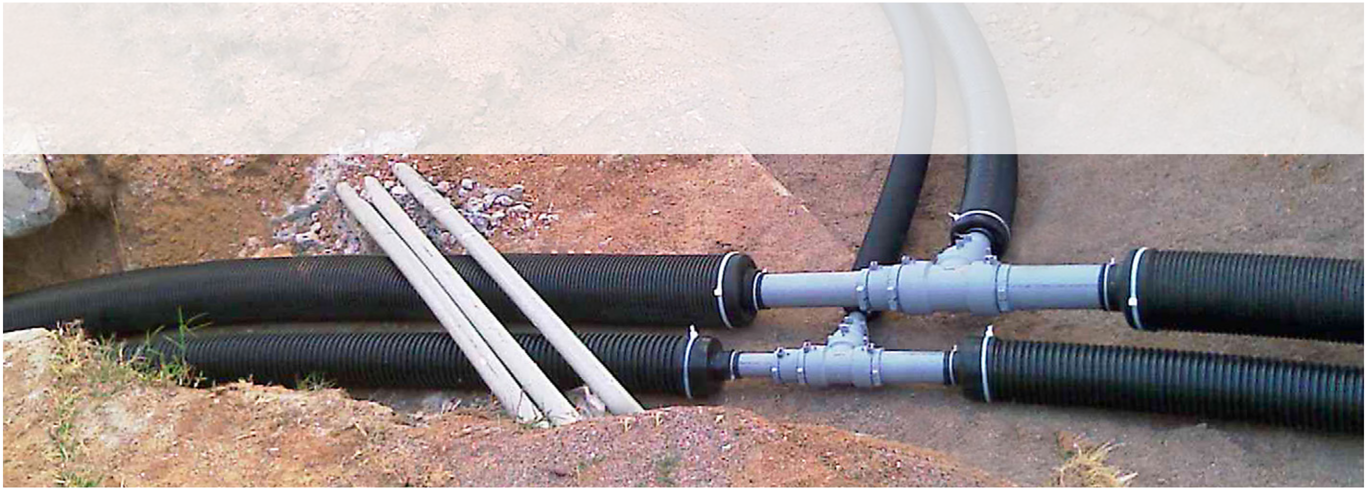
Technical Paper | EN

Polybutene-1 compared to PE-RT & PEX

Advantages for pressure piping systems



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Introduction

Polybutene-1 offers real benefits for piping systems compared to PEX and PE-RT

For pressure piping projects, the true cost variation of piping systems across competing materials is more than a per length cost comparison for the same outside pipe diameter. Specifiers' main criteria are Standard Dimension Ratio (SDR) comparing pipe materials for durability against pressure, but they also look at ease of installation impacting onsite costs; jointing options, long-term system performance and the projected life span. When compared to PEX and PE-RT systems, PB-1 offers significant benefits across a broad range of performance characteristics, all contributing to make PB-1 piping systems the optimum choice for high performance pressure piping installations.

Standard Dimension Ratio (SDR)

WHAT IS SDR?

The SDR or the Standard Dimension Ratio refers to the geometry of a pipe. SDR is a method of rating a pipe's durability against pressure and it describes the correlation between the pipe dimension and the thickness of the pipe wall. SDR 11, for example means that the outside diameter of the pipe is eleven times the thickness of the wall.

SDR rates pipe durability against pressure and correlates a pipe's outside diameter and wall thickness.

- **High SDR ratio**
  The pipe wall is thin compared to the pipe diameter
- **Low SDR ratio**
  The pipe wall is thick compared to the pipe diameter

D = outside diameter
di = inside diameter
s = wall thickness
Ai = inside pipe area

SDR = D/s
di = D – (sx2)
Ai = di^2 x (p/4)

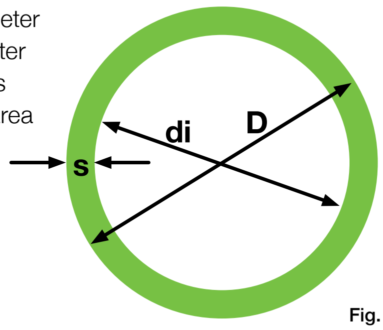


Fig. 1

Example calculation:
SDR for a pipe with an outside diameter of 110mm and wall thickness of 10mm can be calculated as: 110mm / 10mm = SDR 11

Why does SDR matter for piping systems?

Due to the higher SDR classification of PB-1 compared to either PEX or PE-RT, PB-1 piping systems deliver the following benefits because of its lower wall section requirements for the same pressure rating and outside pipe diameter:

- Less material for the same pressure capability
- Less weight per meter of pipe
- In some cases, lower outside pipe diameter for the same performance
- Larger inside area for the same outside diameter providing:
  - Higher flow rate at the same pressure
  - Lower pressure loss, requiring less energy to run a system or pumps with lower capacity

Standard Dimension Ratio (SDR)

The lower the SDR class, the higher the wall thickness, for a given outside diameter (**D**) (Table 1)

SDR	13.6	11	9	7.4	6
D	**s**	**s**	**s**	**s**	**s**
mm	**mm**	**mm**	**mm**	**mm**	**mm**
25	1.9	2.3	2.8	3.5	4.2
32	2.4	3.0	3.6	4.4	5.4
40	3.0	3.7	4.5	5.5	6.7
50	3.7	4.6	5.6	6.9	8.4
63	4.7	5.8	7.1	8.7	10.5
75	5.6	6.9	8.4	10.3	12.5
90	6.7	8.2	10.1	12.3	15.0
110	8.1	10.0	12.3	15.1	18.3
125	9.2	11.4	14.0	17.1	20.8
140	10.3	12.7	15.7	19.2	23.3
160	11.8	14.6	17.9	21.9	26.6
180	13.3	16.4	20.1	24.6	29.9
200	14.7	18.2	22.4	27.4	33.3
225	16.6	20.5	25.2	30.8	37.4
250	18.4	22.7	27.9	34.2	41.6

Table 1

The lower the SDR class, the lower the inside cross section area (**Ai**) of the pipe for a given outside diameter (**D**) (Table 2)

SDR	13.6	11	9	7.4	6
D	**Ai**	**Ai**	**Ai**	**Ai**	**Ai**
mm	**mm²**	**mm²**	**mm²**	**mm²**	**mm²**
25	353	327	296	254	216
32	581	531	483	423	353
40	908	835	755	661	556
50	1,425	1,307	1,182	1,029	866
63	2,256	2,075	1,870	1,633	1,385
75	3,197	2,942	2,660	2,324	1,963
90	4,608	4,254	3,826	3,359	2,827
110	6,910	6,362	5,728	5,001	4,231
125	8,925	8,203	7,390	6,475	5,463
140	11,197	10,315	9,263	8,107	6,851
160	14,612	13,437	12,115	10,605	8,958
180	18,482	17,018	15,350	13,437	11,347
200	22,859	21,021	18,918	16,559	13,977
225	28,893	26,590	23,943	20,970	17,719
250	35,700	32,878	29,620	25,901	21,852

Table 2

SDR Classes and Pipe Dimensions

SDR classes quoted in National Standards for District Energy piping systems

SDR classes are quoted in standards for District Energy. The SDR table below provides the wall section dimensions (**s**), the internal diameter (**di**) and the internal area (**Ai**) for each SDR class across a range of outside pipe diameters (**D**) (Table 3)

SDR	13.6			11			9			7.4			6		
D	**s**	**di**	**Ai**	**s**	**di**	**Ai**	**s**	**di**	**Ai**	**s**	**di**	**Ai**	**s**	**di**	**Ai**
mm	**mm**	**mm**	**mm²**	**mm**	**mm**	**mm²**	**mm**	**mm**	**mm²**	**mm**	**mm**	**mm²**	**mm**	**mm**	**mm²**
25	1.9	21.2	353	2.3	20.4	327	2.8	19.4	296	3.5	18.0	254	4.2	16.6	216
32	2.4	27.2	581	3.0	26.0	531	3.6	24.8	483	4.4	23.2	423	5.4	21.2	353
40	3.0	34	3.4	3.7	32.6	908	4.5	31.0	835	5.5	29.0	755	6.7	26.6	556
50	3.7	42.6	1,425	4.6	40.8	1,307	5.6	38.8	1,182	6.9	36.2	1,029	8.4	33.2	866
63	4.7	53.6	2,256	5.8	51.4	2,075	7.1	48.8	1,870	8.7	45.6	1,633	10.5	42.0	1,385
75	5.6	63.8	3,197	6.9	61.2	2,942	8.4	58.2	2,660	10.3	54.4	2,324	12.5	50.0	1,963
90	6.7	76.6	4,608	8.2	73.6	4,254	10.1	69.8	3,826	12.3	65.4	3,359	15.0	60.0	2,827
110	8.1	93.8	6,910	10.0	90.0	6,362	12.3	85.4	5,728	15.1	79.8	5,001	18.3	73.4	4,231
125	9.2	106.6	8,925	11.4	102.2	8,203	14.0	97.0	7,390	17.1	90.8	6,475	20.8	83.4	5,463
140	10.3	119.4	11,197	12.7	114.6	10,315	15.7	108.6	9,263	19.2	101.6	8,107	23.3	93.4	6,851
160	11.8	136.4	14,612	14.6	130.8	13,437	17.9	124.2	12,115	21.9	116.2	10,605	26.6	106.8	8,958
180	13.3	153.4	18,482	16.4	147.2	17,018	20.1	139.8	15,350	24.6	130.8	13,437	29.9	120.2	11,347
200	14.7	170.6	22,859	18.2	163.6	21,021	22.4	155.2	18,918	27.4	145.2	16,559	33.3	133.4	13,977
225	16.6	191.8	28,893	20.5	184.0	26,590	25.2	174.6	23,943	30.8	163.4	20,970	37.4	150.2	17,719
250	18.4	213.2	35,700	22.7	204.6	32,878	27.9	194.2	29,620	34.2	181.6	25,901	41.6	166.8	21,852

Table 3

Please note that the higher SDR class of PB-1 vs. PE-RT and PEX at any given pipe diameter offers thinner wall sections, less material (therefore less weight) a larger inside diameter and area, or in some cases, a smaller outside pipe diameter.

Pipe Dimensions and SDR Classes

NATIONAL STANDARDS (RU & NL)

The source for District Heating piping dimensions comparing materials PB-1, PEX and PE-RT

The current Russian standard for District Heating (GOST 56730 – 2015) and the Dutch guideline (BRL 5609 - and the draft of renewed BRL 5609) both include a comparison of 3 materials for District Heating piping systems: PB-1, PEX and PE-RT (Fig. 2). Both the Russian standard and the Dutch guideline have the same requirements in relation to the pipe dimensions and SDR classes of the 3 service pipe materials operating at pressures of 6 bar, 8 bar and 10 bar.

Per the Russian standard and the Dutch guideline (Table 4) is an excerpt of the relevant table showing the SDR classes for the listed materials at different pressure ratings. As indicated, for each operating pressure PB-1 is listed in the highest SDR class when compared to either PEX or PE-RT. The section below explains what this means, why standards refer to pipe dimensions and SDR classes and what are the benefits for pipe system specifiers.

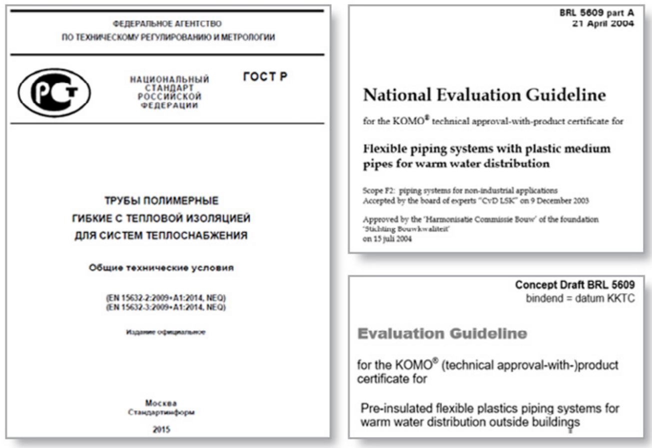


Fig. 2

Service Pipe	Operating Pressure		
	6 bar	8 bar	10 bar
PB-1	SDR 13.6	SDR 11	SDR 9
PEX	SDR 11	SDR 9	SDR 7.4
PE-RT II	SDR 9	SDR 7.4	SDR 6

Table 4

PIPE DIMENSIONS AND SDR CLASSES

PB-1 pressure capability delivers benefits versus PEX and PE-RT

To illustrate the performance of PB-1, PEX and PE-RT in relation to the given operating pressure of 8 bar at the small pipe diameter of 50mm ø, the diagram (Fig. 3) and table (Table 5) compare the internal pipe dimensions required.

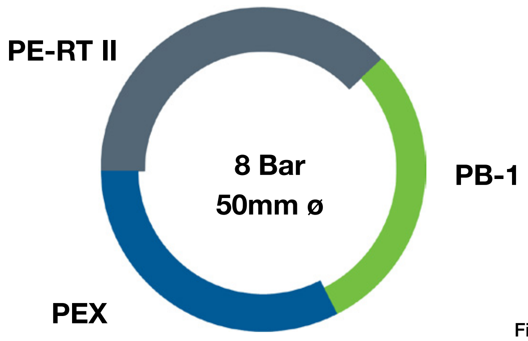


Fig. 3

Example 1: Small pipe – 50mm ø @ 8 bar

PB-1 is stronger than both PEX and PE-RT and with an operating pressure of 8 bar and an outside pipe diameter of 50mm ø the required wall thicknesses are indicated in the table (Table 5). Per the table above (Table 4), at the same water pressure, the larger inside diameter of a PB-1 50mm outside ø pipe delivers a substantially higher flow rate capability than the other two materials.

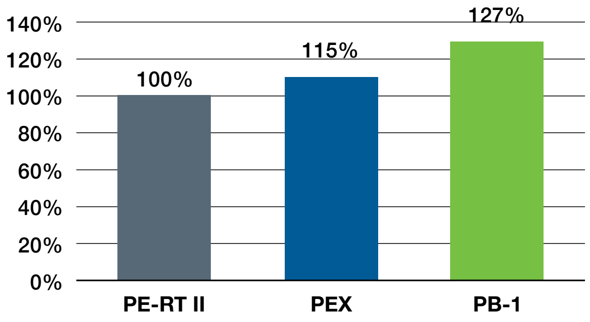
	SDR	Outside Ø (mm)	Wall Thickness (mm)	Pipe Section (mm^2)	Weight Per M (kg/m)
PE-RT II	7.4	50	6.9	1,029	0.934
PEX	9	50	5.6	1,182	0.780
PB-1	11	50	4.6	1,307	0.666

Table 5

Taken the other way, at a given flow rate PB-1 pipes yield a lower pressure loss requiring less energy to run systems and/or pumps with a lower capacity.

Pipe Dimensions and SDR Classes

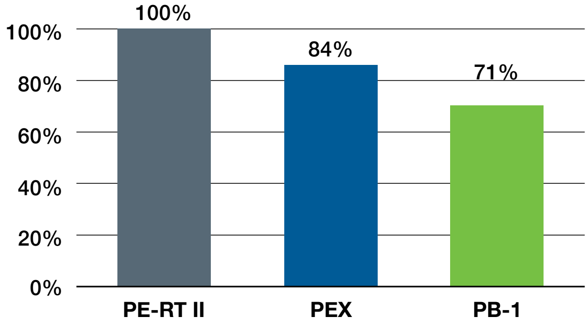
Inside cross section area



PB-1 offers the highest available internal cross section area

Fig. 4

Material contents per meter of pipe

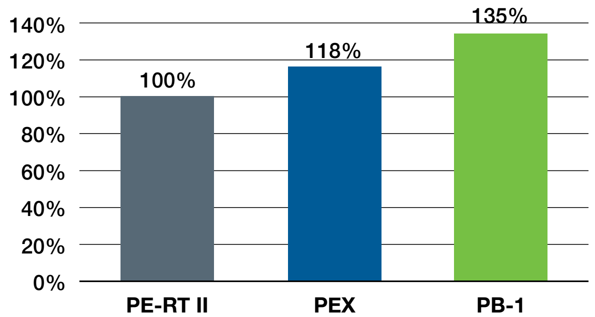


PB-1 provides substantial material savings vs. PE-RT and PEX

Fig. 5

As shown in the charts above and for the purposes of comparison, PE-RT may be considered the benchmark at 100%. When comparing the inside cross-section area of a 50mm ø pipe (Fig. 4) PB-1 clearly outperforms PE-RT with an additional 27% inside pipe volume. In addition, when comparing the amount of material per meter for a 50mm ø pipe rated for 8 bar (Fig. 5), PB-1 pipe uses 29% less material than PE-RT.

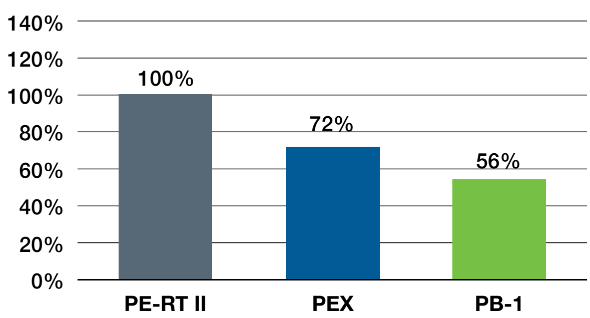
Flow rate at the same pressure



When operated at the same pressure, PB-1 pipes yield up to 35% higher output

Fig. 6

Pressure loss at the same flow rate



PB-1 pipes yield the same output at reduced energy consumption/pump capacity

Fig. 7

Once again for the purposes of comparison, PE-RT may be considered the benchmark at 100%. Per the above chart (Fig. 6), using the same operating water pressure, a 50mm outside diameter pipe (8 bar) made from PB-1 delivers a substantially higher flow rate of +35% when compared to the identically rated PE-RT pipe of the same outside diameter. Measured using the other comparison point (Fig. 7): at a given flow rate (output) PB-1 pipes yield a 44% lower pressure loss versus PE-RT pipes. This means that PB-1 pipes require less energy to run a system - or - can accommodate pumps with a lower capacity for the same output. Over the lifetime of a pipe system (up to 50 years or more) the energy savings potential can be significant.

Example 2: Small pipe – 160mm ø @ 10 bar

Due to a higher SDR rating (and therefore a thinner wall section) a PB-1 pipe of 140mm ø delivers the same performance as a PE-RT pipe of 160mm ø, but with a smaller outside diameter and larger inside pipe cross-section area (Table 6).

Table 6

SDR	9		7.4		6	
D	s	Ai	s	Ai	s	Ai
mm	mm	mm²	mm	mm²	mm	mm²
125	14.0	7,390	17.1	6,475	20.8	5,463
140	15.7	9,263	19.2	8,107	23.3	6,851
160	17.9	12,115	21.9	10,605	26.6	8,958
180	20.1	15,350	24.6	13,437	29.9	11,347

Comparison: PB-1 vs. PE-RT & PEX

At a 10 Bar operating pressure pipe of 160mm outside diameter (Fig. 8):

- **PE-RT @ SDR 6**
  160mm ø pipe has an internal cross section area of 8,958mm²
- **PEX @ SDR 7.4**
  160mm ø pipe has an internal cross section area of 10,605mm²
- **PB-1 @ SDR 9**
  With a smaller outside diameter of 140mm ø PB-1 has an internal cross section area of 9,263mm²

In addition, as shown in the table (Table 7) and chart (Fig. 9), the weight of 160mm outside diameter PB-1 pipe rated for 10 bar is almost half of the weight for the same outside diameter and rating pipe made from PE-RT.

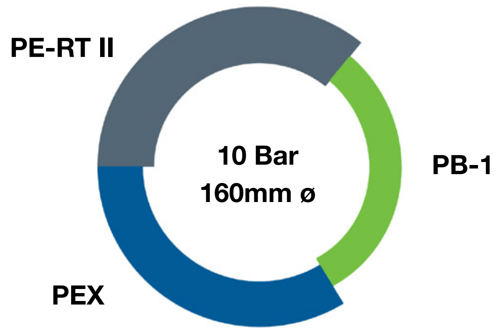
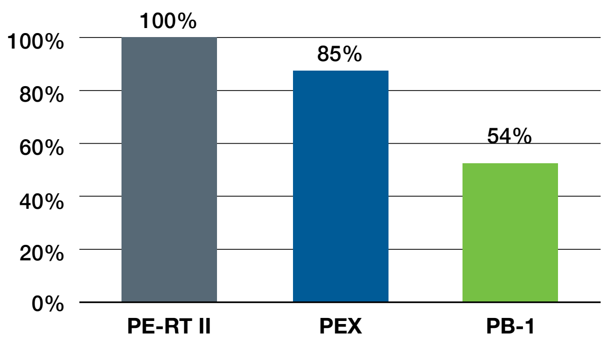


Fig. 8

Material contents per meter of pipe



PB-1 provides substantial material savings vs. PE-RT and PEX

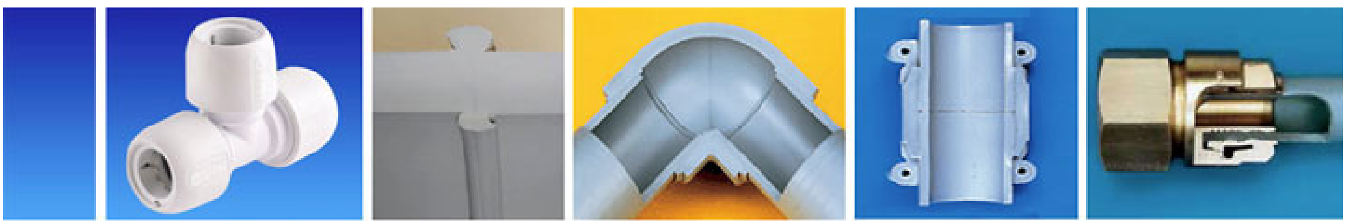
Fig. 9

	SDR	Outside Ø (mm)	Wall Thickness (mm)	Pipe Section (mm²)	Weight Per M (kg/m)
PE-RT II	6	160	26.6	8,958	11.02
PEX	7.4	160	21.9	10,605	9.34
PB-1	9	160	15.7	9,263	5.95

Table 7

JOINTING TECHNIQUES FOR PIPES

PB-1 is a versatile material for all available jointing techniques



	Push-fit	Butt fusion	Socket fusion	Electro fusion	Compression
PB-1	✔	✔	✔	✔	✔
PEX	✔	✘	✘	✘	✔
PE-RT II	✔	✔	✔	✔	✔

Table 8

PB-1 Environmental Considerations

PB-1 PIPING SYSTEMS USE LESS ENERGY

> PB-1 piping systems have significantly lower environmental impact than pipes made from other plastics and also metals – particularly copper and steel.

- **Reason**
  - Lower global warming impact
  - Better life cycle assessment
  - No installation chemicals, heat or naked flame
- **Benefits**
  - Longer system life
  - Lowest carbon footprint vs. alternatives
- **Sustainability**

- Learnings from PB-1 pressure piping systems
The European Plastic Pipes and Fittings Association (TEPPFA) commissioned an independent study by the Flemish Institute for Technological Research (VITO) to measure the environmental footprint of various plastic piping systems based on life-cycle assessment. The study was intended to raise awareness of the value that plastic pipe systems offer for a sustainable future and was validated by the Denkstatt sustainability consultancy in Austria.

An important objective of the project was to provide transparency about the impact of plastic piping systems on our environment. It was also an important step in the development of the Environmental Product Declarations for plastic pipes.

- **Energy Efficiency**

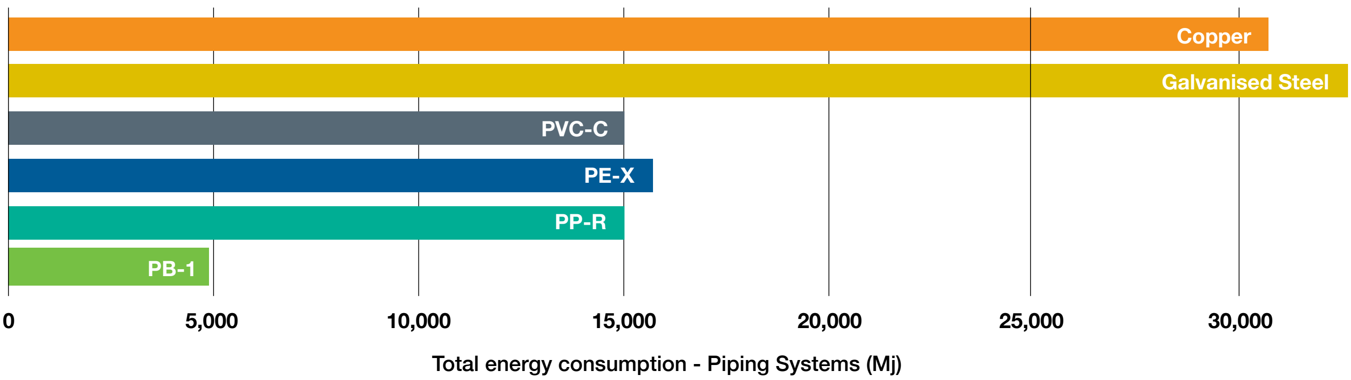
- Learnings from PB-1 pressure piping systems
The Technical University of Berlin conducted an energy efficiency and environmental impact analysis on hot and cold water pressurized piping systems. The study made a comparison of the total energy consumption for the production and installation of a piping system for a multiple dwelling with 16 apartments using a number of competitive metal and plastic systems.

PB-1 piping systems consumed 50% less energy for production and installation than the other systems in the study made from plastics.

A scientifically-based full Life Cycle Assessment (LCA) is the standardised method for fairly comparing a whole range of processes to calculate overall impacts, beginning with the manufacturing of raw materials, to transforming them into products; continuing through the product's transportation and installation, the product's lifetime of use, and ultimately, the product's disposal or re-processing at the end of life.

For the purpose of a direct fair comparison between alternative materials the following identical functional unit was used in the LCA study for plumbing hot and cold solid wall systems - a 50 year lifetime has been assumed which aligns with the normal lifetime expectancy of a building.

Total energy consumption - Piping systems



Prepared for the Future

OPERATING SUCCESSFULLY FOR OVER 50 YEARS

Polybutene piping systems have been successfully used in pipe applications in Europe for 50 years. Installations in district and underfloor heating systems in Austria and Germany in the early 1970s are still operating efficiently today.

Perhaps the most noteworthy success of Polybutene pipes to date has been their use in the Vienna Geothermal project, which since 1974 has utilised very aggressive geothermal water as the heating medium.

The project is still operating today at a constant temperature of 54°C and a pressure of 10 bar. In the same application, metal pipes had previously proved totally unsuitable due to rapid corrosion problems.

The sustainability of Polybutene piping systems is therefore a proven case based on actual end-use performance experience.

Since these first installations, advances in both material technology and production processes, combined with the introduction of stringent standards have furthered the performance and reliability of Polybutene piping systems. International standards protocols now specify a minimum performance for Polybutylene hot water pipes of 70˚C, 10 bar pressure for 50 years.

A Polybutene piping installation over 50 years ago

PB-1 Piping Systems | Conclusions

Compared to PE-RT and PEX pipes, PB-1 piping systems can offer the following benefits:

- **Lower overall project cost opportunity**
- **Highest flexibility**
- **Lower weight**
- **Reduced sound transmission** (Quieter)
- **Extreme cold performance** (Burst resistant)
- **Reduced water hammer** (Reliability, comfort)
- **Reduced environmental footprint** (Greener)
- **Lower operational energy consumption** (Optimal pipe system capacity)

PB-1 piping systems:

- **EASIER** Shipping, handling and installation
- **REDUCED** Operational costs
- **LOWER** Carbon footprint
- **HIGHEST** Building comfort

PBPSA | Polybutene Piping Systems Association

The Polybutene Piping Systems Association (PBPSA) is an international association of market leading companies committed to the use of the thermoplastic material, Polybutene-1 (PB-1) for the manufacture of piping systems. Also known as polybutylene, PB-1 is used worldwide in applications including piping systems for large-scale building projects, district energy networks, heating and cooling, and plumbing installations.

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