REHAU

REHAU RAUGEO

Technical Information 827.600 EN

Subject to technical modifications

TABLE OF CONTENTS

1. Scope of validity

This technical information applies to the planning, laying and connection of the RAUGEO pipe range including the described coupling elements, accessories and tools within the fields of application, standards and guidelines described below.

2. Field of application

The RAUGEO pipe range is used to convey water or heat-bearing fluid to exploit ground heat for cooling, heating or heat storage purposes.

In general, the following applications can be supported:

Room heating
(by radiator heating, underfloor or wall heating and concrete core heat storage)

Room cooling
(by ceiling or floor cooling or concrete core heat storage)

Utility water treatment

Air heating or cooling
(particularly for controlled ventilation)

Outdoor facility heating
Usually, the systems employ a heat pump or a refrigeration machine for heating and cooling to achieve the desired operating temperatures.

For subsurface heating and particularly with concrete core tempering, direct cooling without an intermediate heat pump/ refrigeration machine is possible at least in the transitional period.

Advantages of ground heat exploitation

Ground heat exploitation offers:

- **An economical source of energy largely independent of the weather or season**
- **Substantial reduction of CO2 emission**
- **Energy savings of up to 25% for heating and 85 % for cooling**
- **In conjunction with subsurface heating, a means of cooling and heating with industrial equipment**

The RAUGEO pipe range provides the following systems for these purposes:

- Geothermal probes
- Geothermal collectors
- Energy piles

Fig. 1: Probe

Fig. 2: Collector

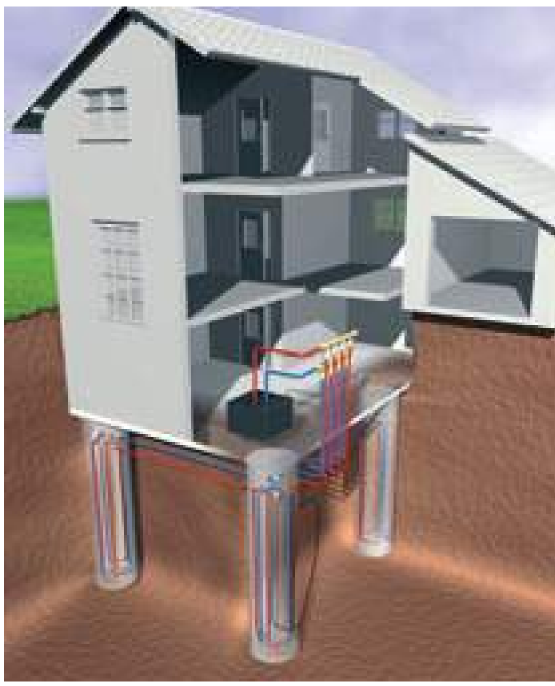


Fig. 3: Energy pile

3. Properties of PE-Xa and PE 100

REHAU offers RAUGEO pipes made of high-pressure crosslinked polyethylene (PE-Xa) and non-crosslinked polyethylene (PE100).

The most important advantages of PE-Xa over PE100 are:

- **No spreading of grooves and notches**
- **Small bending radii possib-le even at low temperatures**
- **No sand filling necessary**
- **Applicable even at tempe-ratures over 40°C, thereby suitable for heat storage purposes**
- **Rugged, rapid and weather-independent compression sleeve jointing technique can be used**

The differences in detail are listed in Table 1:

Properties of	PE-Xa		PE 100	
Illustrations of pipe types				
Material	High-pressure crosslinked polyethylene		Polyethylene	
Compliant with standard	DIN 16892/16893		DIN 8074/8075	
Durability (Safety factor SF=1.25)	Pipes SDR 11 (25x2.3 and 32x2.9)			
20 °C	100 years/15 bar		100 years/15.7 bar	
30 °C	100 years/13.3 bar		50 years/13.5 bar	
40 °C	100 years/11.8 bar		50 years/11.6 bar	
50 °C	100 years/10.5 bar		15 years/10.4 bar	
60 °C	50 years/9.5 bar		5 years/7.7 bar	
70 °C	50 years/8.5 bar		2 years/6.2 bar	
80 °C	25 years/7.6 bar		-	
90 °C	15 years/6.9 bar		-	
Constant operating temperatures	-40 °C to 95 °C		-20 °C to 30 °C	
Minimum laying temperature	-30 °C		-10 °C	
Minimum bending radii	25 x 2.3	32 x 2.9	25 x 2.3	32 x 2.9
20 °C	25 cm	30 cm	50 cm	65 cm
10 °C	40 cm	50 cm	85 cm	110 cm
0 °C	50 cm	65 cm	125 cm	160 cm
Notch impact strength	very high		high	
Crack growth at FNCT (full notch creep test)	no failure		failure after 200-2000 h	
Filling material	surrounding soil		sand	
Pipe roughness	0,007 mm		0,04 mm	
Average thermal coefficient of longitudinal expansion	0,15 mm/(m*K)		0,20 mm/(m*K)	
Building material class to DIN 4102	B2		B2	
Chemical resistance	see annex 1 of DIN 8075		see annex 1 of DIN 8075	
Density	0.94 g/cm³		0,95 g/cm³	
Strength	extremely strong (no growth of grooves and notches occurring during transport and installation)		strong (slow growth of grooves and occurring during transport and installation)	
Requirement on material for piping zone	excavated material (usually has higher thermal conductivity than sand filling)		sand filling	
Suitability for heat storage	unrestricted (operating temp. up to 95 °C)		no (maximum operating	
Suitability for cooling with refrigeration machine	yes (operating temp. up to 95 °C)		temperature 30 °C) (maximum operating temperature 40 °C)	
Applicable fluid	to VDI guideline 4640			
Melting index MFR	-		0.2-0.5 g/10 min	
MFR group	-		003, 005	

Table 1

4. Product range description

4.1 Overview

Table 2 below describes the RAUGEO range and its applications.

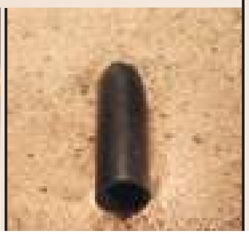
Application							
System designation	RAUGEO probe Xa	RAUGEO probe PE100	RAUGEO collect Xa	RAUGEO collect Xa PLUS	RAUGEO collect PE100	RAUGEO collect Xa PLUS	RAUGEO collect PE 100
Fields of application	Geothermal probe	Geothermal probe	Panel collector	Panel collector	Panel collector	Energy pile	Energy pile
Material	PE-Xa	PE-100	PE-Xa	PE-Xa EVOH and PE sheathed	PE-100	PE-Xa EVOH and PE sheathed	PE-100
Colour (surface)	Grey	Black	Grey	Orange/grey	Black	Orange/grey	Black
Oxygen diffusion	No barrier	No barrier	No barrier	Barrier to DIN 4726	No barrier	Barrier to DIN 4726	No barrier
Laying methods	Borehole	Borehole	Surrounding soil without sand filling	Surrounding soil without sand filling	Soil with sand filling	Cast in concrete Surrounding soil without sand filling	Surrounding soil without sand filling
Dimensions	25 and 32 mm Probe base diameter 110 mm	25, 32 and 40 mm Probe base diameter 84 or 104 mm	20, 25 and 32 mm (SDR 11)	20, 25 and 32 mm (SDR 11)	20, 25 and 32 mm (SDR 11)	20 and 25 mm (SDR 11)	20 and 25 mm (SDR 11)
Use in	■ Restricted space ■ High efficiency requirements, primarily cooling		■ Ample space ■ Low requirements on cooling efficiency ■ RAUGEO collect PLUS is particularly suitable for open systems without heat exchangers. The PE sheath protects the oxygen diffusion barrier during ground laying.			■ Foundation piles and slotted walls required.	
Influence on the environment	Cooling systems heat the ground water.		Little effect on vegetation.			Cooling systems heat the ground water.	
Suitable field of application	Heating with heat pump and cooling direct and/or with heat pump.		Heating with heat pump and limited cooling direct and/or with heat pump. Direct cooling usually with very low efficiency. Exception: e.g. flowing ground water.			Heating with heat pump and cooling direct and/or with heat pump.	
							

Table 2

4.2 RAUGEO probe Xa

4.2.1 Description
The RAUGEO probe Xa is a double-U probe consisting of two single U probes (double-U probe). The PE-Xa medium pipe is manufactured with an angle made by a special bending process, so that no connection is required at the probe base. The medium pipe is equipped with a UV-stabilised, grey outer sheath. The angled section of the probe is cast in fibreglass-reinforced polyester resin.

The medium pipes have a life expectancy of 100 years at 20 °C and max. 15 bar operating pressure according to DIN 16892/93.

4.2.2 Properties
Due to the excellent material properties of PE-Xa, the following technical advantages are provided in practice:
- Extremely reliable as there is no danger of leaks at welded seams or other connections at the probe base
- Optimum safety during insertion into the borehole as PE-Xa pipes are insensitive to notches and grooves and are not subject to crack growth
- Probe base protected by special, high-strength resin
- The two probe sections simply clip together and fasten into a sturdy unit
- Probe connection with electrofusion coupler or the REHAU compression sleeve coupler, which can be used in all weather conditions

4.2.3 Dimensions, delivery package
Probe base diameter: 110 mm.
Supplied lengths: see price list.

Delivery package: two U-probes on a Europallet, in shrink film, incl. fastening screws.

Fig. 4: Installation of a RAUGEO probe Xa

4.2.4 Probe base assembly
The two halves of the probe are clipped together before insertion in the borehole and are joined with the Allen grub screws.

Optionally, a weight can be attached in the groove of the lower probe section, which is also fastened with grub screws. The grub screws are supplied with the probes and the weights. A receiver is fitted in the probe base if the probe is to be inserted using rods.

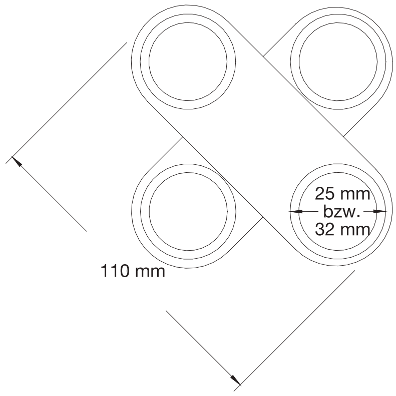


Fig. 6: Cross-section of probe Xa

Fig. 5: Probe base of the RAUGEO probe Xa

4.3 RAUGEO probe PE-100

4.3.1 Description

The RAUGEO probe PE100 is a double-U geothermal probe consisting of two U-shaped probes made of PE100, welded together in the factory at the probe base with a V-shaped connector.

Apart from the ready-to-fit double-U probe, probe bases 1 m long are also available, which consist of a V-shaped connector and straight pipe sections made of RAUGEO PE 100 welded together in the factory. RAUGEO collect PE 100 pipes can be welded on by the customer to form ready-to-fit probes, during which the SKZ test and monitoring regulations for geothermal probes must be complied with.

The RAUGEO probe PE100 and the probe bases are manufactured in compliance with SKZ test and monitoring regulations HR 3.26. The life expectancy is therefore at least 100 years at a pressure of 16 bar and at operating temperatures of max. 15 °C.

4.3.2 Properties

The RAUGEO probe PE 100 has the following important practical advantages:

- Extremely small borehole diameter (84 mm for d 25 or 32 and 104 mm for d 40) possible
- Only two welded seams per probe base
- The two probe sections are simply screwed together with a weight and fastened to form a unit
- The probe pipes are suitable for butt welding, thermal socket welding and REHAU electrofusion coupler

4.3.3 Dimensions, delivery package

Probe base diameter:
84 and 104 mm.

Supplied lengths:

- ready-to-fit probes: see price list
- Probe bases: 1 m.

Delivery package:
two double-U probes on a Europallet sealed in stretch film.

Fig. 7: RAUGEO probe PE100
Building site info

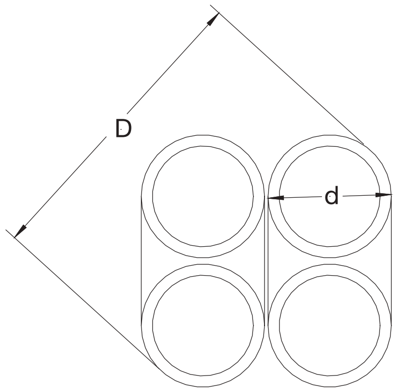


Fig. 9: Cross-section, probe PE100

The probe diameter [D] depends on the pipe diameter [d].

Probe pipe [d]	Probe diameter [D]
25 mm	84 mm
32 mm	84 mm
40 mm	104 mm

Fig. 8: Probe base, probe PE100

4.4 RAUGEO collect Xa

4.4.1 Description
RAUGEO collect Xa is an extremely rugged ground collector pipe made of high-pressure crosslinked polyethylene PE-Xa, equipped with a UV-stabilised, grey outer sheath. The range is completed by the REHAU compression sleeve and REHAU electrofusion couplers, manifolds and wall sockets.

4.4.2 Properties
Due to the excellent material properties of PE-Xa, the following technical advantages are provided in practice:
- Insensitive to notches and spot loads, by which the excavated material can be used as the filling material
- Resistant to stress corrosion
- Therefore reliable even with tight bending radii:
  - 20 cm for pipe 20x1.9
  - 25 cm for pipe 25x2.3
  - o 30 cm for pipe 32x2.9
    (At pipe temperature 20 °C)
- Practically no crack growth
- Highly resistant to abrasion
- Flexible and therefore easy to lay, even at low temperatures
- Can be laid without precautions against sub-zero temperatures
- Extremely long-lived even under high operating loads

4.4.3 Delivery package
100 m coils. Special lengths available on request.

4.5 RAUGEO collect Xa PLUS

4.5.1 Description
RAUGEO collect Xa PLUS is a ground collector pipe with an oxygen diffusion barrier according to DIN 4726 and an additional PE sheath which protects the oxygen diffusion barrier against damage during ground laying.

4.5.2 Properties
The excellent material properties described in 4.4.1 - 4.4.3 also apply, with the exception of the electrofusion coupling fittings, which cannot be used due to the oxygen diffusion barrier.

Fig. 10: RAUGEO collect Xa building site photo

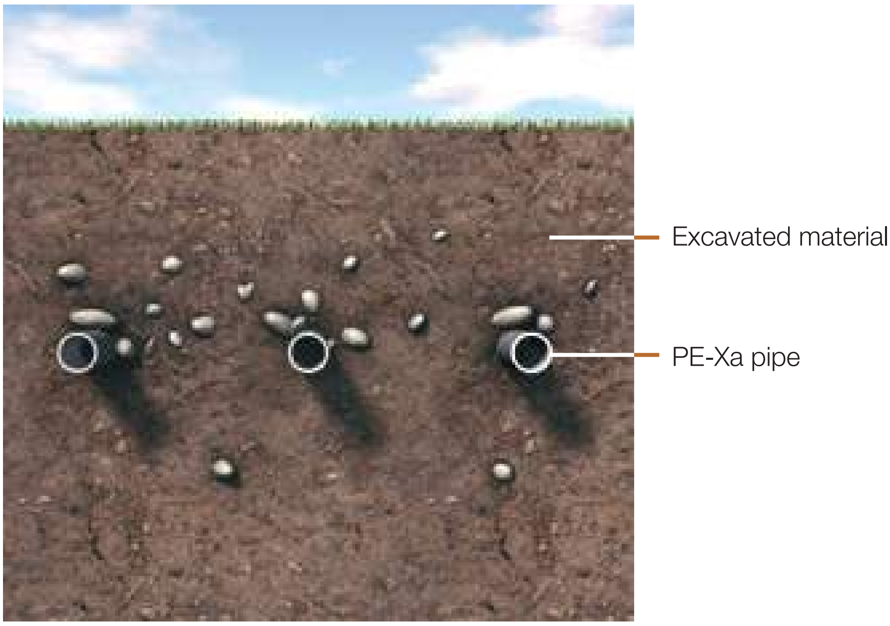


Fig. 11: Trench cross-section, RAUGEO collect Xa and PLUS

4.6 RAUGEO collect PE100

4.6.1 Description
RAUGEO collect PE100 is a ground collector pipe made of black-dyed, UV-stabilised polyethylene (PE100).
The range is completed by the REHAU electrofusion couplers, manifolds and wall sockets.

4.6.2 Properties
Due to the material properties, the following technical features are produced in practice:
- PE-100 pipes must be protected against stones etc. They must therefore be sanded in
- Temperature-resistant up to 40 °C
- The minimum permissible bending radii depend heavily on the laying temperature:

	20x1.9	25x2.3	32x2.9
20 °C	40 cm	50 cm	65 cm
10 °C	68 cm	85 cm	110 cm
0 °C	96 cm	125 cm	160 cm

Table 4: Bending radii

Fig. 12: RAUGEO collect PE100 building site photo

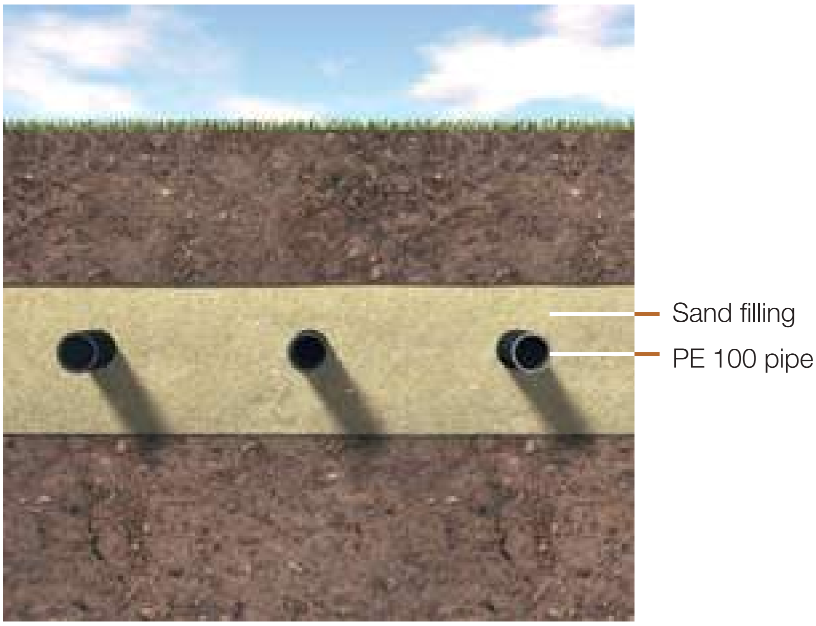


Fig. 13: Trench cross-section, RAUGEO collect PE100

4.7 REHAU energy piles

4.7.1 System description

In modern construction, pipes are used as building foundations for static reasons on non load-bearing or poorly bearing substrates. Energy piles are the designation for pipes equipped with piping to exploit the geothermal energy close to the surface. With the water-bearing pipes laid in the pile, heat can be extracted from the substrate for heating or cold for cooling, depending on the geological conditions. Depending on the concept of the technical equipment used in the building, the REHAU RAUGEO collect Xa Plus pipe may be used, oxygen-tight according to DIN 4726, or the REHAU RAUGEO collect PE 100 pipe without oxygen diffusion barrier.
The piping is laid in a zig-zag in the longitudinal direction of the reinforcement grid. The piping is attached firmly to the reinforcement grid using REHAU-EP grid ties or REHAU cable ties.

4.7.2 System components

- REHAU-EP grid ties REHAU cable ties
- REHAU compression sleeve coupler for RAUGEO collect Xa PLUS pipes
- REHAU adapter 20 x 1.9 mm 25 x 2.3 mm to 3/4“
- REHAU compressed air pipe stopper 20 x 1.9 mm
- REHAU compressed air nipple
- REHAU pressure gauge
- REHAU electrofusion fitting for RAUGEO collect PE 100 pipes
- REHAU heat-shrinkable tubing
- REHAU heat-shrinkable tape

4.7.3 Pipe dimensions

- RAUGEO collect Xa PLUS 20 x 1.9 mm/25 x 2.3 mm
- RAUGEO collect PE 100 20 x 1.9 mm/25 x 2.3 mm

Fig. 14: REHAU energy pile

Fig. 15: Inside view of REHAU energy pile

5. Product accessories

5.1 Accessories for RAUGEO probe and collect

Fig. 16: Weight, probe Xa

5.1.1 Weight, probe Xa

As probe installation aid with fastening material for firm attachment to the probe base.
The set comprises:
1 weight
2 Allen grub screws M10

Material:	steel
Diameter:	80 mm
Lengths	
Weight 12.5 kg:	approx. 350 mm
Weight 25.0 kg:	approx. 650 mm

Fig. 18: Weight, probe PE100

5.1.3 Weight, probe PE100

As probe installation aid with fastening material for firm attachment to the probe base.
The set comprises:
1 weight
2 Allen grub screws M8
2 threaded discs

Material:	steel
Diameter:	80 mm
Lengths	
Weight 12.5 kg:	approx. 350 mm
Weight 25.0 kg:	approx. 650 mm

Fig. 20: Insertion device

5.1.5 Insertion device, probe PE100

For fastening to the probe base with receiver for the rod with thread M10

Material:	V2A
Length: approx.	250 mm

Fig. 17: Y-pipe

5.1.2 Y-pipe

As connection of the feed and return pipes of a geothermal probe. Substantial saving of laying work. Low manifold costs and small manifold space. Connection with heater element and heater coil welding and butt welding possible.

Material:	PE100
Dimensions:	see price list

Fig. 19: Spacer

5.1.4 Spacer

To spread the probe pipes in the borehole.

Material:	PE100
Sizes:	see price list

Fig. 21: Laying aid

5.1.6 Laying aid

To fasten the RAUGEO pipes or domestic connection pipes in the pipe trench or foundation pit. The RAUGEO pipes are held in the soil until weighed down by hammering in the laying aid. The laying aid is then pulled out and can then be reused.

Material:	steel/PE
Length:	200 mm

5.2 Accessories for RAUGEO energy pile

Fig. 22: EP grid tie

5.2.1 REHAU EP grid tie

The REHAU EP grid tie consists of plastic-sheathed wire. It is used to firmly attach the piping to the reinforcement of the pile.

Material:	plastic-sheathed wire
Wire Ø:	1.4 mm
Length:	180 mm
Colour:	yellow

Fig. 24: Twisting tool

5.2.3 REHAU twisting tool

The REHAU twisting tool, made of plastic-sheathed metal, is used for professional and rapid twisting of the REHAU EP grid ties. It is used when the piping is fastened to the reinforcement of the pile.

Material:	steel
Length:	310 mm
Twisting tool Ø:	30 mm
Colour:	black

Fig. 25: Cable tie

5.2.4 REHAU cable tie

The REHAU cable tie can be used as an alternative to the REHAU EP grid tie when the piping is fastened to the reinforcement of the pile.

Material:	PA
Length:	178 mm
Width:	4.8 mm
Colour:	natural

Fig. 23: Adapter

5.2.2 REHAU adapter

The REHAU adapter is used to attach pressure testing equipment with threaded connections to the finished piping of the energy pile and is installed using the REHAU compression sleeve coupler.

Material:	zinc plated brass
Pipe Ø:	20 x 1.9 mm
	25 x 2.3 mm
Length:	52 mm
Connection	3/4“ AG

Fig. 26: Brass fluid manifold

5.3.1 REHAU Brass fluid manifold

Manifold and collector made of brass tubing with KFE valve and manual breather valve
Option:
An automatic breather valve can be screwed in on site in place of the manual breather valve.
A shut-off facility for all fluid circuits is ensured by ball valves in the supply and return pipes. Rugged, sound insulated and zinc plated fittings.

Material:	brass MS63
Main pipe:	1 1/2“/2“
Connection:	G1 1/2“/G2“
Manifold size:	see price list

Fig. 27: Flow controller

5.3.2 Flow controller

Flow controller made of brass to regulate the fluid circuits with a ball valve. The flow meter is installed on the brass manifold. For plastic manifolds, the flow meter is supplied with fitted plastic adapters.

Material:	brass MS63
Main pipe:	3/4“
Flow rate:	8 - 30 l/min
Sizes:	see price list

Fig. 28: Plastic manifold

5.3.3 Plastic fluid manifold

For projects in which the brass fluid manifolds are unavailable in suitable dimensions, fluid manifolds made of plastic can be supplied which are adapted specifically for the project. The manifold pipes are made of PE100. The outlets are made in the factory by a welding process to DVS 2207 and are tested. The manifolds are available with shut-off valves, flow meters and breathers.

Material:	PE 100
Main pipe:	110/90
Connection:	90 x 8.2
Manifold size:	on request

Fig. 29: Seal set

5.3.4 Seal set

For use with unpressurised and pressurised water. For RAUGEO pipes with outside diameter from 20 to 63 mm. Used with RAUGEO liner pipe or core borehole, watertight up to 1.5 bar.
Note: The core borehole must be treated with preservant.

Plates:	stainless steel V2A
Bolts:	stainless steel V4A
Sealing material:	EPDM

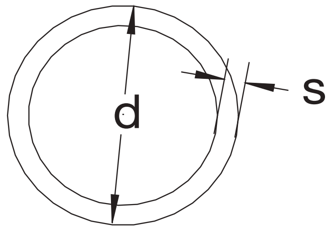


Fig. 30:

5.3.5 REHAU filling, manifold and collector pipes

To fill and press the probe borehole and as collector pipe between the manifold and the heat pump.
Dimensions OD:
PE-X from 20-160 mm
PE100 from 20-400 mm
The RAUGEO pipes are available in type SDR 11. (SDR stands for “Standard Dimension Ratio“ and describes the ratio of the outside diameter [d] to the wall thickness [s] of the pipe.)

Dimensions d x s [mm]	Weight [kg]	Volume [l]
20 x 1.9	0.112	0.20
25 x 2.3	0.171	0.32
32 x 2.9	0.272	0.54
40 x 3.7	0.430	0.83
50 x 4.7	0.666	1.30
63 x 5.8	1.05	2.10

Table 5: Technical data, pipes SDR 11

Fig. 31: Cold insulation

5.3.6 Cold insulation tubing

The REHAU cold insulation tubing is made of water vapour-tight latex material specifically to insulate cooling pipes in buildings. The butt joints must be sealed with latex adhesive.

Insulation thickness:	13 mm
Length:	2 m
Dimensions:	20 - 63 mm

Fig. 32: Pipe holder

5.3.7 REHAU pipe holder
The REHAU pipe holder consists of two shells used as insulating inlays between the pipe and the pipe clip to prevent condensation from forming in the vicinity of the pipe clip.

Insulation thickness:	13 mm
Dimensions:	20 – 63 mm

Fig. 33: Fusion fitting

5.3.8 REHAU fusion fitting
The REHAU fusion fittings are mouldings with integrated resistive wire. This wire is heated to the required welding temperature by an electric current, thereby forming the fusion joint. Each fitting has an integrated identification resistor, which ensures the fusion parameters of the REHAU fusion machine (Article 244762-001). The barcode on all REHAU electrofusion fittings allows all commonly available fusion machines with pen readers to be used. The instructions supplied with the tools must be observed during fitting.

Fig. 34: Warning strip

5.3.9 REHAU warning strip
The REHAU warning strip is made of PE film with black lettering “Caution, heat transfer fluid pipe “. To mark fluid pipes in the ground. The warning strip is laid 30 cm above the heat transfer fluid pipe.

Material:	PE
Width:	40 mm
Length:	250 m
Colour:	green

Fig. 35: Protective tape

5.3.10 REHAU protective tape
The REHAU anticorrosion tape is made of butyl latex with self-adhesive properties. To insulate stripped RAUGEO PLUS pipes or brass fittings in the ground.

Material:	
Width:	50 mm
Length:	5 m
Colour:	grey

Fig. 36: Compression sleeve

5.3.11 REHAU Compression sleeve
The compression sleeve jointing technique is a method developed and patented by REHAU to join RAUGEO Xa and Xa PLUS pipes
- quickly and ready for immediate use
- systematically reliable
- in all weathers
- and permanently sealed.

It consists of only one fitting and the compression sleeve. The compression sleeve joint is made with the REHAU compression sleeve tools. The instructions supplied with the tools must be observed during fitting.

Fig. 37: Heat-shrinkable tubing

5.3.12 REHAU heat-shrinkable tubing
All REHAU compression sleeve fittings can be laid in the ground without protection. However, various substances occur in some regions which can damage the compression sleeve fitting. In cases of suspicion or doubt, the joint can be protected with REHAU heat-shrinkable tubing.

Material:	VPE
Shrinkage range:	20 - 55 mm
Length:	1200 mm
Colour:	black

6. Design of a geothermal heating system

6.1 Principles of shallow level geothermal heating

In geology, "shallow level" means the range from the Earth's surface to a depth of a few hundred metres. This is the range which can be tapped with geothermal collectors, energy piles and probes. Fig. 41 shows the temperature level to a depth of 20 m. This shows values between 7°C and 13°C at a depth of 1.2 – 1.5 m in the course of the year and about 10°C throughout the year at a depth of approx. 18 m. This temperature generally increases by 2 to 3°C per 100 m.

Months in diagram Fig. 41
Line 1 = 1st February
Line 2 = 1st May
Line 3 = 1st November
Line 4 = 1st August

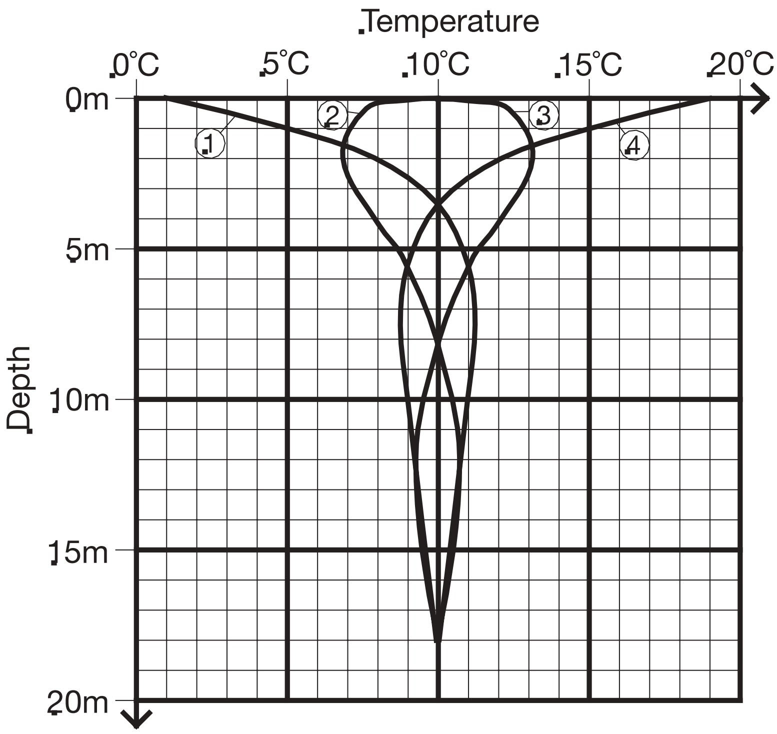


Fig. 41

At a depth of 100 m, the temperature is usually approx. 12 °C and approx. 15°C at 200 m depth. This temperature level can be used very effectively using a heat pump for heating purposes or by direct cooling or with a refrigeration machine for cooling purposes. In the design of a geothermal system, it is important to discern between the heating and cooling power and the possible annual heating and cooling capacity. Due to the thermal conductivity of the ground, restricted to approx. 1-3 W/mK, a geothermal heating system can only be operated for short periods at high extraction rates, during which the surroundings of the pipes and probes are used as a heat buffer which is subsequently regenerated by the geothermal heat flow from the interior of the earth, which is only 0.015 to 0.1 W/m*K. In smaller systems up to a thermal power of 30 kW, VDI Guideline 4640 states simple design rules, the most important of which are contained in this technical information.
For larger systems, it is worthwhile to calculate more precisely on the basis of a soil analysis.

6.2 Effects on the environment

If ground-coupled heat pumps are used with geothermal collectors, underproportioning of the collectors can have locally restricted effects on the vegetation (extension of the cold period). In general, underproportioning causes lower heat source temperatures and thereby a lower annual work index.
In extreme cases, the heat source temperature can reach the lower operating limit of the heat pump. Underproportioning of ground-coupled heat pumps with geothermal probes can also result in very low heat source temperatures to the lower operating limit of the heat pump for short periods at full load. Underproportioning can also lead to falling heat source temperatures from one heating period to the next over a longer time if an adequate regeneration time is not ensured.

6.3 Choice of probe, panel collector or energy pile

The starting point for the choice of the system is always the output, i.e. the heat to be extracted from the ground or, for cooling, the heat to be dissipated in the ground. During planning, the most favourable heat source at the site must be selected and the heating system and auxiliary equipment chosen according to this. The two most frequently used systems are
- horizontal ground heat exchangers (geothermal collectors)
  and
- vertical ground heat exchangers (geothermal probes, energy piles).

The choice of horizontal or vertical ground heat exchangers is made according to the geological conditions of the site and the required space or by constructional circumstances. The main technical criteria for the equipment are:
- designed output of the heat source system
- output of the heat pump (e.g. determined from the heating power and the work index)
- annual operating hours and full load hours
- peak load of the heat source

A good knowledge of geology and hydrogeology allows the thermal and hydraulic properties of the substrate to be determined and thereby allows the suitable extraction technique to be chosen.

6.4 Design and laying of geothermal collectors

6.4.1 Design

The design of geothermal collectors is described in VDI Guideline 4640. The most important aspects are contained below.
The input data for the design of a ground collector system used in conjunction with a heat pump is

- required heating power and power rating of the heat pump, resulting in the output
- flow rate of the heat pump (heat pump data sheet)
- specific extracted power from the ground

The design of the heat pump must be made very accurately. A heat pump manufacturer must therefore be asked about the proportions so that the power rating can be allocated to the heating power and operating mode.

The output is then calculated as follows:

$$\text{Output} = \frac{\text{heating power} \times (\text{power index}-1)}{\text{power index}}$$

Example:
Heating power: 12 kW
Power index: 4

$$\frac{12\text{ kW} \times (4-1) = 9\text{ kW}}{4} = 9\text{ kW}$$

The specific extracted power depends on the annual operating period as shown in Table 6:

Substrate	Specific extracted power at 1800 h	at 2400 h
Non-binding soil	10 W/m²	8 W/m²
Binding soil, moist	20-30 W/m²	16-24 W/m²
Water-saturated soil	40 W/m²	32 W/m²

Table 6: source: VDI 4640

Example:
Output 9 kW
Operating hours: 1800 h/a
Soil: binding, moist

This produces:
Extracted power: 25 W/m²

$$\text{Ground collector area} = \frac{\text{output (W)}}{\text{extracted power (W/m}^2)}$$

Ground collector area = 360 m²

The choice of the pipe dimensions depends on the possible extracted power to be attained from the ground. The higher the extracted power, the higher the required flow rate at the given temperature difference, and therefore the higher the required pipe dimensions. Table 7 provides estimates.

Soil type	**OD x s (mm)**
Non-binding soil	20 x 1.9
Binding soil, moist	25 x 2.3
Water-saturated soil	32 x 2.9

Table 7: Pipe dimensions

The laying interval recommended in VDI 4640 is 50-80 cm.

With a chosen laying interval of 75 cm (0.75 m) and the equation

$$\text{Pipe quantity} = \frac{\text{ground collector area (m}^2)}{\text{laying interval (m)}}$$

a pipe length of 480 m results.

Note: The extracted power and work must not be exceeded as otherwise the generally desired icing of the piping zone becomes too great and the ice radii converge. During spring thaws, the seepage of rain and melt water, which contributes significantly to the warming of the ground, is encumbered.

Because the temperature level in the ground is changed by the geothermal collector, the pipes should be laid at a sufficient distance from trees, bushes and sensitive plants. The laying distance from other supply pipes and buildings is 70 cm. If this distance is not maintained, the pipes must be protected by sufficient insulation.

Ground collectors are only suitable for the direct cooling of buildings under specific conditions:

- Flowing ground water
  Spacing < 0.5 m with conductive soil 2.5 - 3 W/mK
- Ground water temperature in summer < 12 °C

Peak cooling rates can also be covered by a ground-coupled refrigeration machine.

The piping length should not exceed 100 m due to the danger that the pressure loss will be too high.

A program to calculate the pressure losses can be downloaded from the REHAU homepage www.raugeo.de.

6.4.2 Laying

According to VDI 4640, the pipes of geothermal collector systems should be laid at a depth of 1.2 – 1.5 m and at an interval of 50-80 cm.

The regeneration of geothermal collectors occurs mainly from above by solar radiation and rainfall. The geothermal heat flow is small in comparison. The collectors must therefore not be built over or laid under sealed areas!

Exceptions to this rule must be confirmed during planning. For example, this may be possible if a ground collector is used both for heating and cooling and each mode therefore contributes to the regeneration of the soil. It must be particularly observed when laying under buildings that the operating temperature must not reach the frost limit, as this could damage the building by raising the soil.

Either trench or open cast laying can be used to install RAUGEO collect.

For trench laying, one side of the trench is made by a digger, the pipes are laid and then filled with the soil from the other trench side, see Fig. 39.

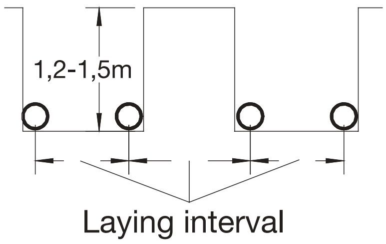


Fig. 39: Trench laying

For open cast laying, the entire collector area is exposed and levelled, see Fig. 43.

Note: This filling material must only be used in conjunction with PE-Xa pipes. Sand must be used to lay PE-100 pipes. See Chapter 4.6.

The PE-Xa collector pipes should not be laid in gravel or grit as air cavities reduce the conductivity. Fine soil must therefore be used around the pipes in such soils so ensure that moisture is absorbed. When PE-Xa pipes are used, stones in this soil must not be avoided.

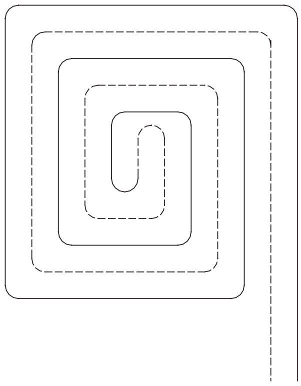


Fig. 40: Spiral laying method

The most common laying methods are shown in Fig. 43 - 45. The spiral laying method can be used for open cast laying.

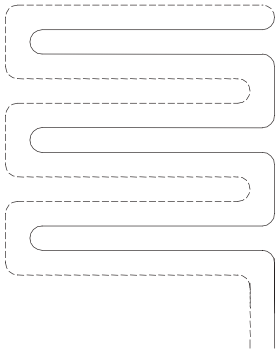


Fig. 41: Double zig-zag laying method

The double zig-zag laying method in Fig. 41 and Tichelmann in Fig. 42 are particularly suitable for trench laying.

The RAUGEO pipes are supplied in coils of 100 m. The collector area must be designed such that each pipe section is equally long. This avoids difficult regulation at the manifold.

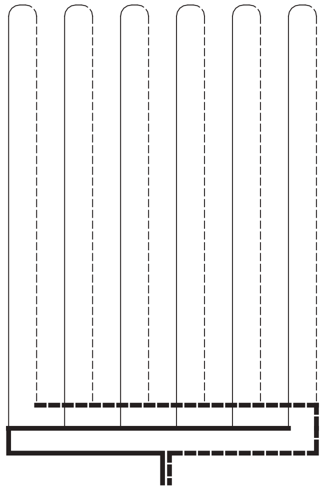


Fig. 42: Tichelmann laying

In open cast laying, the pipes can be fastened using the REHAU laying aid. This allows pipe registers to be simply constructed.

Fig. 43: Open cast laying

Fig. 44:

Installation stage 1

- Choose manifold location at the highest point of the collector system.
- The manifolds can be installed in plastic shafts or under a light cover.

Note: Light shafts must be covered in sunlight because the piping must be protected against UV radiation.

- Connect the pipes to the manifolds and collectors by the Tichelmann method. See Chapter 6.7

Fig. 45:

Installation stage 2
Open cast laying

- Lay and align the pipes and fasten with stakes.
- Ensure that the bending radii of PE-Xa and PE-100 pipes are observed, see Tab. 1.

Fig. 46:

Installation stage 3

- Remove the stakes after covering with soil/sand.

Note: RAUGEO collect 100 pipes must be laid in sand.

Fig. 47:

Installation stage 4

- Fill the pipe with ready mixed heat conveying medium (the ratio of antifreeze to water is specified by the heat pump manufacturer). Frost protection should be 7 K below the minimum evaporator temperature.
- Flush the pipes over an open container until they are free of air.
- Test the piping and system components (manifolds, connecting pipes etc.) at 1.5 times the operating pressure.

6.5 Design and installation of geothermal probes

6.5.1 Design

The extracted power and output are also decisive in the design of geothermal probes for the operation of heat pumps. Tab. 8 contains values which can be used for small systems < 30 kW for heating with heat pumps and for maximum probe lengths of 100 m.

Operating hours	**1800 h**	**2400 h**
Substrate	**Specific extracted power in W/m probe**	
General values:		
Poor substrate (dry sediment) (λ < 1.5 W/mK)	25	20
Normal bedrock substrate and water-saturated sediment (λ < 3.0 W/mK)	60	50
Bedrock with high thermal conductance (λ < 3.0 W/mK)	84	70
Various types of stone:		
Gravel, sand, dry	< 25	< 20
Gravel, sand, water-bearing	65 - 80	55 - 85
With strongly flowing ground water in gravel and sand, for individual systems	80 - 100	80 - 100
Clay, moist	35 - 50	30 - 40
Limestone (solid)	55 - 70	45 - 60
Sandstone	65 - 80	55 - 65
Acid magmatite (e.g. granite)	65 - 85	55 - 70
Alkaline magmatite (e.g. basalt)	40 - 65	35 - 55
Gneiss	70 - 85	60 - 70
(The values can vary widely due to stone formations such as cracks, layers or erosion.)		

Table 8: Specific extracted power of geothermal probes (source: VDI 4640)

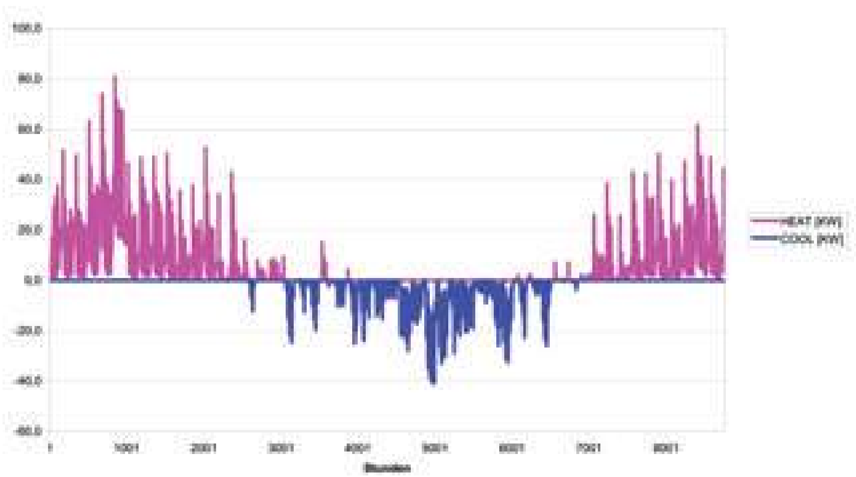


Fig. 48: Example of the heating and cooling requirement curve of a building

The ground type which is decisive to the extracted power of the geothermal probe may be available from geological institutes or the drilling company, or can be determined from the first core drilled by the drilling company.

Example design:

Output 6.8 kW (6800 W)
Operating hours: 2400 h/a
Moist soil

This produces:

Extracted power: 50 W/m

This produces the

$$\text{probe length} = \frac{\text{output (W)}}{\text{extracted power (W/m)}}$$

or 136 m.

6.5.2 Design of large systems

For larger heating systems with heat pump heating power > 30 kW or using additional heat sources (for example cooling), an exact calculation should be made. The heating and cooling requirements of the building must be determined as the basis of this. Fig. 48 shows an example of heating and cooling requirements in a building throughout the year, calculated by a simulation program. A pilot drilling should be made if the geological and hydrogeological situation is unclear to proportion the probe system. This drilling may be geophysically surveyed. On the basis of the results, a simulation program can also be used to calculate the possible annual extracted power for a specific running period of the system.

6.5.3 Installation

Probe systems usually require permission from water conservation authorities.
A minimum distance to the building of 2 m should be maintained. The stability of buildings must not be impaired.
If several geothermal probes are used, the intervals at probe lengths < 50 m should be at least 5 m and at > 50 m at least 6 m.
For geothermal probes used for cooling purposes, the arrangement should be designed as openly as possible to avoid interaction.
The laying distance from other supply pipes is 70 cm. If this distance is not maintained, the pipes must be protected by sufficient insulation.

To simplify the insertion of the probe, it is recommended to fill the probes with water in wet (water-filled) boreholes. The insertion of the probe is further simplified by the REHAU probe weight. If the borehole is dry, the probe must be filled with water before the borehole is backfilled to prevent the probe from floating.

The filler pipe is pushed into the borehole with the probe. At greater depths, a further filler pipe may be necessary to ensure even filling.

The probe is usually pushed into the borehole by an uncoiling device attached to the derrick. The probe can also be unrolled before it is inserted and is then pushed into the borehole over a loop attached to the derrick. Unrolling slightly reduces the residual curve of the probe pipes.

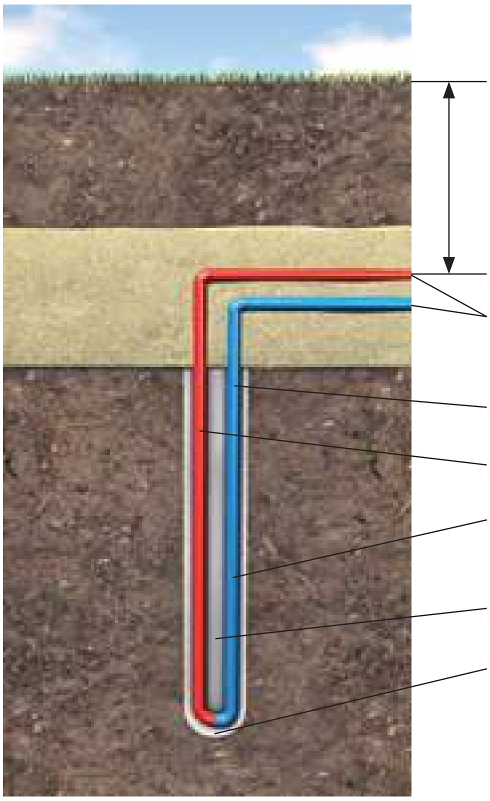


Fig. 49

Note: We do not recommend the method of inserting unrolled pipes into the borehole for the PE100 probes, as the service life of the pipes can be substantially reduced by notches, grooves etc. which can occur when the pipe is pulled along the ground.

After the probe has been inserted, we recommend a flow and pressure test.
The final tests are conducted after the borehole has been backfilled. Function test of the water-filled probe and pressure test with at least 6 bar; wait: 30 min; test duration: 60 min; tolerable pressure drop: 0.2 bar.

If there is a frost hazard, the probe must be drained to 2 m under the ground. This can be conducted by a compressed air connection under low pressure made at one side. This forces out the water at the other side. When the pressure is released, the water columns in the probe equalise.

The probe pipes must be tightly sealed until they are connected.

For complete backfilling of the annular gap, materials must be used depending on the geological conditions which must be chosen according to the respective operating modes.

The geothermal probe pipes should be routed in parallel circles to the manifold. The manifold should be installed at the highest point. A breather device must be fitted at a suitable point. The manifold can be equipped with flow gauges to regulate the probes.

Before the overall system is put into operation, a pressure test must be made at 1.5 times the operating pressure. It must be verified that water flows equally through all probes.

Installation of geothermal probes

Fig. 50: Filling the probe pipes with water

Installation stage 1
- Check the coils for damage before inserting
- Fill the probe pipes with water

Before the probes are pushed into the borehole, they should be inspected to detect any damage caused during transport.

Fill the pipe with water if the borehole is wet to prevent it from floating.

Fig. 51: Fastening the probe weight

Installation stage 2
- Fasten the probe weights to the probe base
- Straighten the probe pipes

To simplify the insertion of the probes, particularly in wet boreholes, the REHAU probe weight or the REHAU insertion tool can be used.

The first 2 m from the probe base can be fastened with strong adhesive tape.

Fig. 52: Compacting the annular gap with an aggregate

Installation stage 3
- Fill the system with a water/ glycol mixture
- Purge the pipes

Fill the piping with ready mixed heat conveying medium (the ratio of the antifreeze to the water is specified by the heat pump manufacturer). Frost protection should be 7 K below the minimum evaporator temperature.

Flush the pipes over an open container until they are free of air.

Fig. 53:

Installation stage 4
- Pressure test
- Manifold connection

The piping and system components (manifolds, connecting pipes etc.) are tested at a pressure of at least 6 bar.

The probe pipes can also be connected directly to the manifold/ collector or at the borehole with the REHAU Y-pipe.

6.6 Design and installation of energy piles

6.6.1 Design

The design of energy piles is conducted in the same manner as for the geothermal probes, see Item 6.1. I must be observed that energy piles must not be operated below zero. This must be taken into account in the calculation. A temperature-controlled shut-off must be provided.

For economical reasons, only the number of piles necessary for stability are considered for equipping. The cost of additional piles dies not justify the expense. Additional heating or cooling power is provided by other, independent systems. Usage can become economical from a pile length of 6 m.

Foundation piles are usually set in the ground water. When this is employed as a cooling water system, the ground water temperature is raised. This must be clarified with the responsible authorities.

6.6.2 Laying methods

The methods vertical zig-zag and U probe can be used to lay the pipes.

Vertical zig-zag

The pipes are laid in endless, zig-zag loops in the reinforcement grid. This method of pipe laying has particular advantages with regard to simple installation. The feed and return pipes are connected to the pipe network at the head of the pile.

U probe

The pipes are laid in a U pattern in the reinforcement grid. The individual pipe loops are coupled at the head of the pile using the proven, permanently sealed REHAU compression sleeve coupler and REHAU fittings.
This method of pipe laying has particular advantages with regard to venting the pipes. The feed and supply pipes are connected to the pipe network at the head of the pile.

Fig. 54: Energy pile pipe laying

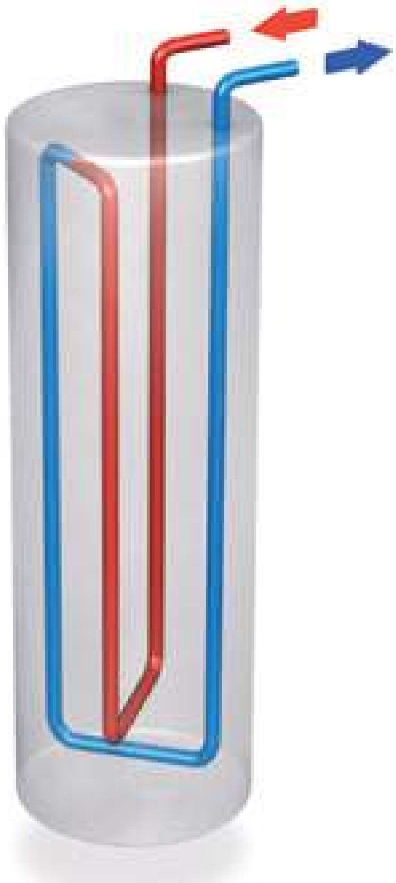


Fig. 55: Vertical zig-zag pipe laying

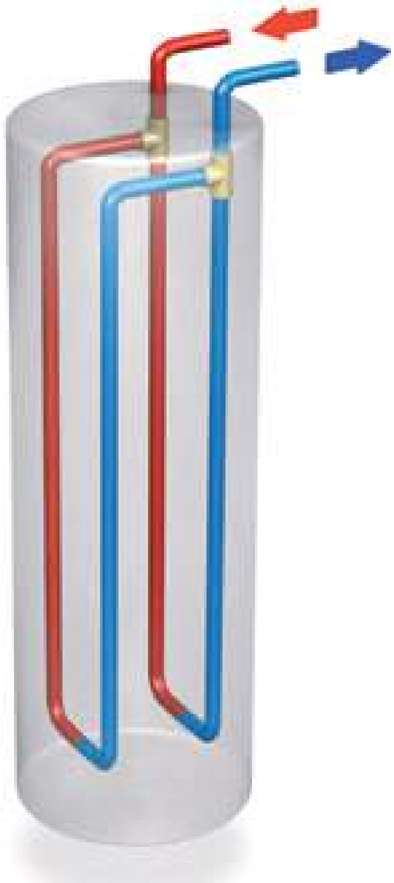


Fig. 56: U probe pipe laying

Fig. 57: Installation stage 1

Installation stage 1

- Lay the pipes in a zig-zag pattern in the reinforcement grid on site

The piping is laid longitudinally in the reinforcement grid.

The firm attachment of the pipe is conducted with REHAU EP grid ties at intervals of 0.5 m to the reinforcement and at the pipe bends.

Fig. 58: Installation stage 2

Installation stage 2

- Fit sleeves to the pipes in the vicinity of the head of the pile, fasten and cut
- Mark the pipes

The connecting pipes are cut to length at the head of the pile and fitted with sleeves.

The energy pile is marked according to the installation plan.

Fig. 59: Installation stage 3

Installation stage 3

- Attach a pressure test unit
- Apply a test pressure of 6 bar

Attach a pressure test unit to the pipe ends using the REHAU adapter with pressure gauge.

Apply the test pressure of 6 bar and record the applied test pressure.

Fig. 60: Installation stage 4

Installation stage 4

- Cast the concrete
- Conduct a 2nd pressure test after casting
- Connect the pipes to the manifold pipes

Record the test pressure after casting.

The energy piles can be connected directly to the manifold pipes or directly to heating or cooling circuit manifolds.

6.7 Manifold installation

6.7.1 Manifold position
The manifold should be positioned at the highest point of the piping. The piping should be laid at a slight gradient to the manifold.

6.7.2 Manifold location
Condensation easily forms on heat transfer fluid pipes, so these should be insulated and impermeable to water vapour inside buildings. Because a manifold can only be insulated with great difficulty, we recommend that is should be installed outside buildings.

6.7.3 Manifold connection
The manifold connection is made with the G 1 1/2“ or G 2“ outside screw union thread. Due to the danger of steam bubbles developing, there are limits to the use of the manifold. The flow rate for the 2“ main pipe is restricted to 8000 l/h when used with heat transfer fluid with 34 % antifreeze. A greater flow rate can be achieved with smaller proportions of antifreeze of by using pure water. If a flow rate > 8000 l/h is required, 2 manifold pipes can be joined in the middle with a tee. A flow rate of 16000 l/h can be achieved in this way.

Fig. 61: Standard manifold

Note:
Brass manifolds must only be operated with water or a water/glycol mixture. If a corrosive medium is employed, plastic manifolds should be used. Plastic manifolds must also be used in systems with inadequate space for the standard manifold. Prices for plastic manifolds on request.

Fig. 62: Plastic manifold

6.7.4 Manifold for ground probe
The feed and return lines of a geothermal probe can be interconnected at the probe head with a Y-pipe or can be routed to a manifold. If an equally long probe pipe length to the manifold cannot be ensured, flow regulators must be fitted. With a water/glycol mixture, the flow controller is only used to regulate the individual circuits, but not to determine the flow rate. This is due to the greater density and weight of the water/glycol mixture.

Fig. 63: Flow regulator

6.7.5 Manifold pipe connection
The pipes should be connected according to the Tichelmann principle to ensure an even flow through all pipes from the collector / probe manifold. See Fig. 64 and 65.

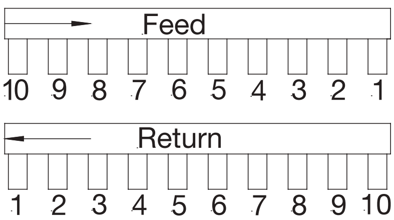


Fig. 64: Single-sided feed and return

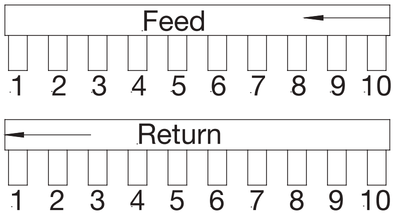


Fig. 65: Alternating feed and return

6.7.6 Manifold connection
The manifold can be installed horizontally or vertically, for which the pipes should be laid in a 90° elbow before the connection to the manifold. This prevents the forces in the pipes caused by thermal expansion and contraction from being applied to the manifold, and compensates them in the pipe elbow.
If the manifold is installed in a light shaft, it must be ensured that the RAUGEO pipes are not in contact with the house wall. Packing with rigid foamed PU plates 4 cm thick prevents the wall from becoming damp with condensation and the pipes from being damaged by changes in length.

6.7.7 Energy pile manifold
In the same way as the REHAU subsurface heating and cooling systems, REHAU energy piles can also be connected to the pipe network by a heating and cooling circuit manifold. Ball valves and flow regulators are recommended to shut off and regulate the flow. A max. pressure loss of 300 mbar per circuit must be taken into account in the design, and that all circuits are approximately the same size.
By laying the pipes and manifold pipes by the Tichelmann method, this is achieved with an almost even pressure loss.

6.8 Heat conveying medium
A certain proportion of glycol is mixed with the water in heat pump systems to prevent the heat conveying medium from freezing. No glycol must be used in systems which are not operated below zero if the pipes are laid away from frost. Before the system is filled, the temperature for which the heat conveying medium must be adjusted must be known. In heat pump systems, this is usually between 10 °C and 20 °C. The REHAU antifreeze is supplied in concentrated form and can be mixed with water according to the table below.

Caution: The added water should not contain more than 100 mg/kg of chlorine as specified by DIN 2000.
The REHAU glycols contain anticorrosives to protect steel components in the system. For the glycol to contain sufficient anticorrosives, the antifreeze content of ethylene glycol should not be less than 20 % and of propylene glycol, 25 %. However, the glycol content should be kept as low as possible to save pump energy.

The mixing ratios are below:

Ethylene glycol:		
-10°C	22 % ethylene glycol	68 % water
-15°C	29 % ethylene glycol	71 % water
-20°C	35 % ethylene glycol	65 % water

Propylene glycol:		
-11°C	25 % propylene glycol	75 % water
-15°C	32 % propylene glycol	68 % water
-20°C	39 % propylene glycol	61 % water

Caution: Mix the glycol with water in a vessel before filling the system. If the system is filled separately, good mixing is not ensured and frost damage may occur.

The adjusted temperature must be verified with an antifreeze tester.

Caution: A suitable antifreeze tester must be used for glycols based on ethylene and propylene.

Every pipe circuit is purged until free of air using a common suction pump. An open vessel must be used for this.

6.8.1 Filling geothermal probes

Geothermal probes are usually filled with water for installation. It must therefore be ensured when filling with a water/glycol mixture that the water is completely discharged before filling with fluid. If this is impossible, a correspondingly higher concentration of heat transfer fluid must be employed. The volume contained in the probe circuit is calculated as shown in Table 9 for this purpose.

Notes:
The safety data sheets for ethylene glycol and propylene glycol can be viewed at the REHAU homepage www.raugeo.de. The sufficient frost protection and pH value of the glycol/water mixture must be verified annually. The pH value should by in the neutral range 7.

Dimensions d x s [mm]	Volume [l/m]
20 x 1.9	0.20
25 x 2.3	0.32
32 x 2.9	0.54
40 x 3.7	0.83
50 x 4.7	1.30
63 x 5.8	2.10
75 x 6.8	2.96
90 x 8.2	4.25
110 x 10	6.36
125 x 11.4	8.20
140 x 12.7	10.31
160 x 14.6	13.43

Tab. 9 Internal pipe volumes

6.9 Backfilling the pit or the pipe trench

6.9.1 General

If the temperature of the pipe is substantially higher than the temperature in the pipe trench due to direct sunlight, the pipe must be lightly covered to achieve low-stress laying before the pipe trench is finally backfilled.
In deviation from DIN EN 1610, the excavated material can be reused for the piping zone and to backfill the remainder of the pipe trench with RAUGEO collect Xa pipes if:
- the excavated material can be well compacted
- the maximum grain size does not exceed 63 mm
- no stones which could pinch the pipe are lying on the pipe

Therefore, gravel, recycled hardcore and ground slag can be used in the pipe zone.
In the vicinity of roadways, the remaining backfilling of the pipe trench must be conducted according to ZTV AstB 97 “Zusätzliche Vertragsbedingungen und Richtlinien für Aufgrabungen in Verkehrsflächen“.
Note: RAUGEO collect PE100 pipes must always be laid in sand.

Potential compensation
RAUGEO pipes must not be used as earth conductors for electrical equipment as specified in DIN VDI 0100.

6.9.2 Outdoor laying

RAUGEO pipes can be stored unprotected outdoors in Central Europe for one year without effect on the life expectancy of the pipe. For longer outdoor storage or in regions with strong solar radiation, e.g. at the sea, in southern countries or at altitudes above 1500 metres, storage with sunlight protection is necessary. Contact with damaging media must be avoided (see Annex 1 of DIN 8075). If a light shaft hood is intended at the location of the manifold, the grating must be covered to stop UV radiation, as the plastic pipes are UV stabilised for normal outdoor storage only, not for decades in use.

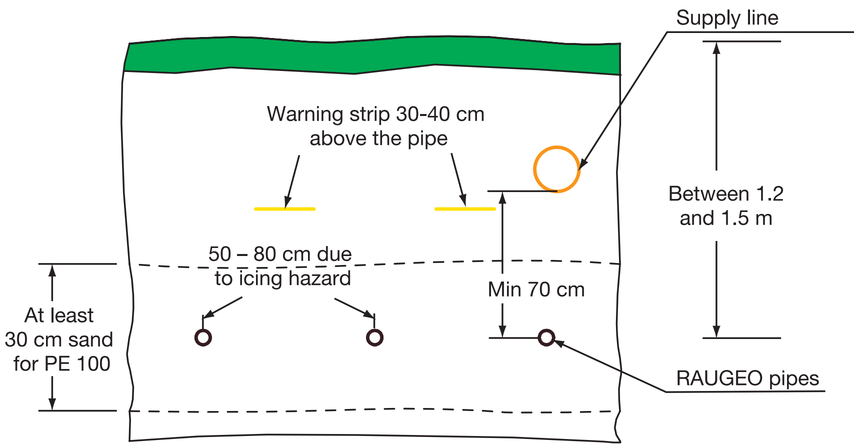


Fig. 66: Laying intervals with warning strip position

7. Entry to buildings

7.1 Insulation

Because the heat conveying medium is usually cooler, than the temperature in the pump room, the pipes located there must be insulated against condensation and water vapour-tight as specified by DIN 4140.
Pipe clips must be equipped with pipe holders as insulators. This prevents cold bridging between the pipe clip and the insulation.

Fig. 67: Pipe holder

7.2 Entry to houses

Entries to houses must also be conducted in compliance with DIN 4140. This states that the pipe passing through the wall must be insulated against condensation. The REHAU wall socket consists of a wall sealing flange, which can also be used against pressurised water. The pipes are sealed flush at the outer wall (see Fig. 68). The pipe passing through the conduit/middle hole is insulated and sealed against vapour by the REHAU insulation. The medium pipe is laid through the liner pipe/middle hole for this. The wall sealing flange must be tightened to the appropriate torque (see price list). The insulation is then pushed from the inside over the pipe towards the wall flange. The end of the insulation at the side of the will sealing flange must be coated with adhesive to make a joint.

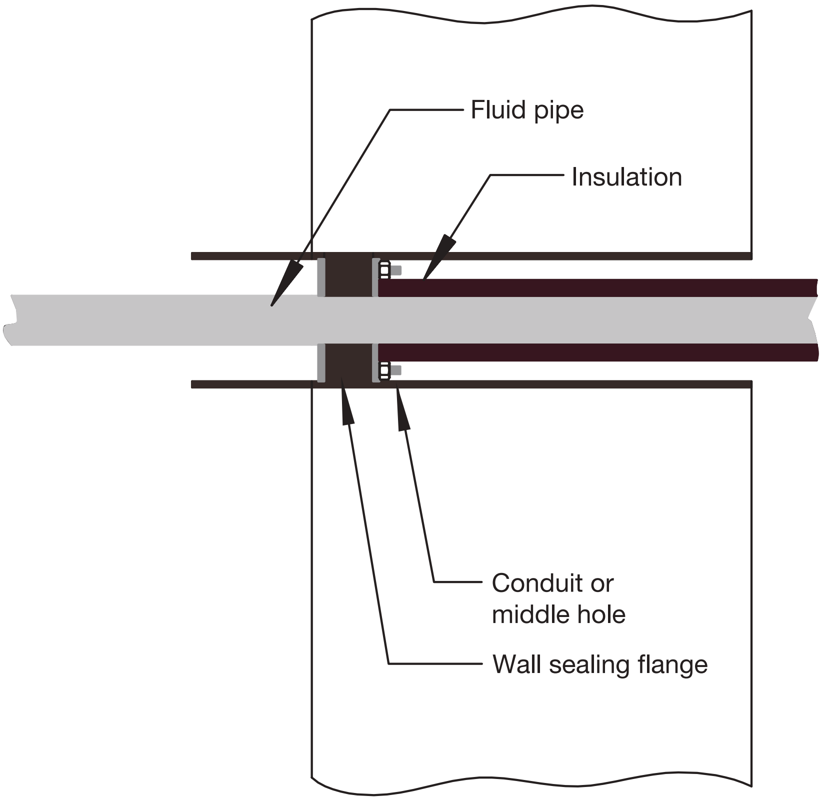


Fig. 68: Entry to house

8. Pressure loss calculation

8.1 General

Heat pump systems must be operated with a mixture of water and glycol. This prevents the heat conveying medium from freezing. The lowest temperature occurs in the heat pump. Depending on the make, this is between -10 °C and -20 °C, although the pipes must not be operated under -5 °C. For the frost protection adjustment of the water/glycol mixture, ask the heat pump manufacturer.

8.2 Design

A water/glycol mixture has a higher viscosity and density than water. The proportion of glycol in the water must therefore be taken into account in the pressure loss calculation. The REHAU pressure loss tables permit designs with different proportions of glycol and for water without glycol. An operating temperature of -5 °C is assumed for the pressure loss tables for heat transfer fluid/water mixtures. This is +15 °C for operation with pure water.

The pressure loss consists of the piping, mouldings, manifolds and heat pump heat exchangers.

Documents on pressure loss calculation can be downloaded from the Internet at **www.raugeo.de**.

9. Required approvals

According to § 3 Sect.3 No.2 Letter b BbergG, geothermal energy is equivalent to non-mined minerals.

9.1 Water conservation laws
The provisions of water conservation laws and state planning objectives must be observed in the planning, construction and operation of energy generating systems for thermal exploitation of the ground. The provisions of the Water Resources Act (WHG) in conjunction with the state water conservation laws and the associated administration rules are applicable.

9.2 Water conservation laws, execution
Works which penetrate the ground do not usually require permission or consent under water conservation laws. However, if it is anticipated that the ground water will be exposed or affected, the work must at least be declared to the water conservation authority as stipulated in § 35 WHG in conjunction with the state rulings (e.g. in Bavaria, Art.34 Sect.1 and 2 BayWG).

9.3 Heat pump systems with geothermal collectors
a) In exceptional cases, water exploitation by the construction or operation of such systems can represent a case of usage requiring permission according to § 3 Sect.2 No.2 WHG, regardless of whether or not ground water is encountered during installation. This can only be assessed individually on the basis of the technical data of the system and the hydrogeological circumstances. A declaration according to § 35 WHG in conjunction with the associated state legislation may be required (see Section 4.1.1).

b) Objectives of water conservation laws
   - Even if ground water is present at the intended installation depth of the geothermal collector, installation can be permitted if an open water surface exists. Geothermal collectors with direct evaporation must be completely above the highest ground water level. RAUGEO pipes must not be used for direct evaporation.
   - The heat conveying medium must fully comply with the requirements in VDI 4640 Page 1, Sections 8.2 and 8.3.

9.4 Heat pump systems with geothermal probes/ energy piles
- Exploitation under water conservation laws
  The simple drilling of a borehole does not usually require permission under water conservation laws. However, it may be necessary to declare a drilling; according to § 35 WHG in conjunction with state laws, this is the case if effects on the ground water are to be expected.

9.5 Associated standards, guidelines, regulations etc.

German standards
DIN 4021
Building land – exploitation by mining and drilling and removal of samples

DIN 4022
Building land and ground water – designation and description of soil and rock
Part 1
Strata list for drilling without continuous core sampling in soil and in rock
Part 2
Strata list for drilling in rock (solid stone)
Part 3
Strata list for drilling with continuous core sampling in soil (loose stone)

DIN 4023
Building land and water drilling; diagrams of the results

DIN 4030
Assessment of water, soil and gases aggressive to concrete
Part 1
Principles and limits
Part 2
Extraction and analysis of water and soil samples

DIN 4049
Hydrology
Part 1
Fundamental terms
Part 2
Terms of water properties

European standards
DIN EN 255
Air conditioners, liquid coolants and heat pumps with electrically powered compressors -heating
Part 1
Names, definitions and designations
Part 2
Tests and requirements on the marking of equipment for room heating
Part 4
Requirements on equipment for room heating and to heat utility water

DIN EN 378
Refrigerating systems and heat pumps – safety and environmentally relevant requirements
Part 1
Fundamental requirements
Part 2
General definitions
Part 3
Classification of refrigerating systems, refrigerants and installation areas
Part 4
Selection of refrigerants
Part 5
Design, manufacture and materials

DIN EN 1861
Refrigerating systems and heat pumps – system flow diagrams, piping and instrument flow diagrams – design and symbols

Guidelines
VDI 4640 Thermal exploitation of the ground
Page 1,
Principles, approvals, environmental aspects
Page 2,
Ground coupled heat pump systems
Page 3,
Underground thermal energy accumulators
Page 4,
Direct usage

Our verbal and written advice relating to technical applications is based on experience and is to the best of our knowledge correct but is given without obligation. The use of REHAU products in conditions that are beyond our control or for applications other than those specified releases us from any obligation in regard to claims made in respect of the products.
We recommend that the suitability of any REHAU product for the intended application should be checked. Utilization and processing of our products are beyond our control and are therefore exclusively your responsibility. In the event that a liability is nevertheless considered, any compensation will be limited to the value of the goods supplied by us and used by you. Our warranty assumes consistent quality of our products in accordance with our specification and in accordance with our general conditions of sale.

Ground to air heat exchanger AWADUKT Thermo, antiseptic

RAUTHERMEX insulated PE-Xa medium pipe

www.REHAU.com
RAUNET@REHAU.com
■ **AUS:** ☐ Brisbane: 27 Deakin Street, Brendale Queensland 4500, Tel.: 6 17/38 89 75 22 ☐ Melbourne: 9-11 Endeavour Way, Braeside Victoria 3195, Tel.: 3/95 87 55 44 ☐ Sydney: 91 Derby Street, Silverwater New South Wales 2128, Tel.: 2/97 48 17 88 ■ **CDN:** ☐ Moncton: 327 Murray Road, Little Shemogue, New Brunswick E4M 3P3, Tel.: 5 06/5 38 23 46 ☐ Montreal: 625 Lee Avenue, Baie d'Urfé, Quebec, H9X 3S3, Tel.: 5 14/4 57 33 45 ☐ St. John's: 13 Sagona Avenue, Donovan's Industrial Park, Mt. Pearl, Newfoundland, A1N 4P8, Tel.: 7 09/7 47 39 09 ☐ Toronto: 1149 Pioneer Road, Burlington, Ontario, L7M 1K5, Tel.: 9 05/3 35 32 84 ☐ Vancouver: 380 Riverside Road, Unit #2, Abbotsford, British Columbia, V2S 7N8, Tel.: 6 04/8 52 45 27 ☐ Winnipeg: 11 Plymouth Street, Unit 100, Winnipeg, Manitoba, R2X 2V5, Tel.: 2 04/6 97 20 28 ■ **GB:** ☐ Birmingham: Tameside Drive, Holford Way, Witton, Birmingham, B6 7AY, Tel.: 1 21/3 44 23 00 ☐ Glasgow: Phoenix House, Phoenix Crescent, Bellshill, North Lanarkshire, ML4 3NJ, Tel.: 0 16 98/50 37 00 ☐ Manchester: Brinell Drive, Irlam, Manchester, M44 5BL, Tel.: 1 61/77 77-4 00 ☐ Slough: Waterside Drive, Langley, Slough, SL3 6EZ, Tel.: 17 53/58 85-00 ☐ For the automotive sector, please contact the Ross-on-Wye Sales Office: Hill Court, Walford, Ross-on-Wye, Herefordshire HR9 5QN, Tel.: 19 89/76-26 00 ■ **HK:** ☐ Hongkong: 22/F, Silver Tech Tower, 26 Cheung Lee Street, Chai Wan, Tel.: 28 98 70 80 ■ **IRL:** ☐ Dublin: 9 Saint John's Court Business Park, Swords Road, Santry, Dublin 9, Tel.: 1/81 65 02-0 ■ **NZ:** ☐ Auckland: 14 Lorien Place, East Tamaki, Auckland, Tel.: 9/2 72 82 24 ■ **SGP:** ☐ Singapore: 1 King George's Avenue, # 06-00 REHAU Building, Singapore 208557, Tel.: 63 92 60 06 ■ **USA:** ☐ Chicago: 500 East Thorndale Rd., Unit H, Wood Dale, Illinois 60191, Tel.: 6 30/7 87 05 00 ☐ Dallas: 2615 Avenue E, East, Arlington, Suite #124, Texas 76011, Tel.: 8 17/6 40 30 92 ☐ Detroit: 33533 West Twelve Mile Rd., Suite 305, Farmington Hills, Michigan 48331, Tel.: 2 48/8 48 91 00 ☐ Grand Rapids: 5075 Cascade Rd. S.E., Suite A, Grand Rapids, Michigan 49546, Tel.: 6 16/2 85 68 67 ☐ Greensboro: 2606 Phoenix Drive, Suite 810, Greensboro, North Carolina 27406, Tel.:3 36/8 52-20 23 ☐ Los Angeles: 1501 Railroad Street, Corona, California 92880-2501, Tel.: 9 09/5 49 90 17 ☐ Minneapolis: 7710 Brooklyn Blvd. Suite 207, Brooklyn Park, Minnesota 55443, Tel.: 763/5 85 13 80 ☐ New York: 3 North Street, Waldwick, New Jersey 07463, Tel.: 2 01/4 47-11 90 ☐ Seattle: 18900 8th Avenue South # 1000, Seatac, Washington 98148, Tel.: 2 06/4 33 18 83
■ For European exporting companies and if there is no sales office in your country please contact: REHAU AG+Co, Export Sales Office, P.O. Box 30 29, 91018 Erlangen/Germany, Tel.: +49 (0) 91 31 92 50, Export.Sales.Office@REHAU.com

827.600 EN 2.05