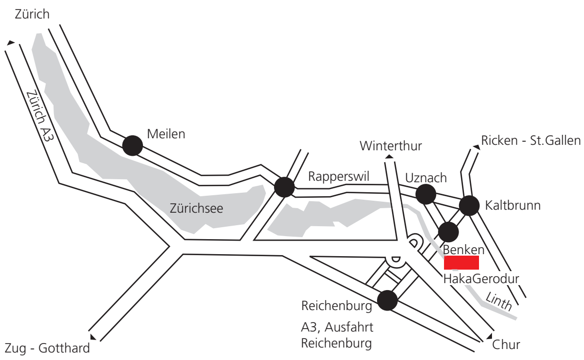
HakaGerodur

Technical Handbook

GEROtherm® Geothermal Systems



How to find us

HakaGerodur AG
Giessenstrasse 3
Postfach
CH-8717 Benken
Telefon +41 (0)55 293 25 25
Fax +41 (0)55 293 25 99
sekretariat@hakagerodur.ch
www.hakagerodur.ch

Disclaimer:
All the information in this work, which is based on standards, ordinances and regulations, etc., has been intensively researched and compiled with the greatest care.

We cannot, however, provide any guarantee for the correctness, completeness and topicality of this information. HakaGerodur AG accepts no liability for any damage resulting from the use of this information.

Date of release to press: 31.01.2010

HakaGerodur
Giessenstrasse 3
CH-8717 Benken
Telefon +41 (0)55 293 25 25
Fax +41 (0)55 293 25 99

Structure of the Technical Handbook for HakaGerodur Geothermal Systems

03/2010 | EWS-2026

HakaGerodur
Giessenstrasse 3 CH-8717 Benken
Telefon +41 (0)55 293 25 25
Fax +41 (0)55 293 25 99

1. Fundamentals of Geothermal Energy

Geothermal energy or soil warmth is the energy that is stored under the Earth's solid surface in the form of heat. 30–50% of this energy originates from the time of the Earth's creation and can be described as the residual heat of the processes that took place at that time; the main part, around 50–70%, is the result of the continuous decay of radioactive elements in the interior of the Earth; a small remnant is due to direct sunlight and/or the indirect heat exchange with the air or from rainwater seeping through the earth.
Temperature fluctuations during the course of a day can be detected down to a depth of around 50 cm, while seasonal differences can be found down to depths of 10–20 m. The soil temperature below a depth of around 20 m is virtually constant. In Central Europe, the soil temperature at this depth is approximately 11 to 12 °C. Below this, the area of the definable geothermal gradients that are unaffected by the surface begins – or, in other words, the area with a constant increase in temperature with increasing depth (around 3K per 100 m). The temperature at a depth of 500 m in the Earth's mantle is a constant 25–30°C; and around 35–45°C at a depth of 1,000 m.

Geothermal energy is becoming increasingly important, as the primary energy is obtained through the utilization of an inexhaustible, regenerative energy source. It has therefore become a great white hope for the supply of energy. It can be used to replace fossil fuels such as oil and gas and will considerably reduce the emissions of CO_2.
Through the use of geothermal probes, soil heat can be exploited as a regenerative energy source. In doing this, by means of a heat transfer medium (mostly a water/glycol mixture), the geothermal energy is made available for heating buildings and for the production of hot water using a heat pump. The air conditioning of buildings would also be feasible with the use of heat pumps and geothermal probes, in which the excess room heat is released underground.
With the use of geothermal probes, thermal energy storage and energy piles, it is possible to air-condition buildings without having to make use of energy-intensive refrigerators. If the two utilisation possibilities, heating and cooling, are considered with regard to economical aspects, the geothermal solution is even more efficient and is interesting from an economical viewpoint. The savings that can be achieved currently lie at around 30–45% in comparison with oil-fired boilers and 20–30% in comparison with gas-fired condensing boilers.

Combined brine-water heat pumps heat with a very large percentage of renewable energy in the form of geothermal energy. 100% of heating heat arises from up to 75% of soil heat and 25% of drive energy. Brine-water heat pumps can thereby make use of energy for heating, cooling and the production of hot water in an extremely efficient manner.
The improved insulation standard for new buildings (Minergie standard) has created good preconditions for the heat pump, because lower heating temperatures are also needed with the reducing need for heating energy. The efficiency, and thereby the economic efficiency of the geothermal energy system is increasing. Together with the reducing need for heat energy, the costs of a brine-water heat pump system are also falling. The same applies in particular for existing buildings to which insulation is installed at a later stage.

With near-surface geothermal energy, soil heat is available to all of us in sufficient quantity. This means that everyone can make use of heat from the Earth for the heating and cooling of detached houses

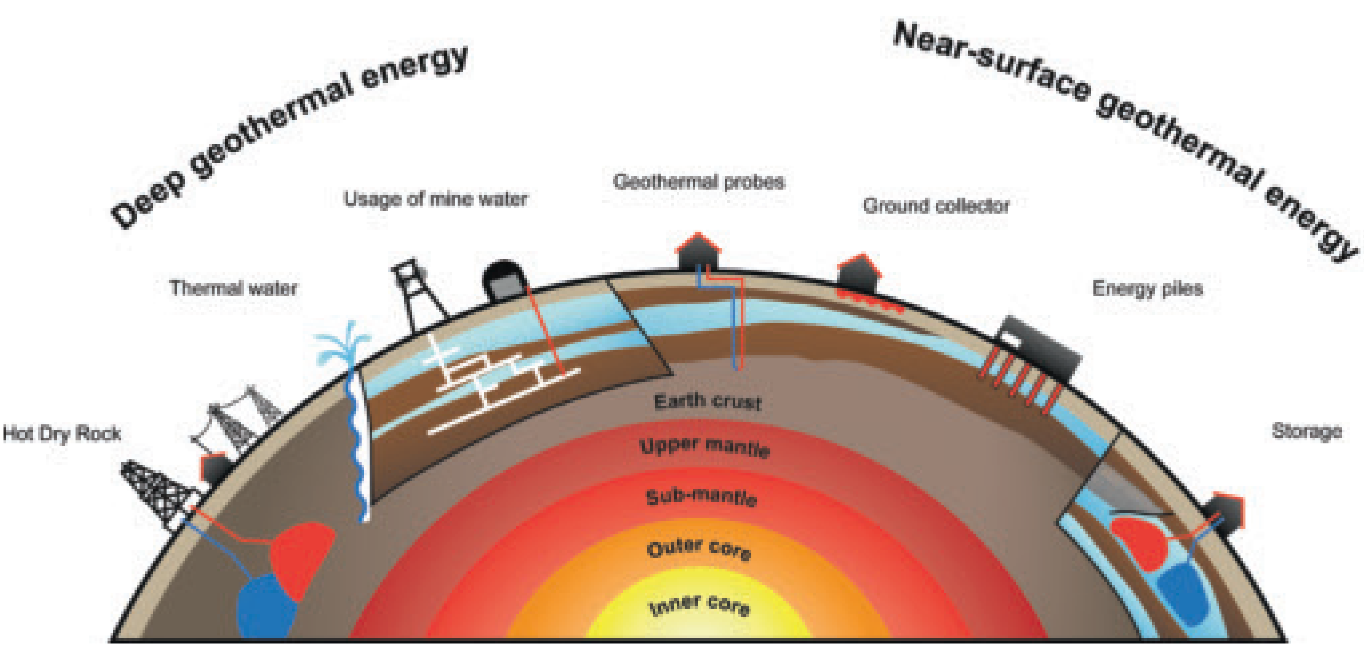


Fig. 1: Overview of geothermal energy

HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99

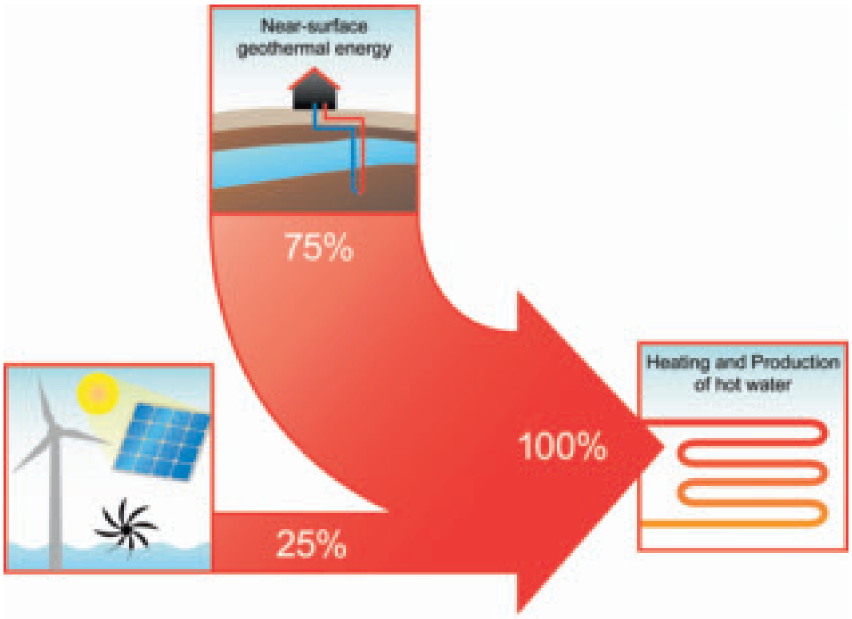


Fig. 2: The energy balance of near-surface geothermal energy

and apartment blocks. Even large offices and commercial buildings can be air-conditioned in this way without any problems. Although near-surface geothermal energy is available everywhere, its utilization is not possible in some cases because boreholes cannot be drilled due to groundwater protection rules.

The advantage of near-surface geothermal energy as a heating source is that no additional heating system is required. The heat provided is completely sufficient to heat and to cool detached and semi-detached houses, as well as larger buildings such as apartment blocks or commercial and industrial real estate with the heat pump alone. The energy is available locally; transportation of the heating fuel, which also contributes to CO_2 emissions, is unnecessary!

2. General information

2.1. Meaning of symbols

⚠ Attention, must be observed for proper and correct implementation.

☞ Note, please observe!

2.2. Planning and execution

⚠ The design and the execution of a geothermal installation must be carried out according to SIA 384/6:2010 or the VDI Directive 4640.

2.3. Correct use

GEROtherm® geothermal systems are produced in accordance with the accepted rules and standards, and are checked against the safety standards. Danger to life and limb and damage to property can, however, arise from improper or incorrect use. The components of GEROtherm® systems are designed for use as heat carriers for heat pump systems with brine circulation. Any other use, or a use going beyond this, is regarded as improper.

☞ Compliance with the separate operating and installation instructions is also a condition for correct usage.

2.4. Warranty

HakaGerodur AG accepts no liability for any damage that occurs as the result of improper use, incorrect use or work carried out by untrained persons, including third parties. Any modifications to components and/or the use of non-original parts will lead to the rejection of any warranty claims for the complete GEROtherm® system.

2.5. Notes

☞ Every delivery must be checked for completeness.

☞ The progress of the construction work shall be continually documented in pictures and words in order to make all piping runs understandable, and in consideration of any future work that may have to be carried out.

☞ All documents and information regarding the system are to be filed.

2.6. Quality mark

GEROtherm® piping systems and distributors/collectors made from PE 100 are produced in accordance with DIN 8074 and 8075, and are continuously monitored by an independent quality control centre according to Directive HR3.26 of the Süddeutschen Kunststoff-Zentrums (SKZ South German Plastics Centre).

2.7. Disposal

Accessories and packaging are to be disposed of in an environmentally-friendly manner.

HakaGerodur
Giessenstrasse 3 CH-8717 Benken
Telefon +41 (0)55 293 25 25
Fax +41 (0)55 293 25 99

3. HakaGerodur GEROtherm® systems

Near-surface geothermal energy, which is also referred to as shallow geothermal energy, includes all geothermal energy installations in the depth range of 0-400 m, although geothermal probes are also possible in the range down to 500 m. The following installations are possible for near-surface geothermal energy:

3.1. GEROtherm® geothermal probes

The GEROtherm® geothermal probe system from HakaGerodur AG is designed to make use of near-surface geothermal energy (soil heat and/or geothermal cooling). Geothermal probes, ground collectors and energy piles are realised from closed and maintenance-free pipe systems made from high-quality polyethylene. The heat transport is carried out with a liquid heat carrier, such as water/glycol mixtures (brine). The connected heat pump generates the necessary temperature level for heating and cooling, as well as for the supply of hot water.

The GEROtherm® geothermal probe system from HakaGerodur AG is an environmentally friendly, qualitatively safe and very economical geothermal probe system that has been in use for more than 20 years.

Table: Systems of near-surface geothermal energy

Near-surface geothermal energy (8–25 °C)		
GEROtherm® geothermal probes	GEROtherm® ground collectors	GEROtherm® energy piles
Some 10 m to 400 m deep	1–2 m deep	10–20 m deep
Closed system		
Utilization through the use of brine-water heat pumps		
Heat generation (heating and provision of hot water) and cooling		

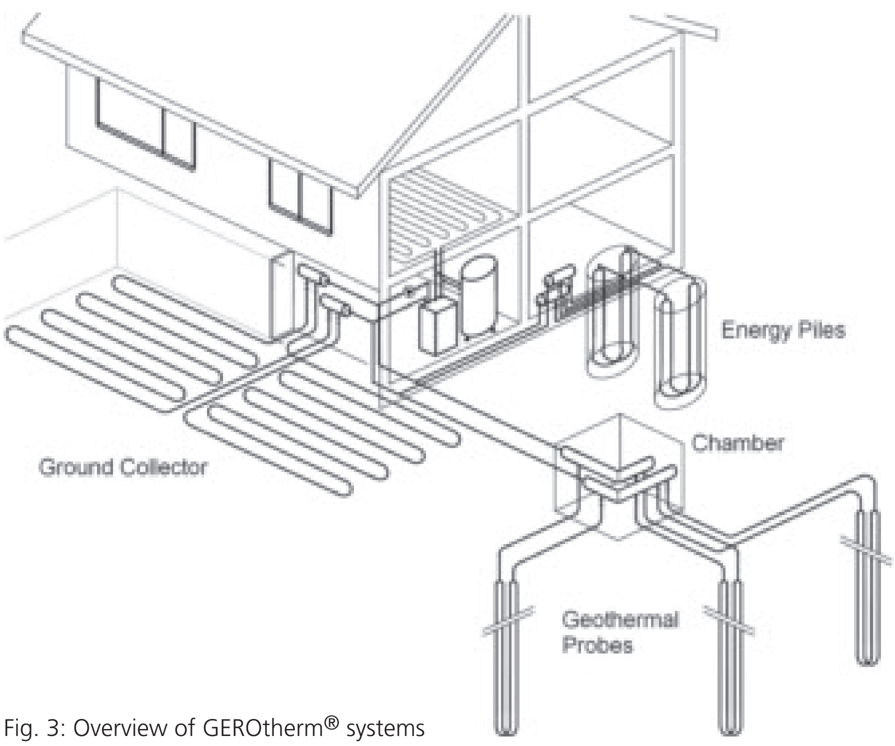


Fig. 3: Overview of GEROtherm® systems

GEROtherm® geothermal probes are sunk into boreholes with depths of up to approx. 400 m.

The geothermal probe construction used consists of:

- **Two geothermal probe U-bends;** with a device for securing weights as an installation aid
- **Four pipes of double U-probes of the pipe series SDR 11/PN16** (ratio of external diameter to wall thickness) made from PE 100, PE 100-RC or PE 100-RT, depending on the installation depth of the geothermal probe, with external pipe diameters of 25, 32, 40 and 50 mm and with lengths from 50 m up to 450 m
- **Two geothermal probe heads** or connection parts (Y-pieces) that connect the vertical pipes to the horizontal connection lines leading to the SAVE distributor/collector or directly to the heat pump.

In April 1999, the Süddeutsche Kunststoff-Zentrum (SKZ South German Plastics Centre) published a directive HR 3.26 called «Pipes and Pipeline components made from PE 100 for geothermal probe pipe systems» for the testing and monitoring of the described pipe system. In addition to the pipes and moulded parts made from PE 100 and PE 100-RC, the various welding procedures that are used for the connection of the pipes and moulded parts, such as

- heater element sleeve welding (HM)
- heating coil welding (HW)
- heater element butt welding (HS)

are tested and monitored. The GEROtherm® geothermal probes manufactured by HakaGerodur and the overall GEROtherm® system have successfully passed the strict initial test, as well as the half-yearly supervisory reviews according to Directive HR 3.26. In the test and supervision provisions, the SKZ confirms a service life of at least 100 years for a pipe system that fulfils these conditions. The HakaGerodur GEROtherm® geothermal probe system therefore has a service life of 100 years (at an application temperature of 20°C; DIN 8075). It is therefore guaranteed that the complete system, the GEROtherm® geothermal probe system, meets the strict criteria, and that the customer will be able to

HakaGerodur
Giessenstrasse 3 CH-8717 Benken
Telefon +41 (0)55 293 25 25
Fax +41 (0)55 293 25 99

benefit from the performance over a long period.

Every GEROtherm® geothermal probe produced is provided with a test certificate according to EN 10204 2.2. (Fig. 4) The user thereby has the security that all delivered geothermal probes correspond to the required standards according to the relevant product standards, and that all the results of the internal product testing are explicitly available for each delivered product. A comprehensive traceability of all parameters back to the raw material batch and the associated test results of the raw material supplier is guaranteed by these test certificates.

☞ In addition, an installation certificate can be drawn up and printed out in the Internet by entering the data of the test certificate at: www.hakagerodur.ch. A 10-year product guarantee for GEROtherm® geothermal probes can also be directly requested from HakaGerodur AG.

3.2. GEROtherm® ground collectors

Ground collectors are used in the detached and semi-detached house sector in rural areas. The heat removal is carried out by horizontally-laid ground collectors in the parts of the property that have not been built on. The heat is mainly provided to the system, which are laid at a depth of max. 2 m, by rain water and solar radiation. It is therefore vitally important to keep the extraction area free from development. Decreasing the calculated area should also be avoided. The ground collectors require a high surface area, and, for this reason, cannot be used everywhere. The possible specific extraction performance for ground collectors depend on the available underground, and can be found in the table. Exact performance details can be taken from VDI 4640 Sheet 2 «Thermal Utilization of the Underground».

⚠ In order to avoid any possible damage, the system must be under pressure when covering over the GEROtherm® ground collectors.

Fig. 4: GEROtherm® test certificate for geothermal probe (semi-probe)

1) Brand name
2) Production date
3) Text acc. to EN 10204 2.2
4) Article number incl. barcode
5) Article designation
6) QSP = Quality self tester; «237» = Identification number of the tester
7) Serial number of Single-U incl. barcode
8) Manufacturer's address

Heat pump operating hours	for 1800 h/a	for 2400 h/a
Subsoil	**Specific extraction**	**Specific extraction**
Dry, non-cohesive soils	10 W/m^2	8 W/m^2
Cohesive soils, damp	20–30 W/m^2	16–24 W/m^2
Water saturated sand/gravel	40 W/m^2	32 W/m^2

Table: Possible specific extraction of ground collectors for 1800 and 2400 operating hours (Source: VDI 4640)

Depending on the laying procedure for the ground collectors, various geothermal energy pipe systems with the corresponding approvals are used:

☞ Laying with a sand bed
GEROtherm® ground collector PE 100, the classic model with SKZ HR3.26/A278 geothermal energy system monitoring for laying with a sand bed

☞ Laying without a sand bed
GEROtherm® ground collector pipe PE 100-RC (high point loading and crack-resistance) with SKZ HR3.26/A278 geothermal energy system monitoring for laying without a sand bed

The use of the currently highest quality polyethylene materials creates the basis for making the installation more cost-effective by avoiding the necessity of a sand bed. Geothermal energy pipe systems of the latest generation of polyethylene (so-called RC types) are thereby used here. These point-load and crack-resistant geothermal energy pipes are approved for laying without a sand bed. The low additional costs for the GEROtherm® KIT with PE 100-RC collectors saves an expensive replacement of the excavated material by re-using it for the refilling.

3.3. GEROtherm® energy piles

Energy piles are foundation piles (drilled or driven piles) that are fitted internally with HakaGerodur plastic pipes or «short» GEROtherm® geothermal probes as heat exchangers. Energy piles are employed above all in the rebuilding of buildings that makes a pile foundation necessary (mostly large constructions).

A differentiation is made between two models:

- Drilled piles consist of reinforcement baskets, to which the 10–20 m long GEROtherm® geothermal probes are fixed. After the fixation, the energy piles are sunk into a borehole and the borehole is then completely filled with concrete.

HakaGerodur
Giessenstrasse 3 CH-8717 Benken Telefon +41 (0)55 293 25 25 Fax +41 (0)55 293 25 99

- In driven piles, the GEROtherm® geothermal probe has already been laid in the factory and has been cast in place with concrete. The driven piles are delivered complete to the construction site and are rammed into the subsoil. In doing this, it must be ensured that the line connections on the end of the pile are not damaged.

Energy piles are generally calculated by experienced specialists.

3.4. Technical data for GEROtherm® systems

The GEROtherm® systems are fully plastic systems made from high quality polyethylene materials PE 100 or PE 100-RC (Resistance to Crack) or PE 100-RT (Resistance to Temperature), which show optimal properties for the geothermal energy applications, such as:

- Long service life (100 years @ 20°C; DIN 8075)
- Low hydraulic resistance
- No corrosion problems, as they are fully plastic pipes
- Resistant to cold and heat
- Impact resistant
- Installation-friendly modular system
- Optimal safety with regard to pollution of the soil (drinking water)
- Patented probe foot (CH Pat. 687 268, EU Pat. 1 036 974)

Polyethylene has been used as a pipe material in the service supply sector (drinking water, heating, gas, industry, etc.) over the last 60 years. This has resulted in many years of experience in the manufacture, processing and use of this material. The polyethylene types used, PE 100, PE 100-RC and PE 100-RT, permit a long service life of 100 years @ 20°C, DIN 8075, according to the valid ISO, EN and DIN standards. The connection procedures, such as butt welding (HS) and heating coil welding (HW), are well tested and require no other materials. Seals or screw fittings in the soil can thereby be avoided. These are therefore material lock connections. The flexibility and the impact resistance of the material permits a problem-free installation of the components, even at extreme temperatures.
Polyethylene has an optimal ecological balance in comparison with other raw materials (see Fig. 5).

Only new material that has been processed following a successful incoming material inspection is used as the starting material (granulate) for the manufacture of HakaGerodur GEROtherm® geothermal probe systems, and no recycled material is thereby used. The relevant parameters are continually monitored during the extrusion process. A 100% check of the geothermal probes with regard to the dimension, wall thickness and pipe surface parameters is carried out in each extrusion line by means of ultrasonic measurements. In the case of deviations from the defined limit values of the parameters, there will be an automatic extraction of the pipe pieces. This ensures that no qualitatively inadequate geothermal probes leave the production factory.
In addition, production samples will be checked at pre-defined, regular intervals in the long-period test bed. The GEROtherm® geothermal probes manufactured by HakaGerodur and the complete system have successfully passed the strict initial inspection, as well as the half-yearly supervision controls according to SKZ Directive HR 3.26. In the test and supervision provisions for a pipe system, the SKZ confirms a service life of at least 100 years for a pipe system that fulfils these conditions. The HakaGerodur GEROtherm® geothermal probe system therefore has a service life of 100 years (at an application temperature of 20°C; DIN 8075). It is therefore guaranteed that the complete system meets the strict criteria, and that the customer will be able to benefit from the performance over a long period

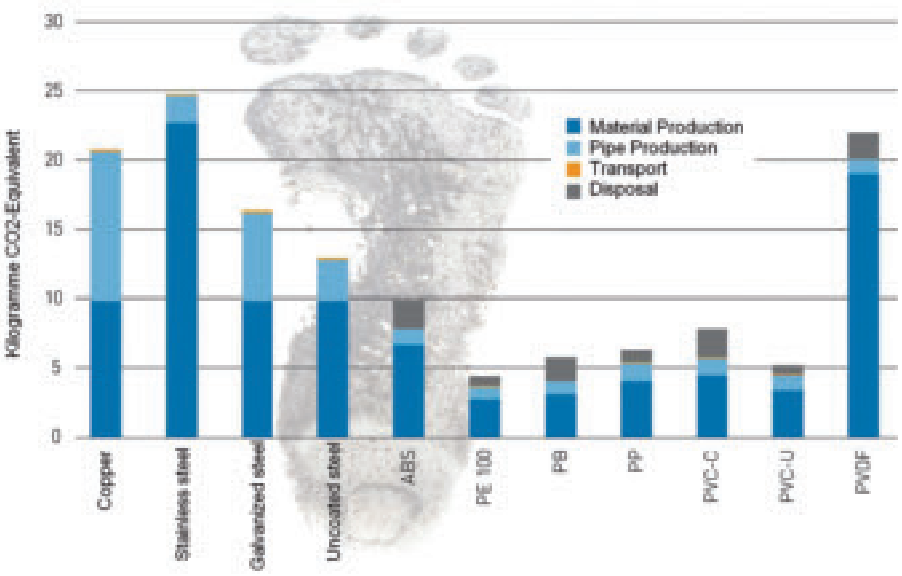


Fig. 5: Total greenhouse gas emissions in the manufacture, transport and disposal of various materials (Source: Georg Fischer GmbH, www.georgfischer.de)

PE 100-RT is used when a higher temperature resistance is required for the geothermal probe. This can be the case with hot thermal sources or a combination of solar and geothermal energy systems. In the summer, the high solar radiation, and thereby the high heat production of the collectors, is thereby offset with the time-offset heat requirement for room heating in the winter. The energy gained in the collectors will be fed to the subsoil in the summer via the geothermal probe after reduction of the temperature level by means of a heat exchanger. The maximum temperature has to be defined according to the relevant regulations.

Depending on the different location factors that are present at the object, geothermal probes from different materials can be selected. The following matrix provides an overview of the different material properties. The values shown are average values.

03/2010 | EWS-2078

HakaGerodur
Giessenstrasse 3 CH-8717 Benken
Telefon +41 (0)55 293 25 25
Fax +41 (0)55 293 25 99

Table: Material properties of GEROtherm® geothermal probes

Properties	Standard	PE 100	PE 100-RC	PE 100-RT
Physical				
Density	ISO 1183	0.96 g/cm³	0.96 g/cm³	0.94 g/cm³
Pipe roughness	acc. to Prandtl-Colebrook	0.01 mm	0.01 mm	0.01 mm
Oxygen permeability	DIN 4726	–	–	<0.1 g/m³xd
Minimum bend radius for pipes at 0°C	–	50 x dn	50 x dn	50 x dn
Minimum bend radius for pipes at 10°C	–	35 x dn	35 x dn	35 x dn
Minimum bend radius for pipes at 20°C	–	20 x dn	20 x dn	20 x dn
Mechanical				
Modulus of tension (23°C, v=1 mm/min, secant)	ISO 527-1, -2	900MPa	900MPa	850MPa
Line tension (23°C, v=50 mm/min)	ISO 527-1, -2	23MPa	23MPa	22MPa
Tensile strain (23°C, v=50 mm/min)	ISO 527-1, -2	9%	9%	8%
FNCT (4.0 MPa, 2% Arkopal N 100, 80°C)	ISO 16770	>/=1000h	>/=8760h	>/=350h*
Elongation at break	EN 638	>/= 350%	>/= 350%	>/= 760%
Available connection technologies	–	HS, HW, HM, Pressing/Clamping	HS, HW, HM, Pressing/Clamping	HS, HW, HM, Pressing/Clamping
Average thermal elongation coefficient	DIN 53752 DIN 52328	$1.8x10^{-4}$ K^{-1}	$1.8x10^{-4}$ K^{-1}	$1.8x10^{-4}$ K^{-1}
Influence				
Impact strength	ISO 179	no fracture	no fracture	no fracture
Hardness				
Shore hardness (Shore D (3 sec))	ISO 868	63	63	59
Thermal				
Max. operating temperature	–	+ 40 °C	+ 40 °C	+ 70°
Min. operating temperature	–	–20°C	–20°C	–20°C
Heat conductance	DIN 52612	0.42 W/mk	0.42 W/mk	0.41 W/mk
Storage				
Max. recommended shelf life from data of production	–	5 a**	5 a**	5 a**
UV stabilisation	–	Yes**	Yes**	Yes**

* Test results with newer material qualities outstanding
**The UV-resistance is ensured by manufacturing black PE pipes through the addition of soot. As the sole manufacturer, the Lyondell-Basell company (formerly Höchst AG) has published investigations in the past in which the black pipes from Hostalen were exposed to open air weather in Frankfurt for up to 18 years, and no significant deterioration of the internal compression stability over time could be measured. ➞ The pipe material used by HakaGerodur AG is stabilised in a comparable manner; this implies that a storage period of five years should present no problems in our latitude.

HakaGerodur
Giessenstrasse 3 CH-8717 Benken
Telefon +41 (0)55 293 25 25
Fax +41 (0)55 293 25 99

☞ This data given are guidelines and can vary depending on the processing procedures. In most cases, these are the average values of measurements carried out on several sample bodies. The listed technical characteristics are only intended as a planning guide. In particular, they do not represent any guaranteed properties.

3.5. Chemical resistance

The HakaGerodur GEROtherm® geothermal probe systems made from PE 100, PE 100-RC and PE 100-RT are resistant compared to conventional heat carrier media. The following heat carrier media can be used.

☞ Low temperatures impair the efficiency of the overall system. The service life of the back-filling can be impaired in the frost zone.

Table: Suitable heat carrier media based on SIA 384/6:2010, SN 546 384/6, Issue 2010

Heat transfer medium	Density at 0°C	Frost protection
Ethylene glycol 20%	1040 kg/m^3	–10.4 °C
Ethylene glycol 20% @ 15°C	1037 kg/m^3	–10.4 °C
Ethylene glycol 25%	1050 kg/m^3	–13.6 °C
Ethylene glycol 25% @ 15°C	1042 kg/m^3	–13.6 °C
Ethylene glycol 30%	1059 kg/m^3	–17.1 °C
Ethylene glycol 33%	1065 kg/m^3	–19.3 °C
Propylene glycol 25%	1033 kg/m^3	–10.1 °C
Propylene glycol 30%	1039 kg/m^3	–13.5 °C
Propylene glycol 35%	1044 kg/m^3	–17.5 °C
Water 5°C	1000 kg/m^3	0.0 °C
Water 15°C	1000 kg/m^3	0.0 °C
Ethanol 20%	969 kg/m^3	–10.5 °C
Ethanol 25%	961.5 kg/m^3	–15.5 °C
Ethanol 30%	954 kg/m^3	–20.5 °C

4. Planning of GEROtherm® geothermal probe systems

⚠ Before designing the geothermal probe systems, an overall energy concept must be drawn up for the object as a first step. In doing this, all the system interfaces (heat source, heat pump and heating circuits) must be taken into account.

The planning of geothermal energy systems must take place working together with the customer/project manager. The following points must thereby be determined:
- The geology of the subsoil
- The number of boreholes
- The type of drilling process to be selected (dry–process /flush drilling process)
- The depth of the boreholes
- The diameter of the boreholes
- The position of the boreholes
- The pressure loss of the system
- Specification of the dimensions of the geothermal probes
- Coordination of the position of the energy storage/cooling fields

⚠ Before carrying out any geothermal probe drilling, the necessary approvals must be obtained from the competent authorities, and must then be passed on to the drilling company involved, as geothermal probe systems are generally subject to approval.

4.1. Planning basics

4.1.1 General planning information

⚠ In addition to the planning notes in VDI 4640 Sheet 2, September 2001, and SIA 384/6: 2010 (SN 546 384/6), the following points must be taken into account in the planning of a geothermal probe system:
- Geothermal probes are generally subject to approval
- The dates on which the drilling will take place must be notified to the competent authorities
- An optimal system efficiency will be achieved through low flow temperatures
- As a rule, a detached house can be supplied using a GEROtherm® geothermal probe of 150–200 m without any additional heating (i.e. monovalent)
- The overall heating and cooling requirement of the object must be taken into account in the dimensioning of a probe field
- Guarantee of an optimal reconciliation of the energy flow within the building
- Geothermal probes with a maximum depth of 150 m are to be planned for the cooling, as the geothermal probe would otherwise take up temperatures that are too high
- The separation between two geothermal probes must be at least 5 m (for a depth up to 50 m) or 6 m (from a depth >50 m); the minimum distance from buildings must be at least 2 m
- The separation from neighbouring land should be at least 5 m
- The brine speed in the geothermal probe should lie within the range from 0.3 –0.7 m/s where possible; i.e. always within the turbulent range
- Geological expert reports are to be obtained, as the physical rock characteristics, and with them the specific extraction performance at a specific location, can also vary with the geology
- The climate at the location will have a decisive effect on the extraction and yield performance of geothermal probes, and must therefore be taken into account in the planning
- Geothermal probe systems may not be used for the drying-out of the building
- The individual circuits of the geothermal probe system are to be hydraulically matched (the corresponding regulation fittings are to be planned at the distributor/collector) and one shut-off device is to be planned per probe circuit

03/2010 | EWS-2078

HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99

- The mutual interaction of geothermal probes is to be taken into account in the planning
- The selected heat transfer medium must be suitable for the selected temperatures
- The heat carrier temperature must not fall below a mean minimum of -1.5°C (for example, inlet to the geothermal probe –3°C, outlet 0°C) during the entire operation

4.1.2. Dimensioning of GEROtherm® geothermal probes

The dimensioning of geothermal probe systems must be carried out by an approved engineering or planning office. The correspondingly valid standards and directives, as well as the existing geology, must be taken into account in the planning.

For smaller objects (single-family house), the nomogram of VDI 4640 can also be used as a first reference point for the rough assessment of the design of the geothermal probe system. The reading must always be checked mathematically, however. SIA 384/6:2010 describes the calculation and design of geothermal probe systems in detail.

The GEROtherm® probe length can be roughly determined mathematically as shown in the following example, taking the heat requirement determination and the existing geological soil conditions into account. The extraction performance of the GEROtherm® geothermal probe corresponds to the cooling performance of the selected heat pump. The heating performance of the heat pump must correspond to the heating requirement of the building. The complete heat requirement of the detached house, including the production of hot water, can be covered with a 150 m GEROtherm® geothermal probe.

⚠ Dry soil has a lower extraction performance (< 30 W/m), whereas earth layers that carry groundwater have a higher extraction performance of up to 80 W/m.

⚠ In systems with three or more GEROtherm® geothermal probes, a lower extraction performance should be selected on the basis of their mutual interaction, as well as in the case of geothermal probe system in mountainous regions.

⚠ Complex systems are to be dimensioned in detail by a planning office, and the carrying out of a Thermal Response Tests (TRT) is recommended for the design of the overall system.

⚠ The mean brine temperature determined at the inlet and outlet of the geothermal probe is a decisive criteria for the design.

⚠ A minimum brine temperature of –1.5°C (e.g. inlet of the geothermal probe –3°C, outlet 0°C) after 50 years of operation is necessary for the extraction of heat.

Example: Detached house, new building, living area approx. 200 m2

Heat requirement: 13.0 kW

COP heat pump: 4.0 at BO-W35
(COP=Coefficient of Performance = efficiency)

Heat pump cooling performance: 9.7 kW

Extraction performance of soil: 50 W/m
(depending on the existing geological soil conditions!)

$$\text{GEROtherm length of probe} = \frac{\text{Heatpump cooling performance} - \frac{\text{Heatpump cooling performance}}{\text{COP}}}{\text{Extraction performance}} = \frac{9.7\text{kW} - \frac{9.7\text{kW}}{4.0}}{50\text{W/m}} = 145.5\text{ m}$$

4.1.3. Design of the SAVE distributor/collector

The GEROtherm® distributors/collectors from HakaGerodur are dimensioned in a correspondingly generous manner, and thereby only result in minimal flow resistance (~15 mbar).

☞ The geothermal probes should be connected to the distributor/collector with feed and return lines that have the same length as far as possible. Expensive flow regulation fittings can thereby be avoided. A difference in the flow volume of up to +/- 15% is permissible.

☞ In the case of large systems, it is recommended that one or more distributor shafts be set up in the middle of the geothermal probe field in order to also be able to avoid the use of flow regulation fittings here.

If these are unavoidable, however, we would recommend the well-proven SETTER balancing valves. These are available for measurement ranges from 2–180 l/min. It should be noted, however, that large pressure losses could arise from the balancing effect in the case of large differences in the flow resistance.

⚠ Individual circuits of the earth collectors and the geothermal probes must be able to be individually shut off. The problem-free venting of the system is thereby always possible during commissioning and any necessary service work.

The GEROtherm® distributors/collectors (feed and return) made from PE 100 meet the set requirements; they are constructed as a modular system. The individual sizes are available for the connection of geothermal probes, earth collectors or energy piles. Geothermal probe pipes with external diameters of Ø25, Ø32, Ø40 and Ø50 mm can be connected.

Selection of suitable GEROtherm® distributors/collectors for geothermal probes

The distributors/collectors should be determined on the basis of the required flow volumes for the heat pump (flow volume in m³/h).The accumulated probe length can also be used as the selection criterion Fig. 6):

- Up to approx. 300 m: Model 97/97L
- Up to approx. 1400 m: Model 125
- Up to approx. 3000 m: Model 180

Larger outputs can be achieved through the parallel connection of the SAVE distributors/collectors.

SAVE 97/SAVE 97L

- Flow volume up to 5.4 m³/h
- Heat pump power up to 16 kW
- 2 to 8 connections
- Connections for DE 25, 32, 40
- Stock article

HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99

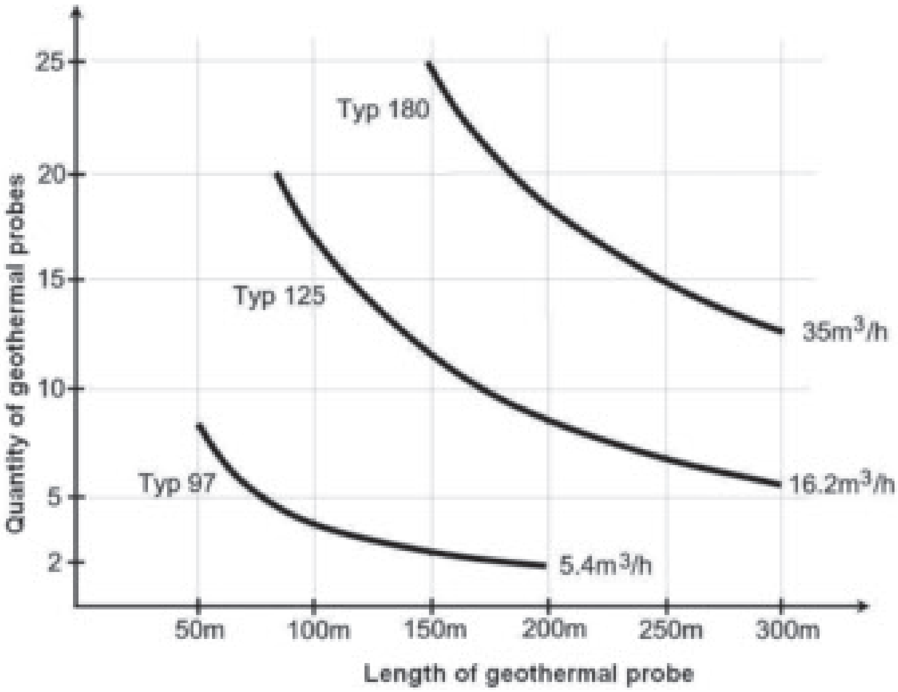


Fig. 6: Layout diagram of the SAVE distributor/collector

SAVE 125
- Flow volume up to 16.2 m³/h
- Heat pump power up to 70 kW
- Modular construction
- Connections for DE 32, 40, 50
- Customer-specific manufacture

SAVE 180
- Flow volume up to 35 m³/h
- Heat pump power up to 150 kW
- Connections for DE 32, 40, 50
- Customer-specific manufacture

5. Installation of GEROtherm® geothermal probe systems

5.1. General installation rules

⚠ In general, geothermal probe boreholes must be carried out according to the state-of the art. In the sector of geothermal energy, this relates to the VDI Directive 4640 «Thermal utilization of the Underground», September 2001 issue, as well as the new SIA 384/6:2010 «Geothermal probes».

The VDI states that the drilling company that carries out the work must be certified according to DVGW W120. The DVGW certification ensures the highest level of quality for the subsequent system operator and guarantees the proper sequence of measures. Drilling companies that also hold the quality seal for geothermal probe drilling companies will guarantee a high quality level in the set-up and use of geothermal probe systems.

Drilling companies that hold the quality seal guarantee
- a high customer benefit and optimal consultation for the building owner
- an environmentally friendly installation of the system
- that the boreholes will be sunk according to the latest state-of-the-art
- the use of technically high quality probe material
- the greatest possible safety on the construction site

5.2. Transport/storage of GEROtherm® geothermal probes and components

The active stores management at HakaGerodur and at our partner companies ensures the required readiness to deliver and flexibility. The geothermal probes are protected with a stretch film during transport and storage.

⚠ The following rules must be observed in the transportation and storage of GEROtherm® geothermal probes:

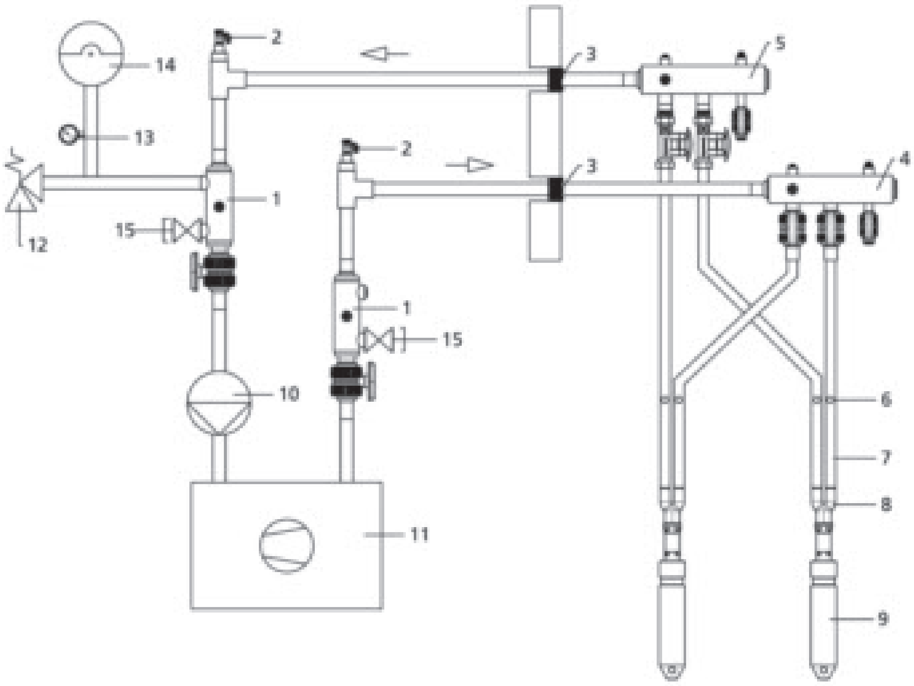
- GEROtherm® geothermal probes must be transported and stored carefully. Geothermal probes that are damaged during transportation or storage must not be installed
- Always store and transport GEROtherm® geothermal probes on the pallets available from the factory
- Do not remove the stretch film of the GEROtherm® geothermal probe during transportation/storage; the film may only be removed shortly before the installation. Carry out a visual inspection for damage before removing the film!
- The factory-welded GEROtherm® probe foot with test certificate is also protected from damage by a plastic bag
- GEROtherm® geothermal probes must be stored in a protected location on the construction site
- Geothermal probes made from PE 100-RT must be stored protected from light, while probes made from PE 100 and PE 100-RC can also be stored in sunlight
- The recommended max. storage time for GEROtherm® geothermal probes of PE 100 and PE 100-RC is 5 years from the date of production.

5.3. Sinking of GEROtherm® geothermal probes

⚠ The following points should be noted when sinking GEROtherm® geothermal probes:
- The setting-up of the geothermal probes should only be carried out by a certified drilling company
- Access to the drilling location must be ensured for the drilling unit
- Only drilling units/machines that are suitable for the existing site may be used
- Carry out an optical inspection for possible mechanical damage before sinking the geothermal probe
- A coiler must be used to sink the geothermal probe
- In general, geothermal probes are sunk with the greatest care in order to avoid any mechanical damage
- Damaged geothermal probes must not be installed (for example, transport/storage damage)
- The probe foot of the GEROtherm® geothermal probe is welded together and

03/2010 | EWS-2078

HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99



1 Universal adaptor fitting
2 Air vent
3 Wall lead-through
4 SAVE distributor with ball valves
5 SAVE collector w. balancing valves
6 Y-piece
7 GEROtherm® geothermal probe
8 Probe foot deflectors
9 Weight for the geothermal probes
10 Brine circulation pump
11 Heat pump
12 Safety valve
13 Manometer
14 Expansion vessel
15 Filling/emptying valve

Fig. 7: Installation overview of the GEROtherm® SAVE distributor/collector

checked 100% in the factory. Welding a probe foot on the construction site is not permitted.

- Always sink the GEROtherm® geothermal probe with a weight (12.5 kg or 24 kg)
- As a maximum, a total weight of 100 kg may be attached per Single-U for the sinking of the geothermal probe
- The geothermal probe must not be subjected to any high dynamic forces during the sinking
- The pressure relationships must be observed while installing the geothermal probe – and, in particular, the differential pressure (inner/outer pressure). The differential pressure must not exceed 21 bar internal pressure (inner to outer) during the installation and the compression process or 8 bar external pressure (outer to inner)!
- Sealing using the GEOtight fabric packer for geothermal probes if groundwater, or water or gas under pressure appears in the borehole

☞ An installation certificate can be created and printed out in the Internet at: www.hakagerodur.ch by entering the serial number of the GEOtight fabric packer.

- In the case of dry drilling, it is recommended that the borehole be filled to good 1/3 with water before the empty or partly filled probe is sunk. If the probe is in place, it should then be filled with water. The geothermal probe must be secured in order to prevent any floating up of the probe during the injection.
- Protruding piping from the sunk geothermal probes must be protected against damage on the construction site
- Geothermal probes must be firmly sealed up with caps up to the connection to the SAVE distributor/collector, and the caps must be secured with adhesive tape
- The distance between two geothermal probes must be at least 5 m (for a depth down to 50 m) or 6 m (for a depth >50 m); the minimum distance from buildings must be at least 2 m
- Chronological reporting of the drilling work by the machine operator (see the Sample Drilling Report in the appendix)
- The waste water arising from the drilling must be disposed of according to the valid regulations
- The pipe work must be carefully removed without damaging the geothermal probe any twisting of the geothermal probe must be avoided
- The injection pipe is to be secured on the probe foot and be sunk down to the upper edge of the geothermal probe foot

5.4. Test procedure after the sinking (pressure check/flow check analogous to SIA 384/6:2010)

⚠ The checks on the installed geothermal probes are to be carried out analogous to SIA 384/6 (issue 2010). The acceptance test includes three checks, for which all the measurement results are to be recorded in writing in an acceptance report:

- Flushing: Each geothermal probe circuit must be completely flushed out at least once
- Flow-through check: The differential pressure between the feed and the return will be measured at a constant flow rate, and will be compared with the theoretical value given in the SIA standard. The deviation between the two values may not exceed +/-15%
- Leakage test: This test must take place immediately after the back-filling, similar to SN EN 805.

HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99

Leakage test according to SIA 384/6 (2010 issue)

The following preconditions must be complied with in the test:

Horizontal interconnection lines:
- Constant temperature of the pipe wall throughout the duration of the test
- No direct sunlight on the pipes

Geothermal probes:
- Complete back-filling with a plastic or free-flowing suspension, and the suspension has not cured
- In fissure zones and in permeable areas where, in agreement with the responsible authorities, the back-filling is not completely carried out, the pressure test must be adapted to the circumstances in order to prevent any damage to the geothermal probe tubes. This also applies in the case of back-filling with other densities.
- The test pressure is to be selected so that the over-pressure in the pipes at the foot of the geothermal probe will amount to 0.5 bar throughout the entire test, that the head pressure will be a minimum of 7.5 bar, and that a pressure of 21 bar will not be exceeded over the complete length.

Implementation:
Check that the above-mentioned preconditions have been fulfilled.
a) 1 h rest time in the unloaded state for the pipes that are to be measured
b) Build-up of the test pressure (10...12 bar)
c) Maintenance of the test pressure for 10 minutes
d) Waiting period of 1 hour, during which the pipe can fully expand
e) Measurement of the remaining pressure. A decrease of 30% compared to the test pressure is acceptable due to the pipe expansion. Larger deviations could be due to air pockets or leakages. The test will have to be restarted from Point a).
→ Rapid pressure relief by 2 bar by the discharge of water. The amount of drained water and the new pressure value are to be measured. Check the water volume according to SIA 384/6.
f) After 10 minutes: 1st pressure measurement

After a further 10 minutes: 2nd pressure measurement
After a further 10 minutes: 3rd and final pressure measurement

☞ The pressure test has been passed if a maximum pressure drop of less than 0.1 bar is determined at the 3rd measurement compared to the 1st measurement.

Material: Manometer with a resolution better than 0.01 bar, pressure range corresponding to the test, minimum 12 bar; 2 valve; purge; pressure pump; 1 l measuring cup; All connections are to be designed for 16 bar.
The results are to be entered into a report or are to be printed out as a diagram corresponding to the example below.

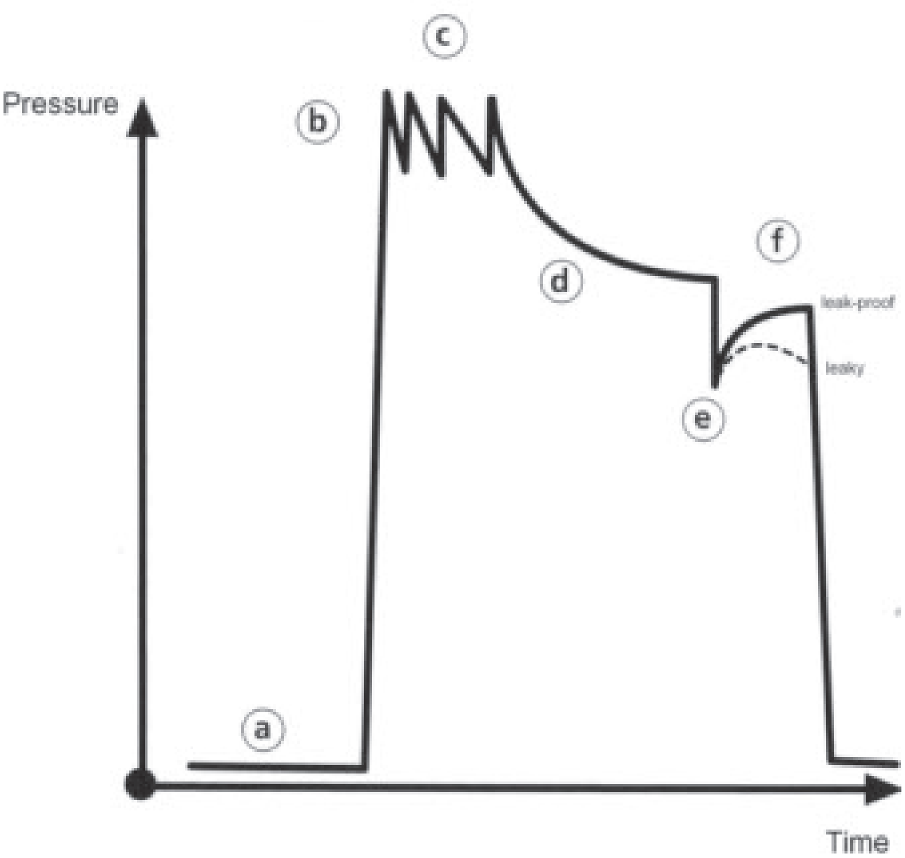


Fig. 8: Pressure testing of the geothermal probes on the basis of SN EN 805

5.5. Back-filling the borehole

The back-filling of the borehole has basically three purposes; to create a complete and permanent seal, to ensure stability and to ensure a high heat conductance (SIA 384/6).

⚠ The following rules are to be followed in the back-filling of the borehole:
- During the back-filling, the geothermal probe pipes must be completely filled with water, be sealed pressure-tight at the top and be fitted with a pressure gauge (manometer), so that the pipes will not be pressed together and so that any possible pressure drop can be detected.
- When pressing in the geothermal probes, the pressure conditions must be observed – in particular, the differential pressure (inner over-pressure/outer pressure). The differential pressure may not lie above 21 bar inner positive pressure (inside to outside) during the pressing process, or 8 bar external positive pressure (outside to inside)!
- The injection pipes are designed for a short-term (< 1 h) maximum pressure of 34 bar at 20°C (with higher external temperatures, the maximum permissible pressure reduces by 40–50%!).
- Secure the filling pipe to the geothermal probe foot and insert it into the borehole during the sinking of the geothermal probe.

03/2010 | EWS-2078

HakaGerodur
Giessenstrasse 3 CH-8717 Benken
Telefon +41 (0)55 293 25 25
Fax +41 (0)55 293 25 99

- Press a suitable suspension (filling material) into the borehole from the bottom to the top.
- The specifications of the authorities with regard to the back-filling must be observed!
- Avoid any hollow spaces and air pockets.
- The filling suspension is to be created and used in accordance with the manufacturer's specifications; only suitable suspensions may be used.
- The quantity of the filling suspension is to be registered, recorded in writing and will be compared with the theoretically-calculated filling quantity.
- Depending on the depth of the borehole and the existing subsurface conditions, several injection pipes will be inserted into the borehole.
- After hardening, the compressed suspension must guarantee a permanently sealed, chemically and physically stable introduction of the geothermal probe into the surrounding rocks
- The injection pipe remains in the borehole, completely filled with compressed material
- When using several injection pipes, the sequence of the back-filling must be observed
- Checking the back-filling:
  – After the completion of the work, all the back-fillings of the geothermal probes must be checked once again
  – If it is found that the injection level has fallen by more than 2 m, an additional post-injection will be necessary

5.6. Installation of HakaGerodur SAVE distributors/collectors

⚠ The following installation rules must be observed:

- Damaged distributors/collectors, connecting lines and connection components may not be used
- When connecting the GEROtherm® geothermal probes to the SAVE distributor/collector, the geothermal probes are to be fed to the distributor in circuits connected in parallel
- Two probe circuits can be connected to a distributor outlet using a Y-piece
- The connection of the GEROtherm® geothermal probes to the SAVE distributor/collector must be carried out using approved fittings and tools
- Installation of the SAVE collectors/distributors at the highest point of the system, otherwise a venting device must be provided at the highest point of the system
- Individual GEROtherm® geothermal probes are to be fitted with valves for regulation and shut-off if no HakaGerodur SAVE distributors/collectors are used
- Install as many of the components of the geothermal probe system as possible outside the building in order to minimise the insulation outlay (condensation water)
- A degassing device is to be provided at a central location of the geothermal probe system.

5.7. Connection lines for geothermal probes and distributors/collectors

These general laying directives and laying hints apply for PE 100, PE 100-RC and PE 100-RT connection lines that are laid in the earth from GEROtherm® geothermal probes to GEROtherm® distributors/collectors.

⚠ The preparation and laying of connection lines from geothermal probes and distributors/collectors may only be carried out by trained specialists.

The following rules apply in general when setting up the connections

- The corresponding national and regional regulations apply for the laying of connection lines for the geothermal probes:
  – DIN 8074/8075 (pipes made from PE)
  – DIN 16963 Part 1- Part 15 (pipeline components made from PE)
  – HR 3.26 from SKZ Würzburg
  – VDI 4640 «Thermal Utilization of the Underground»
  – SIA 394/6
  – DVS 2207-1
  – VKR RL02 «Soil covered pressure pipelines made from PE 80 and PE 100», 07/2007
- Damaged connection components (e.g. E-sleeves, T-pieces, angles, PE pipelines etc.) must not be used
- The bending radius may not be less than the quoted minimum bending radius
- Only welded connections may be used for connections that are to be laid in the ground!
- Establishing of connections (welded connections) by trained specialists (welder's certificate according to VDS or Welder's Passport according to VKR)
- The pipe trench is to be dug so that the prescribed minimum coverage of 1.0–1.8 m depending on the climate and soil will be guaranteed for all the connection lines.
- The valid safety regulations of the authorities must be followed when carrying out the excavation of the trench!
- The base of the trench is to be dug so that the pipelines will lie on it evenly
- In the case of several feed/return runs, these must be laid in one trench in such a way that they will be thermally separated from each other
- All connection runs are to be of the same length and are to be laid with a uniform gradient down to the geothermal probes
- The use of approved, tested and maintained tools
- Welded connection are to be individually marked with the date, time and signature (proof of the connection welding carried out → Fill in a welding report)
- A venting unit is to be fitted to each distributor/collector, or at the highest point of the system
- When unwinding the pipes from drums or coils, it should be noted that the end of the pipe could whiplash when releasing the fixations (risk of accident!)

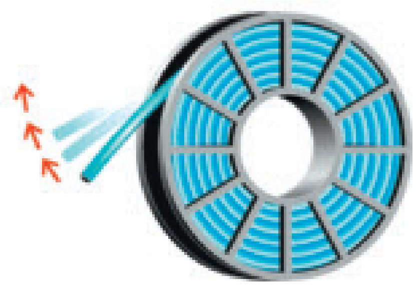


Fig. 9: Reel for PE lines

- When unwinding, it should be noted that the flexibility of the PE pipes will be affected by the ambient temperature.

⚠ The temperature-dependent elongation must be taken into account when laying the connection lines and cutting

HakaGerodur
Giessenstrasse 3 CH-8717 Benken
Telefon +41 (0)55 293 25 25
Fax +41 (0)55 293 25 99

them to length. The pipe becomes longer with an increase in temperature, and, with a fall in temperature, a 1 metre length of PE pipe reduces in length by 0.2 mm per °K!
On the basis of the certification from an independent test institute, GEROtherm® connection lines made from PE 100-RC are suitable for laying without a sand bed. The back-filling of the pipe trench is carried out with material that corresponds to the compression classifications V1–V3 of the ZTVA StB 97.
Heated-coil welding (HW) is recommended for the connection of GEROtherm® geothermal probes to the connection line to the distributor/collector, and high quality ELGEF® Plus connection elements are available for this. The ELGEF® Plus modular system offers the greatest flexibility.

Summary of the work instructions according to DVS 2207-1 for the heated-coil welding of GEROtherm® EWS and connection lines, Y-pieces, distributors/collectors made from PE 100 and PE 100-RC:

1. Set up the permissible working conditions; e.g. protection from damp, wind, temperatures < 0°C, etc.
2. Connect the welding unit to the power source and check its functionality.
3. De-bur the right-angle separated geothermal probe ends on the outside.
4. Where necessary, ensure the roundness of the pipe ends using re-rounding tools, permissible ovality 1.5%.
5. Machine the tube surface by removing metal with a rotation peeler (constant chip removal max. 0.2 mm).
6. Remove the electrofusion fittings from their original packaging
7. Clean the machined surface of the GEROtherm® geothermal probes and the inner surface of the electrofusion fitting with a cleaning liquid that is approved for PE surfaces (e.g. Tangit cleaner; refer to the safety data sheet) and a lint-free, ink-free paper.
8. Insert the geothermal probe and connection pipe with parallel faces and without force into the electrofusion fitting, secure with the integrated screws and visibly mark the insertion depth. CAUTION: Ensure the correct insertion depth!

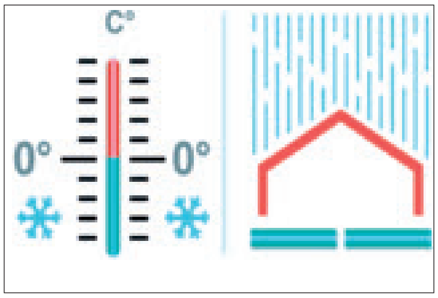


Fig. 10: Comply wirth the permissible working

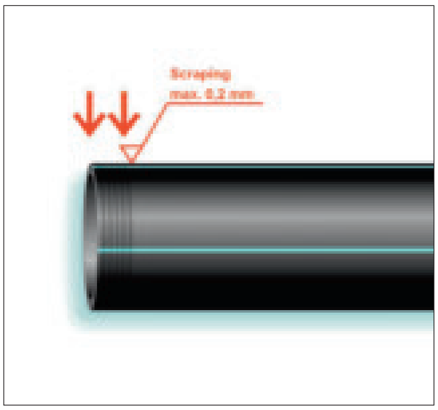


Fig. 11: Metal cutting machining in the weld area

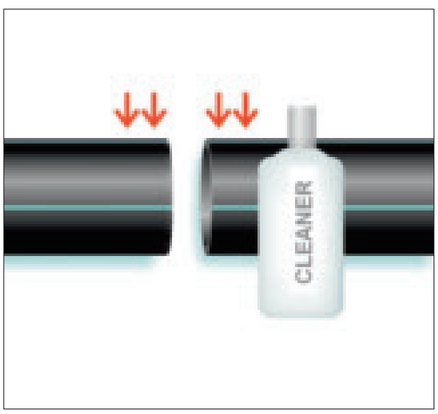


Fig. 12: Cleaning the machined surface

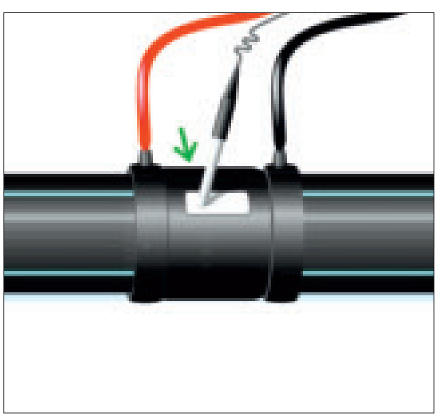


Fig. 13: Scanning the parameters, weld and observe the cooling time

9. Connect the cable of the welding unit to the electrofusion fitting socket with the weight relieved.
10. Where necessary, check the settings and/or the data display on the device display, and enter the welding data (scanning the barcode of the electrofusion fitting).
11. Carry out the welding sequence as described in the manufacturer data, and check the result.
12. After finishing the welding, remove the unit cable from the electrofusion fitting.
13. Observe the cooling-down time according to the manufacturer's data.
14. If no automatic logging has taken place, a welding report is to be drawn up by hand + the weld is to be marked in writing (date, signature, time after the end of the cooling time)

Correctly executed heated-coil welding may only be carried out once per coupler!

5.8. Filling the GEROtherm® Geothermal probe system and the pressure test

⚠ The operating instructions for the heat pump are to be followed. The filling and the carrying out of a pressure test probe may only be carried out by specialists. The test report is to be handed over to the building owner. The following important points must be observed when filling:

- The filling of the GEROtherm® geothermal probe system may only be carried out with the permissible heat carrier media that do not endanger water (see table in Section 3.5.).
- Other liquids may not be used.
- All connected geothermal probes are to be individually flushed out until total freedom of air before the filling. Air pockets are to be avoided in all cases.
- Each probe circuit must be filled individually and the filling quantity per circuit must be checked
- The flushing must take place in both directions with sufficiently large flushing pumps
- The concentration of the brine is to be set up here according to the data from the heat pump manufacturer and is to be recorded in writing.

HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99

⚠ The brine must be homogenously mixed before the filling. The material Safety Data Sheets (MSDS) for the chemicals used must be observed.

The following table gives a summary of the volumes per m of GEROtherm® geothermal probe for the determination of the necessary brine volume.

7. Maintenance of GEROtherm® geothermal probe systems

A GEROtherm® geothermal probe system is generally maintenance-free. Standard heat pumps are also mostly maintenance-free. Please check the corresponding maintenance instructions of your heat pump manufacturer in this respect.

Table: Overview of volume per m geothermal probe

GEROtherm® **(outer diameter/wall thickness)**	**Double U-probe** **(2 circuits/4 pipes)**
25 mm (25 x 2.3 mm)	**1.31** litres/m (4 x 0.327 litre/m)
32 mm (32 x 2.9 mm)	**2.14** litres/m (4 x 0.535 litre/m)
40 mm (40 x 3.7 mm)	**3.34** litres/m (4 x 0.835 litre/m)
50 mm (50 x 4.6 mm)	**5.23** litres/m (4 x 1.307 litre/m)

If the system has been completely filled, the pressure test takes place with 1.5 times the operational pressure. The following is to be noted here:

- All brine circuits are to be subjected to the pressure test.
- Only a suitable heat transfer medium is to be used as the pressure test liquid.
- Sensitive fittings (e.g. safety group expansion vessel) are to be corresponding safeguarded.
- The pressure conditions in the geothermal probe are to be monitored (see Sections 5.3.– 5.5.)

Once the pressure test has been completed, components that were removed are to be put back into operation.

6. Operation of GEROtherm® geothermal probe systems

The initial commissioning must be carried out by a specialist company. The information and operating instructions of the heat pump manufacturers are to be followed!
It is imperative to observe the following before commissioning the geothermal probe system with heat pump:

– All brine circuits must be vented and be filled with the homogenously mixed heat transfer medium
– All fittings must be in their operating positions

The filling pressure of the geothermal probe should be checked annually. Refill quantities are to be logged.

8. Shutting down geothermal probe systems

When putting geothermal probes out of service, the heat transfer medium must be completely flushed out, and be disposed of correctly in accordance with the applicable regulations.
The geothermal probe is then to be completely and fully pressed down with cured material. The proper shut-down of the geothermal probe system is to be reported to the responsible authorities.

9. Appendix

Relevant charts and printouts can be found on the following pages.

HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99

9.1. Pressure loss tables of water in pipes PE 100 S 5/PN 16/SDR 11

de x e	25 x 2.3 mm		32 x 2.9 mm		40 x 3.7 mm	
l/m					0.835	
v m/s	Q l/s	R mbar/m	Q l/s	R mbar/m	Q l/s	R mbar/m
0.10	0.0327	0.10	0.0531	0.062	0.0835	0.073
0.15	0.0490	0.27	0.0796	0.200	0.1250	0.150
0.20	0.0654	0.44	0.1060	0.320	0.1670	0.240
0.25	0.0817	0.65	0.1330	0.470	0.2090	0.350
0.30	0.0981	0.90	0.1590	0.650	0.2500	0.490
0.35	0.1140	1.18	0.1860	0.860	0.2920	0.640
0.40	0.1310	1.49	0.2120	1.090	0.3340	0.810
0.45	0.1470	1.84	0.2390	1.340	0.3760	1.000
0.50	0.1630	2.22	0.2650	1.620	0.4170	1.210
0.55	0.1800	2.63	0.2920	1.920	0.4590	1.440
0.60	0.1960	3.07	0.3190	2.250	0.5010	1.680
0.65	0.2120	3.55	0.3450	2.600	0.5430	1.950
0.70	0.2290	4.06	0.3720	2.970	0.5840	2.230
0.75	0.2450	4.60	0.3980	3.370	0.6260	2.530
0.80	0.2610	5.17	0.4250	3.790	0.6680	2.840
0.85	0.2780	5.78	0.4510	4.230	0.7090	3.170
0.90	0.2940	6.41	0.4780	4.700	0.7510	3.520
0.95	0.3110	7.08	0.5040	5.190	0.7930	3.890
1.00	0.3270	7.78	0.5310	5.700	0.8350	4.280

de x e	50 x 4.6 mm		63 x 5.8 mm		75 x 6.8 mm	
l/m	1.307		2.074		2.960	
v m/s	Q l/s	R mbar/m	Q l/s	R mbar/m	Q l/s	R mbar/m
0.10	0.1310	0.054	0.2070	0.040	0.2940	0.032
0.15	0.1960	0.110	0.3110	0.081	0.4410	0.064
0.20	0.2610	0.180	0.4150	0.130	0.5880	0.110
0.25	0.3270	0.270	0.5190	0.200	0.7350	0.160
0.30	0.3920	0.370	0.6220	0.270	0.8820	0.220
0.35	0.4580	0.480	0.7260	0.360	1.0300	0.290
0.40	0.5230	0.610	0.8300	0.460	1.1770	0.370
0.45	0.5880	0.750	0.9340	0.560	1.3240	0.450
0.50	0.6540	0.910	1.0370	0.680	1.4710	0.550
0.55	0.7190	1.080	1.1410	0.810	1.6180	0.650
0.60	0.7840	1.270	1.2450	0.950	1.7650	0.760
0.65	0.8500	1.460	1.3490	1.090	1.9120	0.880
0.70	0.9150	1.680	1.4520	1.250	2.0590	1.010
0.75	0.9810	1.900	1.5560	1.420	2.2060	1.140
0.80	1.0460	2.140	1.6600	1.600	2.3530	1.280
0.85	1.1110	2.390	1.7640	1.790	2.5000	1.440
0.90	1.1770	2.650	1.8670	1.980	2.6470	1.600
0.95	1.2420	2.930	1.9710	2.190	2.7950	1.760
1.00	1.3070	3.220	2.0750	2.410	2.9420	1.940

HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99

9.1. Pressure loss tables of water in pipes PE 100 S 5/PN 16/SDR 11

de x e	90 x 8.2 mm		110 x 10.0 mm		125 x 11.4 mm	
l/m	4.252		6.359		8.199	
v m/s	Q l/s	R mbar/m	Q l/s	R mbar/m	Q l/s	R mbar/m
0.10	0.4250	0.0250	0.636	0.0190	0.820	0.016
0.15	0.6380	0.0510	0.954	0.0390	1.231	0.033
0.20	0.8510	0.0840	1.272	0.0650	1.641	0.056
0.25	1.0640	0.1300	1.590	0.0970	2.051	0.083
0.30	1.2760	0.1700	1.909	0.130	2.461	0.110
0.35	1.4890	0.2300	2.227	0.180	2.871	0.150
0.40	1.7020	0.2900	2.545	0.230	3.281	0.190
0.45	1.9150	0.3600	2.863	0.280	3.692	0.240
0.50	2.1270	0.4300	3.181	0.340	4.102	0.290
0.55	2.3400	0.5100	3.499	0.400	4.512	0.340
0.60	2.5530	0.6000	3.817	0.470	4.922	0.400
0.65	2.7650	0.7300	4.135	0.540	5.332	0.460
0.70	2.9780	0.8000	4.453	0.620	5.742	0.530
0.75	3.1910	0.9100	4.771	0.710	6.153	0.600
0.80	3.4040	1.0200	5.089	0.800	6.563	0.680
0.85	3.6160	1.1400	5.407	0.890	6.973	0.760
0.90	3.8290	1.2700	5.726	0.990	7.383	0.840
0.95	4.0420	1.4000	6.044	1.090	7.793	0.930
1.00	4.2540	1.5400	6.362	1.200	8.203	1.030

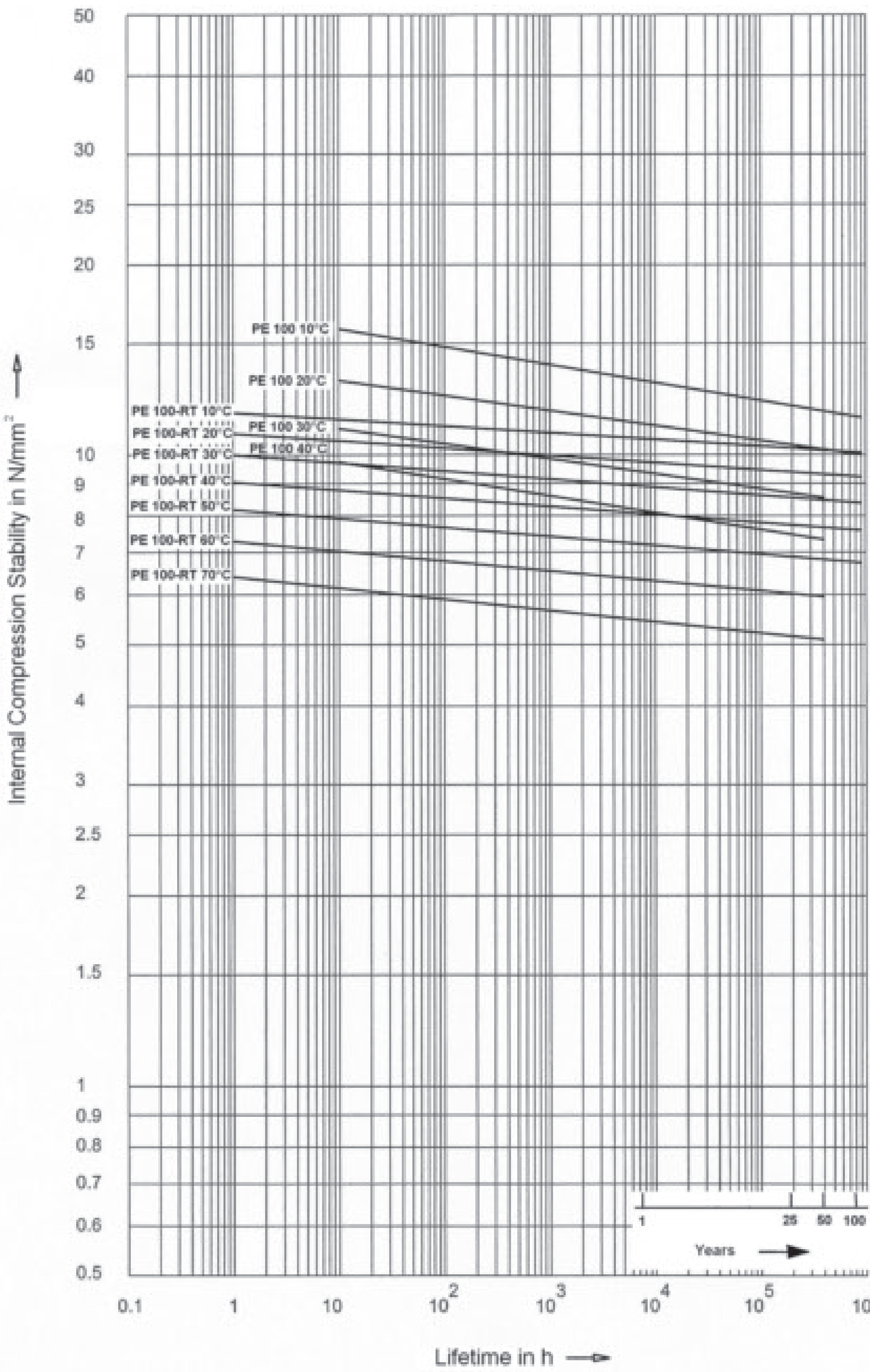
de x e	140 x 12.7 mm		160 x 14.6 mm	
l/m	10.310		13.430	
v m/s	Q l/s	R mbar/m	Q l/s	R mbar/m
0.10	1.028	0.014	1.344	0.012
0.15	1.542	0.029	2.016	0.025
0.20	2.056	0.048	2.687	0.041
0.25	2.570	0.072	3.359	0.061
0.30	3.084	0.099	4.031	0.084
0.35	3.598	0.130	4.703	0.110
0.40	4.112	0.170	5.375	0.140
0.45	4.625	0.210	6.047	0.170
0.50	5.139	0.250	6.719	0.210
0.55	5.653	0.300	7.390	0.250
0.60	6.167	0.350	8.062	0.300
0.65	6.681	0.400	8.734	0.340
0.70	7.195	0.460	9.406	0.390
0.75	7.709	0.520	10.078	0.450
0.80	8.223	0.590	10.750	0.500
0.85	8.737	0.660	11.422	0.560
0.90	9.251	0.730	12.093	0.620
0.95	9.765	0.810	12.765	0.690
1.00	10.279	0.890	13.437	0.760

03/2010 | EWS-2078

HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99

9.2. Internal compression stability test-over-time diagram for PE 100 and PE 100-RT

Reference characteristics for the internal compression stability test-over-time (minimum curve) of pipes made from PE 100 according to DIN 8075: 1999-08 and for PE 100-RT according to DIN 16833: 2009-9

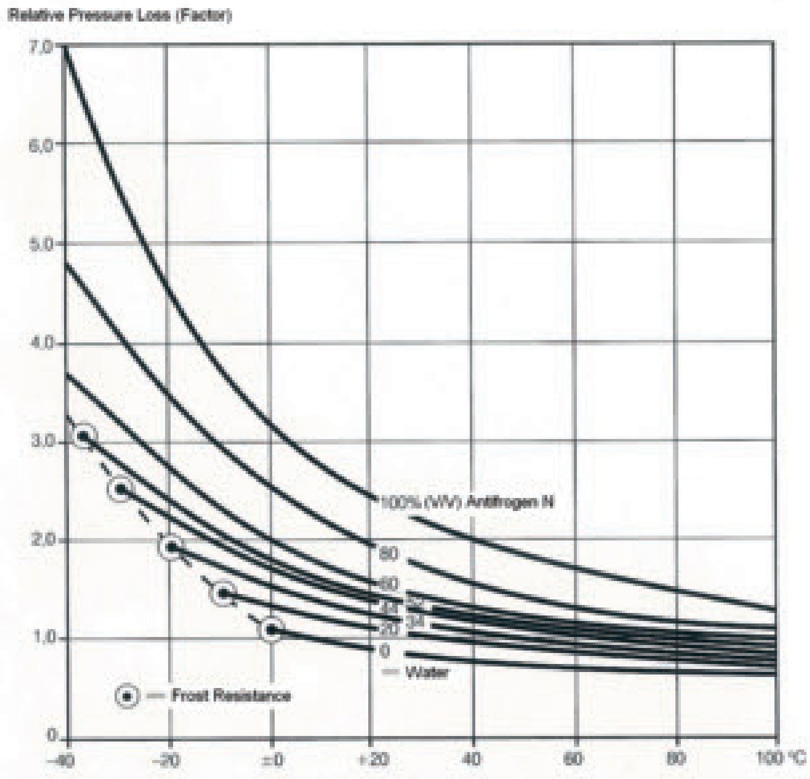


03/2010 | EWS-2078

HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99

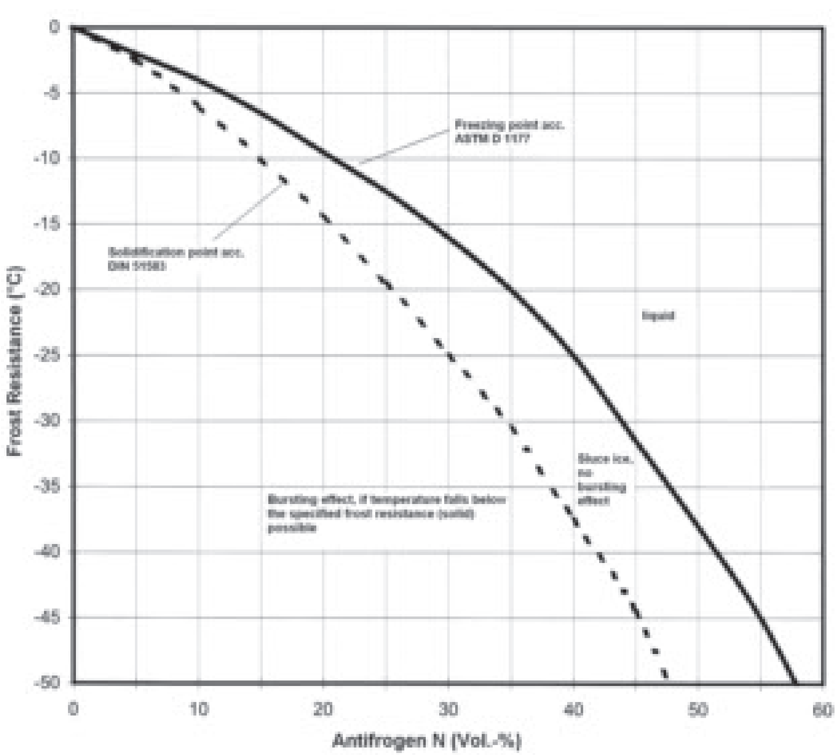
9.3. Diagram of relative pressure loss (factor)

for Antifrogen® N-water mixtures in comparison with water (t = +10°C) in turbulent flow
Source: Clariant Products Germany GmbH, D-65840 Sulzbach



9.4. Frost safety diagram

for Antifrogen® N-water mixtures (crystallisation point according to ASTM D 1177)
Source: Clariant Products Germany GmbH, D-65840 Sulzbach



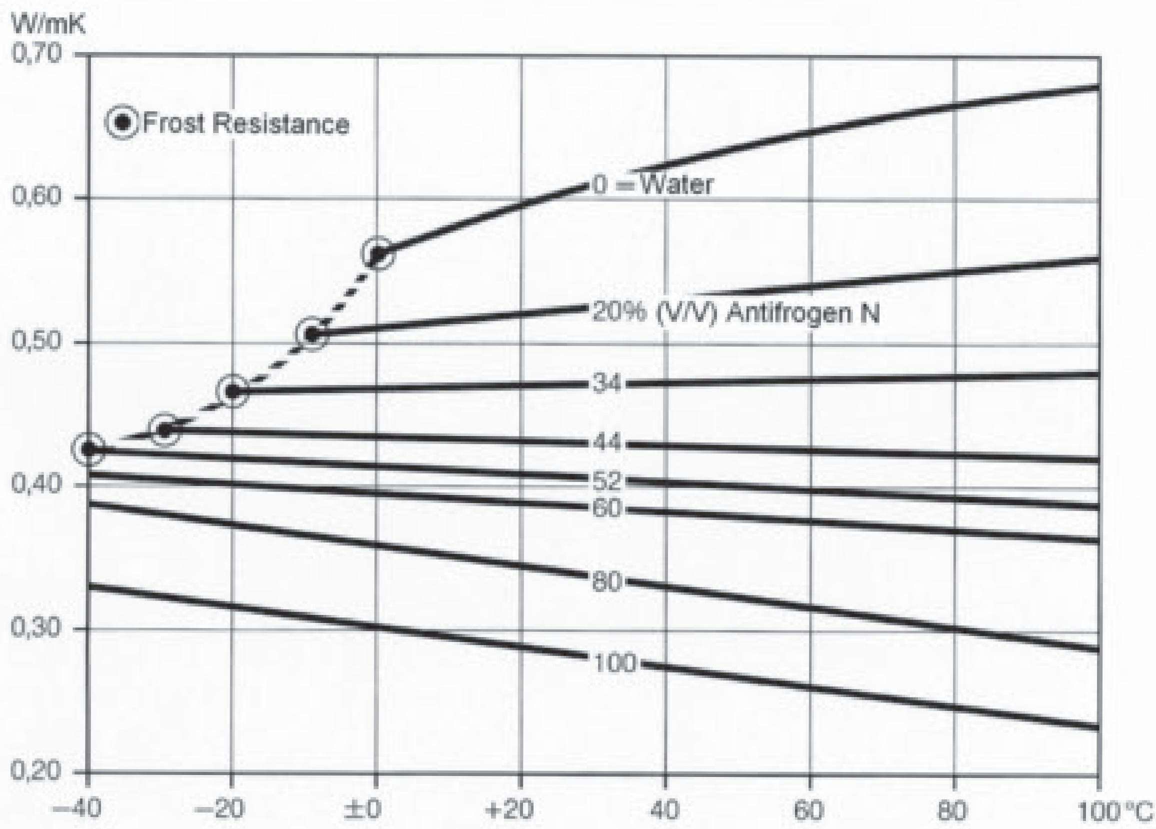
HakaGerodur

Giessenstrasse 3
CH-8717 Benken

Telefon +41 (0)55 293 25 25
Fax +41 (0)55 293 25 99

9.5. Heat conductance diagram

for Antifrogen® N-water mixtures of various concentrations.
Source: Clariant Products Germany GmbH, D-65840 Sulzbach



HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99

9.6. Coil dimensions of geothermal probes

Art. No	de	Length	ID	AD	H	Weight	VPE	Pallet
PE 100-RC	mm	m	mm	mm	mm	kg	units/pallet	cm
06.6010	25	50	705	925	470	35	4	80x80
06.6011	25	60	690	950	470	42	4	80x80
06.6012	25	70	635	905	575	49	4	80x80
06.6020	32	50	670	960	590	55	3	80x80
06.6021	32	60	640	990	590	66	3	80x80
06.6022	32	70	780	1115	600	77	3	100x100
06.6023	32	80	690	1135	740	88	2	80x80
06.6024	32	90	635	980	865	99	2	80x80
06.6025	32	100	725	1070	865	110	2	100x100
06.6026	32	112	660	1050	865	123	2	100x100
06.6027	32	125	760	1160	865	137	2	100x100
06.6028	32	137	695	1145	865	150	2	100x100
06.6029	32	150	780	1235	865	164	2	100x100
06.6030	32	162	710	1220	865	177	2	100x100
06.6040	40	50	690	970	900	87	2	100x100
06.6041	40	60	845	1135	900	104	2	100x100
06.6042	40	70	730	1095	900	121	2	100x100
06.6043	40	80	650	1070	900	139	2	100x100
06.6044	40	90	760	1190	900	156	2	100x100
06.6045	40	102	697	1180	900	177	2	100x100
06.6046	40	112	805	1285	900	194	2	100x100
06.6047	40	127	855	1200	1400	220	1	100x100
06.6048	40	140	865	1285	1250	242	1	120x120
06.6049	40	152	810	1235	1400	263	1	120x120
06.6050	40	165	830	1335	1250	285	1	120x120
06.6051	40	175	895	1380	1250	303	1	120x120
06.6052	40	185	825	1315	1400	320	1	120x120
06.6053	40	200	870	1415	1250	346	1	120x120
06.6054	40	225	870	1495	1250	389	1	120x120
06.6055	40	250	800	1510	1250	432	1	150x150
06.6056	40	275	925	1565	1400	476	1	150x150
06.6057	40	300	865	1575	1400	519	1	150x150

VPE = Packaging unit
ID = Mean internal diameter
AD = Mean external diameter
H = Mean height of a probe on the pallet or probe width on the reel
Tolerances = ID + AD = ,+/- 20 mm

☞ Subject to changes; Status at 31.01.2010, the latest version of the coil dimensions can be requested from HakaGerodur AG.

HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99

9.7. Sample Drilling Report (according to SIA 384/6:2010 ©FWS Mustervorlage rev. SIA)

Drilling report/Lager description

Approval No.: .... dated: .... Order No.: ....

Drill Master: .... Object: .... Location/Municipality: ....

Drilling start : .... end: .... Coordinates: .... Height: .... (☐ estimated, ☐ measured) Borehole No. .... of .... Borehole acc. to location sketch

Depth	Description of the material drilled / layer description		Water content			Drill type	Wet / Dry	Remarks	Incidents relevant to water protection					
to	Type, Properties	Colour	wet	damp	dry	S / H	drilled	Observations	WZ	SV	IV	K	G	Depth
									☐	☐	☐	☐	☐	
									☐	☐	☐	☐	☐	
									☐	☐	☐	☐	☐	
									☐	☐	☐	☐	☐	
									☐	☐	☐	☐	☐	
									☐	☐	☐	☐	☐	
									☐	☐	☐	☐	☐	
									☐	☐	☐	☐	☐	
									☐	☐	☐	☐	☐	
									☐	☐	☐	☐	☐	
....	Final depth (drill depth)								☐	☐	☐	☐	☐	

Drill unit:		Piping, →	
Drill elevation:	.... +"/- 0.0m drill elevation	to depth in m	
☐ Inclined bore:	Direction: .... Angle:	Drill bit (Model, →): (SM: step bit, RM: roller bit, IH: Down-the-hole hammer, EX: Eccentric)	

S = Flush boring
H = Hammer drilling

~ = wet drilled
- = dry drilled

Sampling: all ....

Samples: ☐ collected
☐ taken
☐ deposited

➔ where................

Water entry
Flushing losses
Injection losses
Caverns
Suspicion of gas

Date:

Signature Drill master

Source: SIA 384/6:2010

Source: SIA 384/6:2010)

HakaGerodur
Giessenstrasse 3 CH-8717 Benken
Telefon +41 (0)55 293 25 25
Fax +41 (0)55 293 25 99

9.8. Sample Test and Acceptance Report (according to SIA 384/6:2010)

Object:						Order No. :				
Geothermal probes	**No.**									
Factory Identification Number	ID:									
Roll pair number (e.g. 0040)	No.									
Length (integrated probe)	m									
External diameter / Wall thickness	mm	/			/			/		
Flow check	Test date									
		KL1/KL2	KL1	KL2	KL1/KL2	KL1	KL2	KL1/KL2	KL1	KL2
Water flow volume	l / min									
Pressure during flow	bar									
Condition met?	Yes / No									

Leakage test acc. to SIA 384/6 (based on SN EN 805) Read-out accuracy 0.01 bar		Test date									
			Set value KL1/KL2	Actual value KL 1	KL2	Set value KL1/KL2	Actual value KL1	KL2	Set value KL1/KL2	Actual value KL1	KL2
Sequence in minutes	Test pressure procedure for: (Dependent on the length of the EWS and the density of the back-filling; see SIA 384/2 Appendix B2 Tab. 4)	bar									
	Filling probe with water										
0	Apply test pressure	bar									
10	Pressure at end of pressure maintenance	bar									
60	End of static pressure drop (perm. pressure drop acc. to manufacturer)	bar									
	Pressure after pressure reduction (Reduction 10% of the test pressure, min. 1 bar)	bar									
	Quantity of drained water (acc. to SIA 384/6, Appendix B2, Tab. 5)	l									
65	Pressure read out	bar									
75	Pressure read out	bar									
90	Pressure at end of main test	bar									
Condition met:		Yes / No									

Back-filling Standard: 100 kg Bentonit, 200 kg cement, 900 l water	Date									
		Bentonit	Cement	Water	Bentonit	Cement	Water	Bentonit	Cement	Water
Quantity in **kg** Bentonit, cement, water										
or ready-mix: manufacturer, water/100 kg										
Total quantity of back-filling in **kg** / spec. gravity in kg/m3										
		yes/no	Metre UK Terrain		yes/no	Metre UK Terrain		yes/no	Metre UK Terrain	
Until UKT met, Yes, if NI up to Metre UKT										

Acceptance SIA Norm 118

Polish: ....

Place and date: ....

Construction manager: ....

Source: SIA 384/6:2010

HakaGerodur
Giessenstrasse 3 Telefon +41 (0)55 293 25 25
CH-8717 Benken Fax +41 (0)55 293 25 99

9.9. Sample report for the heated-coil welding of pipelines

VKR

Welding and laying of pipelines from PE laid end-to-end

7. Heated –coil welding

Welding Report

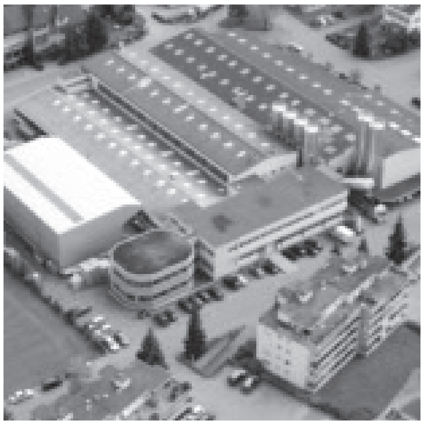
for electrofusion (heated –coil welding)

														PE 100 ☐
Building owner		**Company carrying out the work**		**Welding unit**		***Weather**		***Construction site protection**						
Object		Welder		Manufacture		sunny	1	None	1					
						dry	2	Screen	2					
						rain	3	Tent	3					
								Heated	4					
No.	**Date**	**Pipe Ø**	**Series/SDR**	**Ohm Ω**	**Volt (sec. voltage)**	**Resistance**	**Welding time**	**Cooling time**	**Temperature**	***Weather**	***Construction site protection**	**Mains operation**	**Generator**	**Signature fitter**
						☐								

 A 7.2

Source: VKR, Verband Kunststoff-Rohre and Rohrleitungsteile (Association for Plastic Pipes and Plastic Pipe Components, 5000 Aarau, Switzerland

Gossau



Benken

Neustadt in Sachsen

HakaGerodur AG
Mooswiesstrasse 67
Postfach
CH-9200 Gossau SG
Telefon +41 (0)71 388 94 94
Fax +41 (0)71 388 94 80
sekretariat@hakagerodur.ch
www.hakagerodur.ch

HakaGerodur AG
Giessenstrasse 3
Postfach
CH-8717 Benken SG
Telefon +41 (0)55 293 25 25
Fax +41 (0)55 293 25 99
sekretariat@hakagerodur.ch
www.hakagerodur.ch

GERODUR MPM
Kunststoffverarbeitung GmbH & Co. KG
Andreas-Schubert-Strasse 6
D-01844 Neustadt in Sachsen
Telefon +49 (03596) 58 33-0
Fax +49 (03596) 60 24 04
info@gerodur.de
www.gerodur.de

Overall Sales Program

Heating and Sanitary Equipment Division, Gossau/Neustadt

- Underfloor heating pipes made of PE 100-RT, PB and PE-X
- Multilayer laminated tubes made of plastic/metal
- Sanitary piping
- Special piping. e.g. for ceiling cooling systems and oil product supply lines

Pipe Systems Division, Benken/Neustadt

- PE pressure pipes for gas/water supply/waste water
- GEROfit® pipe with protective jacket
- Sewage and seepage pipes
- Cable ducts
- Domestic drainage pipes
- Pipes for industrial applications (to transport liquids/gases)
- Ready-made plastic parts

Geothermal Probes Division, Benken

- Pipework systems to exploit the geothermal energy near the surface of the earth for air-conditioning in buildings (cooling and heating)
- Comprehensive range of accessories

Product division profiled sections, Gossau

- Profiled sections made of polyolefins/technical plastics, e.g. for machine building, environmental technology, lighting, construction, furniture.
- Own construction (CAD) with toolmaking

Medical Technology Division, Gossau

- Serological pipettes extruded in polystyrene in variable sizes for the use in laboratories. Applications in research, pharma-, medical-, cosmetics- and food industries.