detachable cross links’,
- high resistance against gouging or scratches
- no growth from notches up to 20% of the wall-thickness
- very resistant to dynamic loads (water hammer)
- no rapid crack propagation down to temperatures of -50 °C and 20 bar pressure

12) **What about the danger of Legionella**

Over and over again, cases of the so-called legionella disease are known to the public. In heating and distribution systems, there is danger of a longer stagnation of water within the pipe system which could create conditions for growth of legionella bacteria. The temperature range in which legionella growth appears is often between 30 and 45 degrees Celsius.

**Measures regulating legionella growth**

**Origins of Legionella Growth**

Legionella growth can occur where stagnated water and favourable temperatures (25 to 50 degrees Celsius) dominate. According to special reports, they are able to survive at temperatures lying between below freezing up to plus 60 degrees Celsius. With single and two family houses in which the water runs only short distances within the pipe system and a regular and complete water exchange takes place within this system, there is only...
a very low risk of legionella growth. This can be different in larger buildings equipped with a more complex equipment.

Contamination sources within drinking water systems may be e.g.:
less or non-used system areas (especially 'dead pipes'),
Ventilation pipes
Evacuation pipes
Drinking water heater
Membrane expansion container
Therefore, operating conditions, building size including a possibly complex network (e.g. hospitals, row showers or indoor swimming pools etc.) and the type of use (e.g. whirlpools) are of great importance.

Most cases mistakes with planning, installation, assembly (design, hydraulic comparison etc.) are responsible for the legionella growth within a pipe system.

13) The material from which pipes are made is rather insignificant. Legionellas can settle on all kind of materials such as iron, steel, copper, plastics, ceramic or glass. Preferentially, they grow in imperfections of the inner pipe surfaces.

14) What PEX-pipe dimensions are available?

Dimensions
The dimensions of the pipes are given in table 6. For the determination of the dimensions, the ISO 3126 method is followed.

<table>
<thead>
<tr>
<th>d_n</th>
<th>(d_em)</th>
<th>Out of roundness</th>
<th>Wall thickness</th>
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<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
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<td>25.3</td>
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<td>63.6</td>
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<td>75.7</td>
<td>1.4</td>
</tr>
<tr>
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<td>90.0</td>
<td>90.9</td>
<td>1.4</td>
</tr>
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<td>126.2</td>
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## PE-X pipes

### Table 6 – Requirements for PE-X pipes

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Requirement</th>
<th>Test parameter</th>
<th>Test method</th>
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<tr>
<td>Dimensions</td>
<td>According table 5</td>
<td>Dimensions</td>
<td>EN 496</td>
</tr>
<tr>
<td>Appearance</td>
<td>Smooth without any flaws</td>
<td>Soundness??</td>
<td>Visual inspection</td>
</tr>
<tr>
<td>Extent of cross linking(^1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE-Xa Peroxide system</td>
<td>≥ 70 %</td>
<td>EN 579</td>
<td>EN 579</td>
</tr>
<tr>
<td>PE-Xb Silane system</td>
<td>≥ 65 %</td>
<td>EN 579</td>
<td>EN 579</td>
</tr>
<tr>
<td>PE-Xc Radiation System</td>
<td>≥ 60 %</td>
<td>EN 579</td>
<td>EN 579</td>
</tr>
<tr>
<td>PE-Xd AZO-system</td>
<td>≥ 60 %</td>
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<td>EN 579</td>
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<td>Resistance to internal pressure</td>
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<td></td>
<td>≥ 1 h(^3)</td>
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<td>≥ 22 h(^3)</td>
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<td>≥ 165 h(^3)</td>
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</tr>
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<td>≥ 1000 h(^4)</td>
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<td>Thermal stability</td>
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<td>Influence of heat</td>
<td>≤ 3 %(^5)</td>
<td>Change of length</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>EN ISO 15875-2</td>
<td></td>
</tr>
</tbody>
</table>

1) The maximum allowed percentage of cross-linking of the system must be stated by the manufacturer. The percentage measured during the determination according the above-mentioned method, shall be in between both values.
2) σ(N/mm²)
3) After the test, the test pieces may not show any cracks, blisters or cavities.
4) Minimum required test time