LK PEX Pipes

Technical Brochure

www.lkpex.se

LK Pex

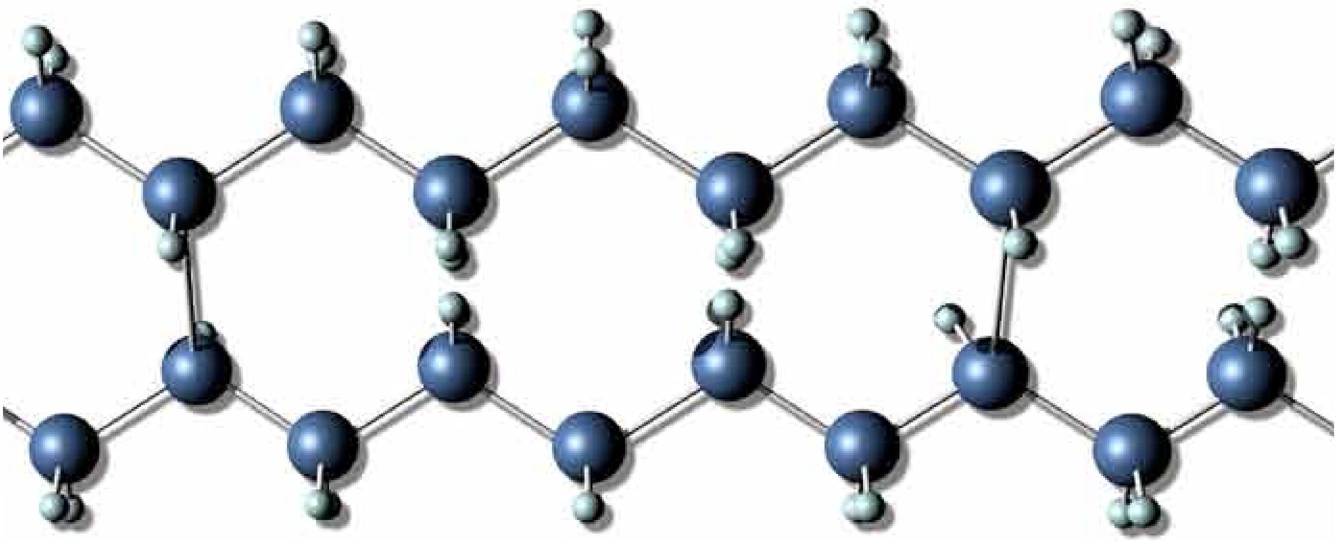
Have you seen ”Slinky”?

What’s Slinky got to do with our PE-Xa pipe?

You know Slinky? Those springs that walks down the steps. Formed like a tube and it bends around itself amazingly narrow as it walks the steps. The shape is round (not oval) although it bends. So it never kinks although the bending radius is minimal. Still, as a tube it is very strong. Slinky and LK PEX tubing has a lot in common. In the PEX version, the molecular chains are stretched out like fibers and oriented around the tubing. Like the flat wire circles around the Slinky spring. Making the tubing very flexible and kink-resistant. But still it is very strong to withstand inside pressure.

Of course you know about fiber strength. A tree has its fibers oriented along its length. Boards are cut out of logs along their length. These boards are fairly stiff and strong. You can’t easily break a ½” board by hand. But now, if you cut a log across and make a ½” board, you can easily break it. It is not stiff or strong in that direction. Are molecules like fibers? You bet they are. Take Polyamide as an example. That’s Nylon. You may mold Polyamide into a form and you can then test its tensile strength. Now, instead of molding the same plastic you can stretch it from its melt. Pull it out from its molten stage and make a fishing line. The strength of the fishing line is many, many times stronger than the molded piece of the same material. The molecules in the fishing line are untangled and stretched out side by side along the line. It’s very strong and very stiff as compared to the molded piece. So what about PEX? The conventional PEX is like the molded piece. The molecules are not stretched out or oriented. But in LK PEX tubing we have done it! We let the molecular chains circle around the tubing. The fibers are stretched to be strong in the direction inside pressure is applied. And in the same time lined up to be flexible – like Slinky!

No ovalization, not even close to kink. Radius of around 2 inches.



The molecular chains in a PEX-pipe are untangled and oriented around the tubing circumference, similar to the flat wire that makes up the “Slinky” spring and allows it to bend around itself. There are a few stiffening “fibers” along the tubing length. This makes the LK PEX pipe uniquely flexible and easy to install.

LK PEX tubing key benefits

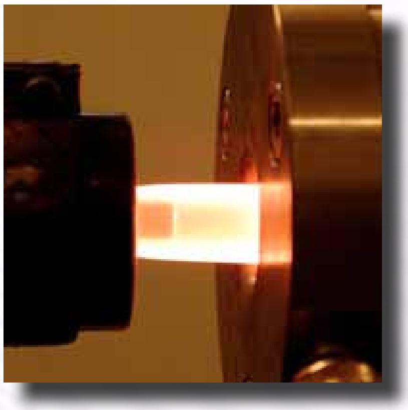
Crosslinking Process

LK PEX tubing is crosslinked using peroxide crosslinking, a so called PEX-a process. By means of heat, a peroxide mixed into the PE raw material is split into radicals. These radicals react with the PE polymer chain and absorb hydrogen atoms to become inert. The polymer chains, now becomes radicals. They, in turn, become inert by joining together – forming crosslinks.

As mentioned, the peroxide is split by means of heat. That means that the tubing material needs to be quite hot for the reaction described above to take place. It must be well over the crystalline melting point temperature of around 132,2 °C (270 °F). The material must also be correctly shaped (must have its tubing form) while the crosslinking takes place inside the polymer melt. After crosslinking has taken place, the material is cooled down and the crystals are formed around the crosslinking points, reinforcing these areas. These principles are valid for all PEX-a processes.

High technology manifacture of PE-Xa pipes.

For other crosslinking methods like radiation crosslinking (PEX-c) and Silane crosslinking (PEX-B) the crosslinking takes place at temperatures well below the crystalline melting point. For these methods, when tubing is heated over the melting point, there will be a loss of crystals when the material is cooled down again. The crosslinks will partially disturb the formation of previously existing crystals. So there will be a loss of strength after this reheating – which is not the case for PEX-a tubing.



Crosslinking inside the polymer melt.

PEX-a is crosslinked while melted, and as described above, this will result in a lowered crystallinity. Typically, a lower crystallinity means a lower strength. Therefore, the raw material utilized in traditional PEX-a processes need to have a quite high density (which is practically the same as high crystallinity). Typical raw material density is at least 950 kg/m³, and this results in density of around 939 kg/m³ after crosslinking. This is approximately the minimum density required in order to meet the ASTM F 876/877 and EN ISO 15875-2 strength requirements.

Radiation and Silane crosslinked tubing have densities that are approximately the same as the raw material they are produced of – around 940 to 941 kg/m³. This is approximately the required minimum for them to meet the ASTM PEX standards. Since density is directly related to stiffness (or flexibility) we note that Radiation and Silane tubing are slightly stiffer than traditional PEX-a processes (their density is approximately 2 kg/m³ higher – and this makes up a clearly noticeable difference). The LK Pex tubing process starts with a raw material with a density of around 940 kg/m³ and the final product has a density of around 930 kg/m³! This is considerably less than other PEX process, and results in very flexible tubing. How is it possible that a material with this low density still exceeds the ASTM requirements for PEX? The reason is that inventors of this process have succeeded to align most molecular chains AROUND the tubing circumference! Traditional extrusion processes does not provide any orientation of molecules, but their orientation are at random. By having the molecules aligned around the tubing they are ready to absorb the stress caused by inside pressure. So in spite of lower density this tubing can actually resist a higher inside pressure than traditional PEX tubing! At the same time, since few molecules are stretched along the tubing, the flexibility is even better than what is explained by the density alone! Welcome to test the pressure resistance. Just hook up our tubing in series with a competitor's tube and increase the pressure until one of them bursts. It will not be the LK Pex tubing.

Another major difference is the homogeneity. Traditional PEX-a processes have raw materials with high density and high molecular weight making the polymer flow characteristics quite poor. The material is mainly pushed through the extruders and raw material particles are just melted together. The flow is very little stirred during the extrusion. Not so in the LK PEX-a process. The material is thoroughly worked, the original raw material particles are thoroughly blended, and even stretched out to orient the molecules around the tubing. The result is excellent homogeneity, antioxidants well disbursed, and better overall properties. Check homogeneity by holding tubing samples towards a bright light. Turn slowly and look. You will notice the difference!

Property comparisons

Property	LK PEX-a pipe	Traditional PEX-a pipe
Flexibility	Considerable more flexible than any other PEX tubing meeting ASTM.	Somewhat better flexibility than Radiation and Silane crosslinked tubing.
Strength	Withstands somewhat higher inside pressures than other PEX tubing.	Meets ASTM
Homogeneity	Excellent	Not very good. Worse than Radiation and Silane.
Thermal memory	Excellent	Good. Better than Radiation and Silane.
Repairability	Excellent	Excellent
Kinking resistance	Excellent	Fair. Better than Radiation and Silane.
Barrier property	8 times less than DIN 4726 (measured).	Meeting DIN 4726
Thermostability	Excellent	Better than ASTM requirements.
Memory effect of being coiled	Little. Easy to bend in any direction.	Fair. Better than Radiation and Silane.
Minimum bending radius	Narrower than any other PEX tubing.	Fair. Better than Radiation and Silane.
Process uniqueness	There is just one manufacturer.	Several manufacturers – not unique.
Commercial dependence	None	Uponor dominates

Long Term Strength

Long Term Strength – and its consequences for PEX figure 1 and 2

Figure 1.

“Figure 1” is a chart displaying long term strength of a polymer pipe. To find these curves you start a large number of pressure tests at different stress (inside pressure) levels. And you wait until most samples have failed (pressure disappeared). Each black dot in “Figure 1” represents such a failure. By entering the data in mathematical formulas (see for example ASTM D 2837 or ISO 9080) you can calculate the average line that describes the strength (the three lines in “Figure 1”). As you see, you will normally be able to find 3 lines with different slopes describing the material’s long term strength. At short times you will see a line with comparatively small slope. All failures here are ductile (the pipe “bubbling out” quite much before it bursts. This is called “Stage 1”.

For intermediate to long term you will find a line with larger slope. The early failures on this line have mixed mode (some expansion of the pipe before it bursts), but most failures (all but the first few on this line) will be brittle (a longitudinal crack in the pipe). This is called “Stage 2”. The line describing the strength at long term is approximately vertical. That means that the failure is virtually independent of the stress applied. Pipes with very different pressures fail at approximately the same time. All failures are very brittle. This is “Stage 3”. It is caused by thermal degradation of the material.

(The definition and description of Stage 1, 2 and 3 was first internationally introduced in the book “Water & Pipes” Lenman/Skarelius 1982. Then also at the International Plastics Pipes Conference V in York, UK, 1983, Paper 35, 9 pages “Flexible Plastics Pipes for Hot Water, and the Effects of Oxygen Diffusion”; T Lenman).

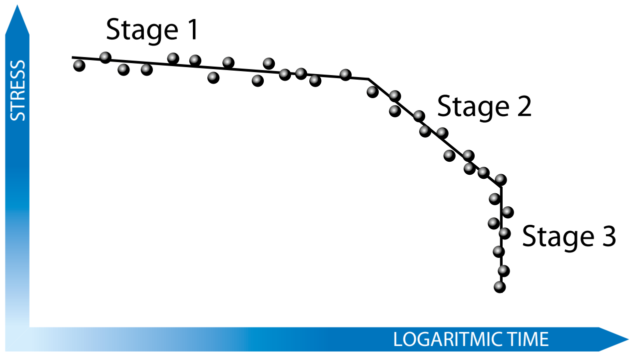


Figure 1.

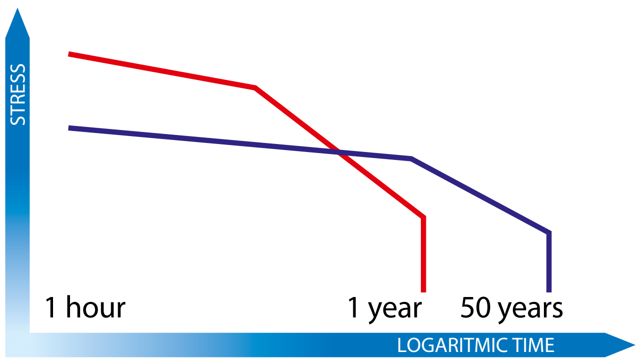


Figure 2.

Figure 2.

“Figure 2” is provided in order to show that there are wide variations to different Polymer properties. The molecular chains can be more or less branched. These branches may be long or short. There may be some other chemical groups inserted in the molecular chains. These “disturbances” may come regularly, or at random.

All these factors (and some more) give different properties to the material. Compare the two tubing qualities in the “Figure 2”. The material described by the red line has much higher strength at short term exposure. But the material described by the blue line has much better long term strength. Some sample times are inserted in the “Figure 2”. Then that chart could be true at 82,2 °C (180 °F) for two different Polythylene or Polybuthylene qualities.

Long Term Strength – and its consequences for PEX figure 3 and 4

Figure 3.

Lets first see what crosslinking does to the material. The uncrosslinked material is the line to the very left and lowest. The same material with 70% or more of crosslinking is highest/most at right. In between these lines you have gradually higher crosslinking. Crosslinking makes two things: It decreases the slope of "Stage 1", and it delays the occurrence of "Stage 2". It does not noticeably affect the occurrence of "Stage 3". Note that "Stage 2" completely disappears when 70% of crosslinking is achieved. According to internationally published papers also for Silane crosslinked PEX. The time of occurrence of "Stage 3" is mainly dependent on the type and amount of antioxidants in the material. It is true that fewer "disturbances" in the molecular chains (fewer tertiary carbons) may contribute to delay the occurrence of "Stage 3", but the antioxidants recipe is the most important parameter.

Density of a material will directly affect the level of the "Stage 1" line. Increased density would move the "Stage 1" level upwards. To be able to hold higher pressures. Test temperature will directly affect the level of "Stage 1". Decreased temperature would move the "Stage 1" level upwards and increased temperature downwards. Temperature will also move the timing of occurrence of "Stage 3". Increased temperature towards shorter time and decrease of temperature towards longer time.

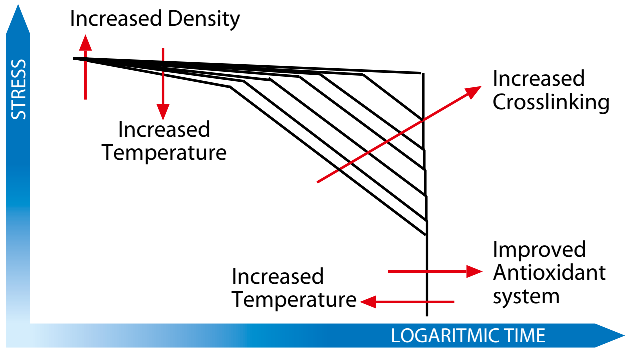


Figure 3.

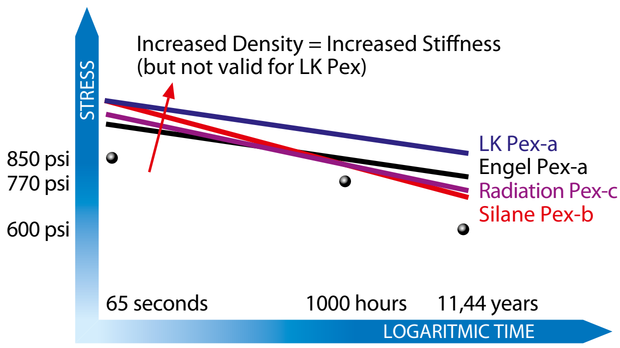


Figure 4.

Figure 4.

"Figure 4" displays the experience regarding the long term strength of different PEX makes at 82,2 °C (180 °F). (Slight deviations may be at hand for different makes). You can see three black dots in the chart. These represent the ASTM F 876/877 and the EN ISO 15875-2 strength requirements. The dot at left is the burst pressure strength requirement. The one in the middle is the sustained pressure requirement. The one at the right is the pressure rating requirement (see all occurring standards). If we made a straight line through the left and right dots we can see that the middle dot is at a considerable higher level than that line. That means that this is the most difficult control point to meet. That is the point that will decide the exact composition of the PEX material to be selected for each process.

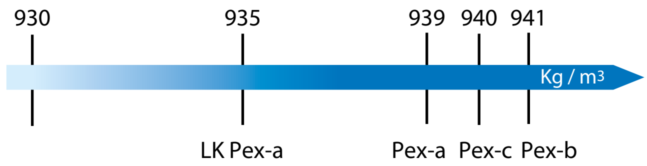
Let's disregard the blue line for now and compare the other three. The black line (Engel PEX-a) has the smallest slope of the three. That means that this material can have lesser density than the other two and still meet the strength control point at 1,000 hours. And be somewhat more flexible. Radiation crosslinked has bigger slope and needs higher density to "make it". And Silanes slope is biggest and needs the highest density, and becomes the stiffest material.

Now we see the blue line representing LK PEX tubing. Here the same relation between strength and density is not valid any more. That is because many of the PEX molecular chains are oriented around the tubing. In the same direction as the stress. So a much lower density material will still be able to hold higher stress. A much more flexible material. The slope of the long term strength line is little – typical for PEX-a materials. The strength is still quite much higher than other materials for all long term times. Possible around the same as Silane for very short times.

Long Term Strength – and its consequences for PEX figure 5

Figure 5.

"Figure 5" outlines the difference in density for the four materials discussed. As you can see there is a vast difference in flexibility between LK PEX tubing and conventional PEX a, b, and c. Since density and stiffness follow virtually proportionally – you can see the flexibility of LK PEX tubing.



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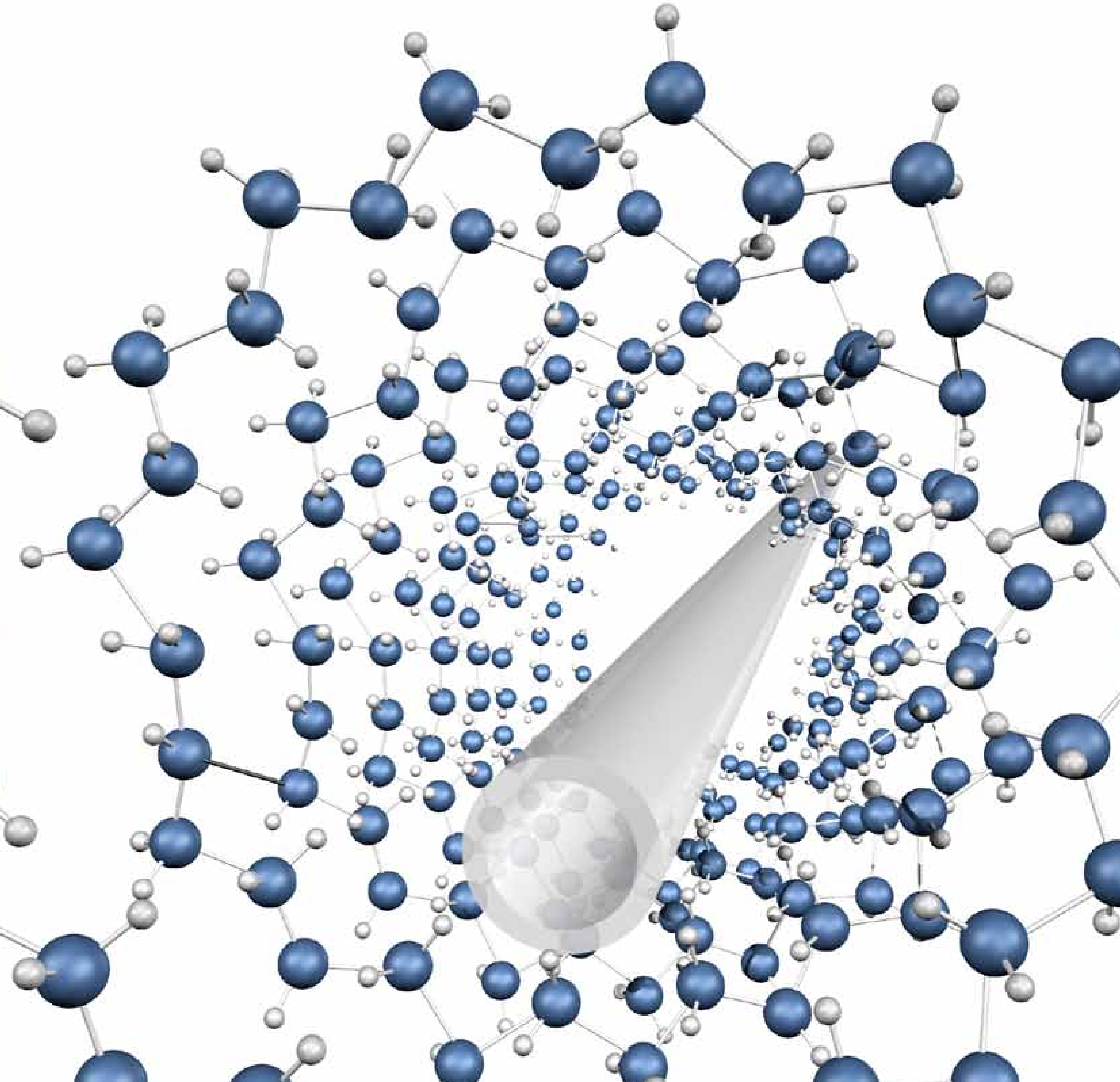

The PEX pipes from LK Pex are:

- Able to hold higher pressures than all other PEX-pipes *(Safety for user)*
- Considerably more flexible than all other PEX-pipes *(Convenience and speed for installer)*
- Much more kink resistant than all other PEX-pipes *(Convenience for installer)*

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