Polybutene
Piping Systems Association

Polybutene-1 compared to PE-RT & PEX

Advantages for projects using piping systems

Polybutene Piping Systems Association

www.pbpsa.com

Introduction

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

For construction 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 look at: ease of installation impacting onsite costs; jointing options, long-term system performance and projected life span; and Standard Dimension Ratio (SDR) comparing pipe materials for durability against pressure. When compared to PE-RT and PEX systems, PB-1 offers significant benefits across a broad range of performance categories, all contributing to make PB-1 piping systems the optimum choice for high performance piping installations.

Images – pp 1& 2 – Thermaflex

Standard Dimension Ratio (SDR)

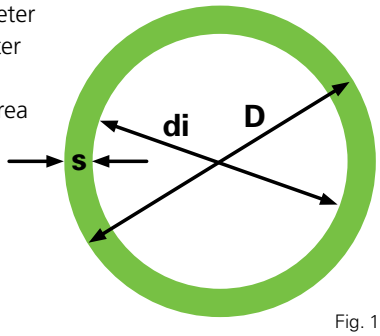
What is SDR?

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 (π/4)

Fig. 1

Example calculation:
SDR for a pipe with an outside diameter of 100mm and wall thickness of 5mm can be calculated as:
100mm / 5mm = SDR 20

Why does SDR matter for piping systems?

Due to the higher SDR ratio of PB-1 compared to either PE-RT or PEX, 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
- 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

Images – Thermaflex

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 alternatively, a smaller outside pipe diameter.

SDR Classes and Water Hammer

A column of moving water within a pipeline contains stored kinetic energy arising from its mass and velocity. Since water is essentially incompressible, this energy cannot be absorbed when a valve is suddenly closed.

The result is a high instantaneous pressure surge normally referred to as 'Water Hammer'. (See Fig. 2)

The higher the SDR Class the lower the water hammer at a given flow rate. PB-1 has the highest SDR Class compared to PP-H, PP-B, PE-RT and PEX

With people living together in greater density the noise levels and acoustic properties of piping systems are a significant issue. Piping systems that minimise fluid noise and water hammer where pipework passes through ceilings and walls are a key element in addressing residents' noise concerns.

Five factors determine the severity of water hammer:

- Velocity
- Modulus of elasticity of the pipe material
- Inside diameter of the pipe
- Wall thickness of the pipe
- Valve closing time

Repetitive water hammer can be destructive to piping systems. Beside the noise, water hammer can cause pipelines to break if the pressure is high enough.

The maximum theoretical value of pressure surge Ps is:

$$v0 \cdot a \cdot \rho = ps$$

v0 = velocity of the medium [m/s]
a = propagation rate of the pressure wave [m/s]
ρ = density of the medium [kg/m³]
ps = pressure surge – water hammer [N/m²]

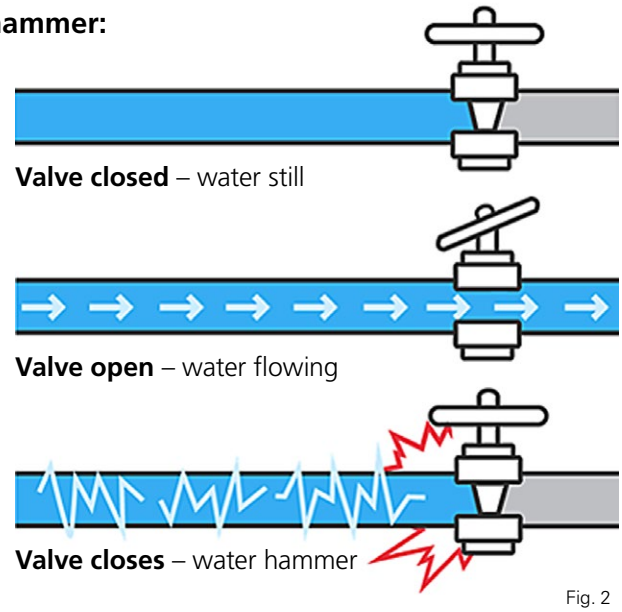


Fig. 2

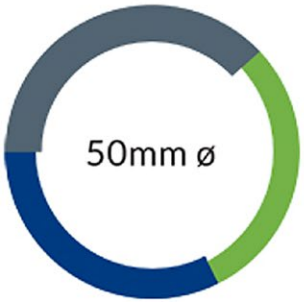


Fig. 3

$v_0 \cdot a \cdot \rho = p_s$

	SDR	Wall Thickness (mm)	Pipe Section (mm²)	Velocity (%)	Propagation Rate (%)	Water Hammer (%)
PP-H, PP-B	6	8.3	875	100	100	100
PEX, PE-RT, PPRCT	9	5.6	1,182	74	82	61
PB-1	13.5	3.7	1,425	61	40	24

Table 4

The maximum surge pressures caused by water hammer can be calculated using the following equation taken from the 'Handbook of Thermoplastic Piping System Design', Thomas Sixsmith and Reinhard Hanselka, Marcel Dekker Inc., pp 65-69

Ps = V((3960 E t)/(E t + 3 x 105 DI))½

where:
Ps = surge pressure (psi)
V = water velocity (ft/sec)
DI = inside diameter of the pipe (in)
E = modulus of elasticity of the pipe material (psi)
t = pipe wall thickness (in)

The low elastic modulus of Polybutene-1, combined with reduced wall thickness gives rise to a low surge pressure for a given pipe OD and pressure rating.

The table below compares maximum surge pressure for 38.1 mm (1-1/2") OD pipes of different plastic materials, designed for the same pressure service.

	E	E	DI	I	V	Ps	Ps
	[psi]	[MPa]	[mm]	[mm]	[ft/s]	[psi]	[bar]
PB-1	65,000	450	32.5 (1.28")	3.8 (0.15")	5.0	49.5	3.4
PEX	87,000	600	28.9 (1.14")	5.6 (0.22")	5.0	72.4	5.0
PP	116,000	800	26.7 (1.05")	6.6 (0.28")	5.0	93.0	6.4
CPVC	507,000	3,500	30.9 (1.22")	4.6 (0.18")	5.0	140.6	9.7

Table 5

When compared to PP-H, PP-B, PE-RT and PEX, PB-1 has the highest SDR Class and delivers the best acoustic capabilities including the lowest level of water hammer.

National Standards (RU & NL)

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

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, PE-RT and PEX (Fig. 4). 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.

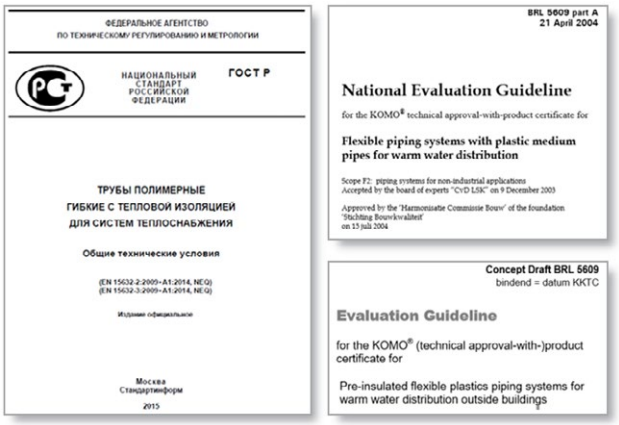


Fig. 4

Per the Russian standard and the Dutch guideline (Table 6) 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 PE-RT and PEX. 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.

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 6

Pipe Dimensions and SDR Classes

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

To illustrate the performance of PB-1, PE-RT and PEX in relation to the given operating pressure of 8 bar at the small pipe diameter of 50mm ø, the diagram (Fig. 5) and table (Table 7) compare the internal pipe dimensions required.

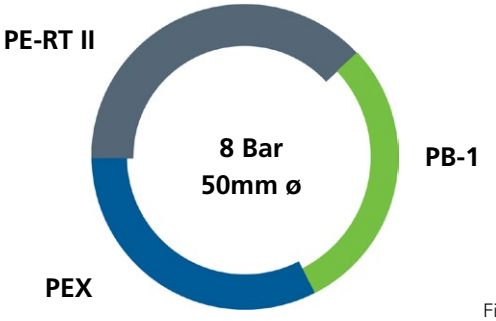


Fig. 5

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

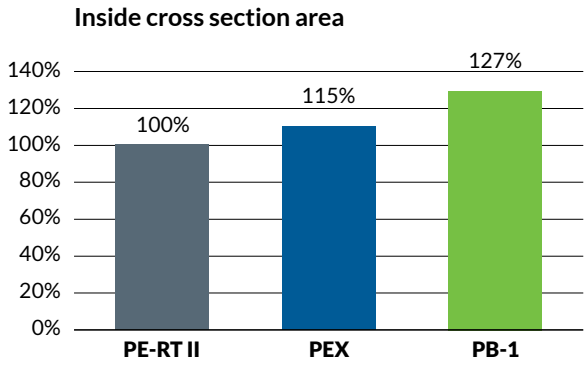
PB-1 is stronger than both PE-RT and PEX and with an operating pressure of 8 bar and an outside pipe diameter of 50mm ø the required wall thicknesses are indicated in the table (Table 7).

	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 7

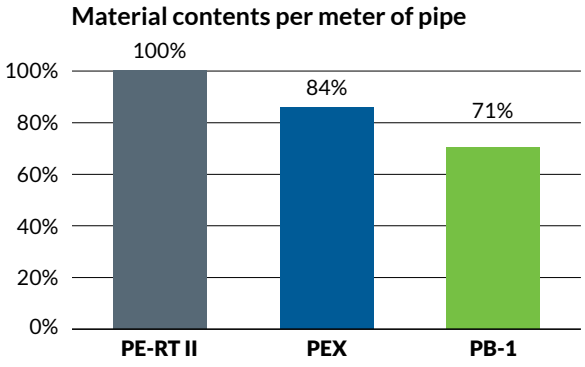
Per the table above (Table 6), at the same water pressure, the larger inside diameter of PB-1 50mm outside ø pipe delivers a substantially higher flow rate than the other two materials.

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.



PB-1 offers the highest available internal cross section area

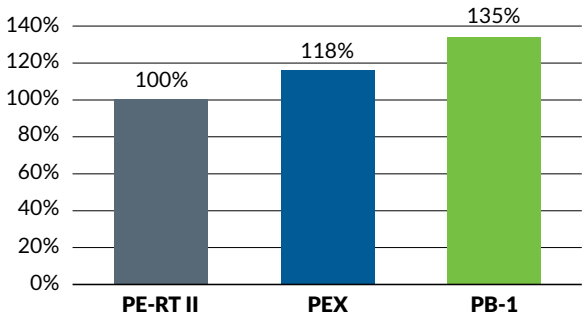
Fig. 6



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

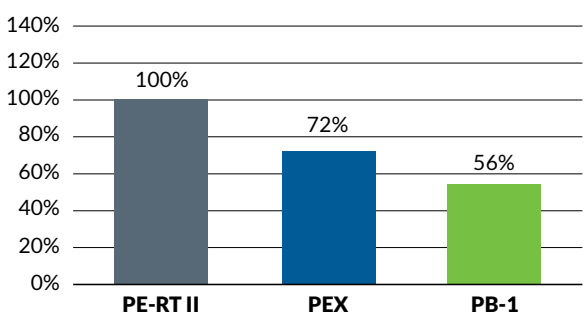
Fig. 7

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. 6) PB-1 clearly outperforms PE-RT with an additional 27% of volume. Also, in comparing the amount of material per meter for a 50mm ø pipe rated for 8 bar (Fig. 7), PB-1 pipe uses 29% less material than PE-RT.



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

Fig. 8



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

Fig. 9

Once again for the purposes of comparison, PE-RT may be considered the benchmark at 100%. Per the above chart (Fig. 8), 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. 9): 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.

Example 2: Large 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 8).

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

Table 8

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

- **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 9) and chart (Fig. 11), 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.

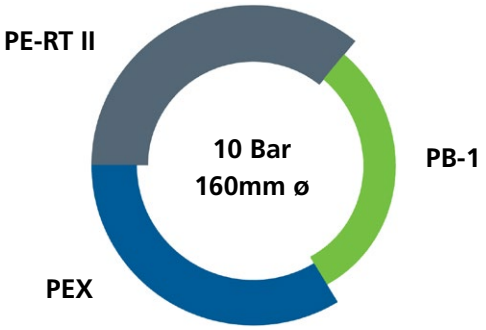
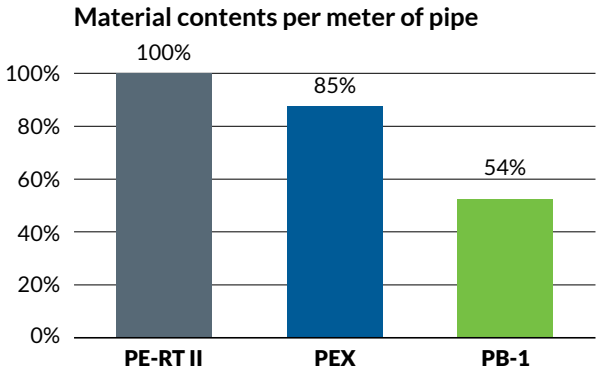


Fig. 10



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

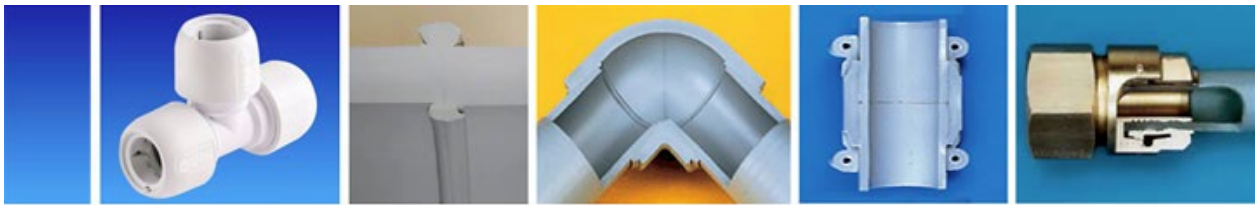
Fig. 11

	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 9

Jointing Techniques for District Heating 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 10

The Bottom Line

Specifying PB-1 piping systems for District Energy offers:

Substantial material saving opportunities, while at the same time increasing the capacity of the system

- thinner walls
- increase of the available inside cross section area

A higher degree of design freedom for District Energy grids

- opportunity for using smaller outside pipe and fitting diameters

A clear opportunity for reduced integral installation cost and operating cost

- smaller pipe support frames
- use of less insulation material
- smaller pumps running at reduced energy consumption
- lighter overall weight for easier handling and lower shipping costs

The capability to utilize all available jointing techniques

Best in class acoustics including the lowest level of water hammer

The ability to be fully recycled

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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