REHAU®
Unlimited Polymer Solutions

RAUTITAN WATER SERVICES

TECHNICAL INFORMATION

Subject to technical modifications
Valid from January 2010
www.rehau.com

Construction
Automotive
Industry

This technical information on piping, connection and system guidelines is valid from **January 2010**.

This publication means that the previous version of RAUTITAN Installation System Technical Information is no longer valid.

The latest version of this Technical Information can be found at **www.rehau.com** for download.

All measurements and weights are of approximation values.
Errors and changes are excepted.

RAUTITAN INSTALLATION SYSTEM

TABLE OF CONTENTS

1. INFORMATION AND SAFETY ADVICES

NOTES ON THIS TECHNICAL INFORMATION

Validity
This technical information is valid for South East Asia.

Other applicable REHAU technical information:
- Piping, connection and system guidelines

Navigation
At the beginning of this document you can find a detailed content page which lists the individual chapters and their respective page numbers.

Definitions
- **Supply lines or piping** consist of pipes and their joints (e.g. compression sleeves, fittings, threads or similar). This applies to gas piping, drinking water and heating piping and all other pipes in this Technical Information.
- **Piping systems, installation, systems**, etc. consist of the pipes and the necessary components.
- **Connection components** consist of fittings with the corresponding compression sleeves and pipes, as well as seals and threaded connections.

Display
Illustrations for individual subsystems are listed in the corresponding pipe, fitting and compression sleeve colours.

Illustrations which are applicable for system-wide applications, such as drinking water, heating, gas installation or underfloor heating/cooling are illustrated with grey piping and white fittings and compression sleeves.

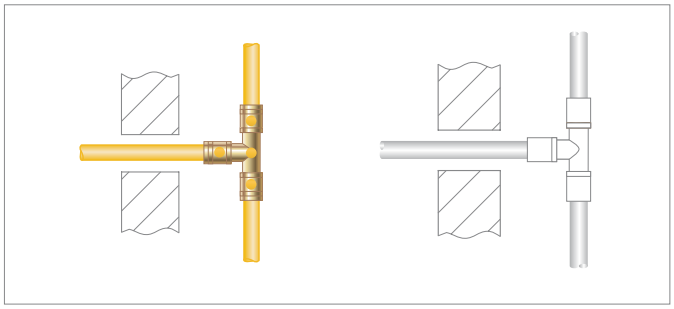


Fig. 1-1 Example: illustration for gas installation sub-system (left) and example: illustration for system-wide application (right)

Explanation of symbols

Safety Information

Legal information

Important information, which needs to be taken into account

Information in the internet

Your benefits/advantages

Latest technical information
For safe usage of REHAU products, please check regularly if a newer version of the technical information is available to you. The date of issue of your technical information can be found on the back cover in the bottom right hand corner. The latest technical information manuals are available from the REHAU sales office, appointed wholesalers as well as from our website: www.rehau.com.

Safety advice and operating instructions
- Please read these safety instructions and technical information carefully and completely for your own safety and other's before beginning the installations.
- Please keep this copy for your future reference.
- If you have any questions or need further clarifications on the safety instructions and/or the individual installation instructions, please contact your nearest REHAU sales office.
- **Failure to observe the safety information/instructions can result in damage to property and persons.**

Intended use
The REHAU system components and compression sleeve jointing technique is considered as proprietary systems and should be designed, installed, and operated in accordance to REHAU's Technical Information. Any other use that does not fall within the intended use of the system is prohibited.

When installing this pipe system, please observe all applicable national and international regulations on installation, accident prevention and safety together with the information contained in this Manual.

Also observe the applicable laws, standards, guidelines and regulations (e.g. DIN, EN, ISO, DVGW, TRGI, VDE and VDI) as well as regulations on environmental protection, provisions of professional associations and regulations of the local public utility companies.

Any applications not described in this Manual - i.e. non-standard applications - must be discussed with our Technical Applications Department. For more detailed advice, please contact your REHAU Sales Office.

The design and installation information related solely to the specific REHAU product. Occasionally, references are made to parts of applicable standards and directives. Always observe the current version of any guidelines, standards or directives.

Further standards, directives and guidelines related to the design, installation and operation of drinking water, heating or buildings services systems should also be referred to, but these do not form part of this Technical Information.

General safety measures

- Keep your workplace tidy and free of obstructions.
- Ensure there is always sufficient light.
- Keep children, pets and unauthorized persons away from tools and installation areas. This is especially important when carrying out refurbishment/repair work in occupied areas.
- Only use those components in the corresponding piping system, which have been generally approved by REHAU. Using components which are not part of the system or tools which do not originate from the respective REHAU installation system can lead to accidents or other hazards.

Trades qualifications

- Only authorized and trained persons are allowed to install REHAU systems.
- Work on electrical systems and cables shall only be carried out by qualified, competent and authorized specialists.

Work clothing

- Wear eye protection, adequate work clothing, protective shoes, safety helmets, and a hairnet if you have long hair.
- Do not wear lose clothing or jewelry as these can be caught by moving parts.
- A safety helmet must be worn especially when carrying out installation work at face level or overhead.

Follow the installation instructions

- Read carefully and observe at all times the Operating Manual for the REHAU installation tool which is being used.
- Incorrect handling of tools can cause cuts and crushing or sever limbs.
- Incorrect handling of tools can damage jointing components and cause leaks.
- The REHAU pipe cutters have a sharp blade. Store and handle them in such a way that the REHAU pipe cutters will not create any risk of injury.
- When cutting the pipe to the desired length, keep a safety distance between the holding hand and the tool (pipe cutter).
- When cutting, do not reach into the cutting zone of the tool or near its moving parts.
- After the pipe expansion process, the expanded end of the pipe will return to its original shape (due to memory effect). During this time, do not put any other objects into the end of the expanded pipe, except for the intended REHAU fitting.
- Keep your hands away from movable parts or the tools pressing area during jointing.
- Before the joint is completed, the fitting may fall out of the pipe. Injury hazard!
- Always disconnect the power from a tool prior to carrying out maintenance work, changing over any moveable parts (e.g. compression jaws) or when moving the tool to a new location on site.

Operating parameter

If the operating parameters are exceeded, the pipes and joints may become overstrained. Not adhering to the operating parameters is thus not allowed.

Keeping within the operating parameters must be ensured by safety/control equipment (e.g. pressure reducers, safety valves, etc.)

2. OVERVIEW

2.1 BENEFITS AT A GLANCE

REHAU compression sleeve jointing technique

- Universal and robust jointing, highly suitable for construction site
- Connection without O-ring (self-sealing pipe material)
- Simple visual inspection
- Good hydraulic properties, pipe is expanded at the joint
- Joint can be immediately pressurized
- Pipe does not need to be calibrated or deburred
- Same jointing technique and tools for water services, gas and heating installation
- Permanently sealing compression sleeve jointing technique according to DIN 1988, DVGW worksheet W 534 and DVGW VP 625
- Approved for flush-mounted installation according to DIN 18380 (VOB)

RAUTITAN his 311 pipe

- Corrosion resistance of RAUTITAN pipes: No pitting
- Acoustic insulation properties of RAUTITAN his 311 pipe material
- No tendency to deposits or encrustation
- High impact toughness of RAUTITAN his 311 pipe material
- Good resistance to abrasion
- Pre-insulated pipe for hot water services
- Application-oriented delivery packaging of the pipes as coils or straight lengths
- Pipe size from 16 to 63 mm
- Complete installation of manifold, rising and connecting pipes

REHAU fittings

- RAUTITAN fittings and RAUTITAN compression sleeves for water services
- RAUTITAN MX fittings for water services are made of special dezincification-resistant brass according to DIN EN 12164, DIN EN 12165 and DIN EN 12168 standards, Grade A and are equivalent to the highest requirement category

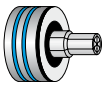
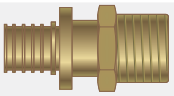
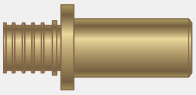
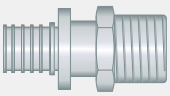
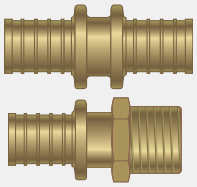
Universal tools RAUTOOL from REHAU

- Manual, hydraulic, or electro-hydraulic drives
- Suitable for all pipe dimensions

2.2 SYSTEM COMPONENTS OVERVIEW

RAUTITAN – THE NEW GENERATION

RAUTITAN his 311 system for drinking water

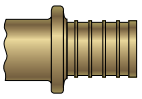
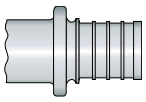
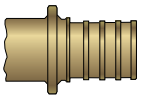
	Size 16 – 40	Size 50 – 63	RAUTOOL	Tool
Pipe	Hot and cold water pipe RAUTITAN his 311			
Compression sleeve	 **RAUTITAN PX** PVDF	 **RAUTITAN MX** Brass		
Fitting	 **RAUTITAN PX** PPSU  **RAUTITAN MX** Dezincification-resistant special brass  **RAUTITAN MX** Gunmetal  **RAUTITAN SX** Stainless steel	 **RAUTITAN MX** Dezincification-resistant special brass		

3. SYSTEM OVERVIEW

RAUTITAN HIS 311

3.1 IMPORTANT INFORMATION FOR INSTALLING RAUTITAN PX FITTINGS AND RAUTITAN PX COMPRESSION SLEEVES.

RAUTITAN system for drinking water installation

Compression sleeves and fittings		
Compression sleeve	Size 16 - 40  **RAUTITAN PX**	Size 50 - 63  **RAUTITAN MX**
Material	PVDF	Brass
Threadless fittings	Size 16 – 40  RAUTITAN PX	Size 50 – 63  RAUTITAN MX
Material	PPSU	Brass
Fittings for screwing, soldering, clamping	Size 16 – 32  **RAUTITAN SX**	Size 16 – 63  **RAUTITAN MX**
Material	Stainless steel	Brass **RAUTITAN RX**
Material		Gunmetal

Tab. 3-1 Allocation of the RAUTITAN compression sleeves and fittings for drinking water installation

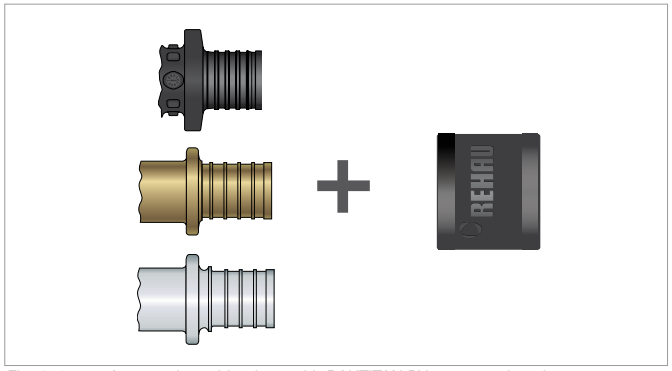


Fig. 3-1 Approved combinations with RAUTITAN PX compression sleeves

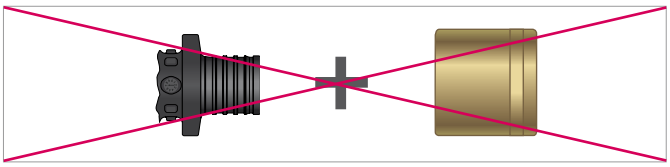


Fig. 3-2 Unapproved combination: RAUTITAN PX with RAUTITAN MX compression sleeves

Only compress polymer RAUTITAN PX compression sleeve (black) with polymer RAUTITAN PX fittings (black).

Push on direction of the RAUTITAN compression sleeves.

Always slide the brass compression sleeves onto the pipe with the chamfered side facing the joint.

With RAUTITAN PX compression sleeves, the sliding-on direction does not matter.

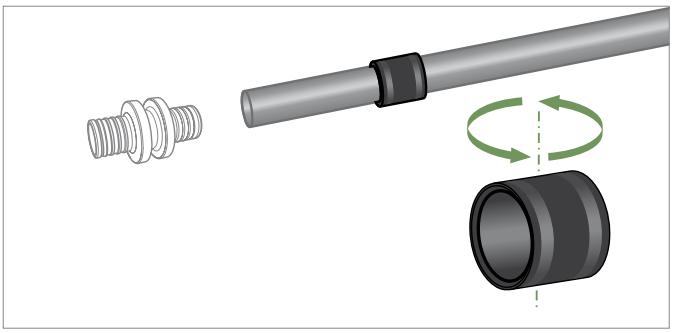


Fig. 3-3 Sliding-on direction of RAUTITAN PX compression sleeve: any direction

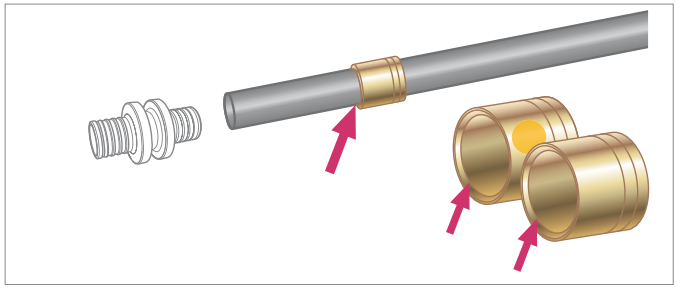


Fig 3-4 Sliding-on direction of RAUTITAN MX compression sleeves: chamfered side facing the joint

4. POLYMER MATERIALS

4.1 PE-X MATERIALS

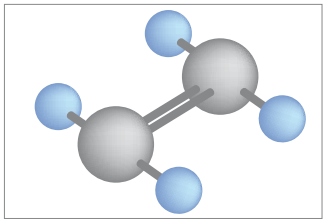


Fig. 4-1 Ethylene

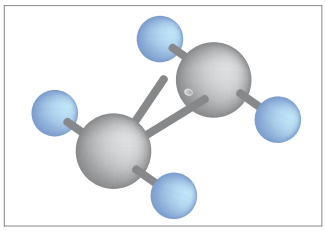


Fig. 4-2 Ethylene, detaching double bond

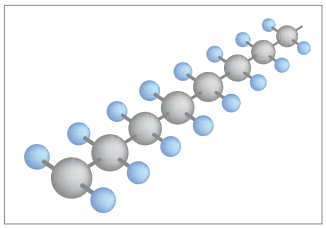


Fig. 4-3 Polyethylene (PE)

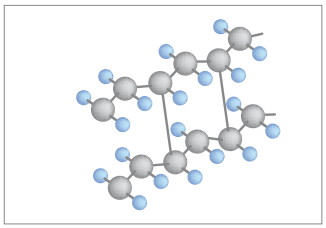


Fig. 4-4 Crosslinked polyethylene (PE-X)

- Corrosion resistance of pipes: no pitting
- No tendency to deposits
- Polymer pipe material reduces sound transmission along the pipe
- Good resistance to abrasion
- Toxicologically and physiologically harmless
- All RAUTITAN pipes with DVGW registration comply with the KTW recommendations

Peroxide-crosslinked polyethylene

Peroxide-crosslinked polyethylene is designated as PE-Xa. This method of crosslinking is conducted at high temperature and pressure with the aid of peroxides. Here, the individual molecules of the polyethylene combined to form a three-dimensional network. This high-pressure crosslinking is characterized by crosslinking in the melt away from the crystallite melting point. Crosslinking occurs during the moulding of the pipe in the tool. This method of crosslinking ensures an even and very high degree of crosslinking over the entire cross-section of even thick-walled pipes.

4.2 MATERIAL – PIPE (OVERVIEW)

Composition / Material	Pipe
- RAUTITAN his 311	RAUTITAN his 311
- Polyethylene outer layer	RAUTITAN his 311

Tab. 4-1 Pipe composition/material, from interior to exterior

4.3 MATERIAL – RAUTITAN PX FITTINGS (PPSU) AND RAUTITAN PX COMPRESSION SLEEVES (PVDF)

The materials used to date (e.g. dezincification-resistant special brass according to DIN EN 12164, DIN EN 12165 and DIN EN 12168 standards, stainless steel, red bronze) of the RAUTITAN system for water services and heating installation are supplemented with the polymer materials PPSU and PVDF.

4.3.1 RAUTITAN PX FITTINGS MADE OF PPSU

Polyphenyl sulphone (PPSU) is a high-performance polymer, which has proven itself over the years in the area of supply technology.

- High impact strength
- Good chemical resistance
- High temperature resistance
- Corrosion resistance
- Hygienically harmless
- No tendency to encrustations
- Light weight

4.3.2 RAUTITAN PX COMPRESSION SLEEVE MADE OF PVDF

Polyvinylidene fluoride (PVDF) is a tried-and-tested, thermoplastic polymer with high solidity.

- Good sliding behaviour
- Flexible material
- Less compression force required, longer battery operation time
- Compression sleeve can be slid in from both sides
- Light weight

Fig. 4-5 Result of a burst pressure test with the universal pipe RAUTITAN flex

4.4 MATERIAL TESTING AT REHAU

At REHAU, all types of pipes are subjected to constant quality assurance and pass through numerous short and long-term tests to ensure the quality of the REHAU pipes. Several standards tests conducted in the REHAU test laboratory are described below. For polymer pipe materials subjected to thermal and mechanical loads, it must be observed that deformation and the strength depend on the temperature and exposure time. To determine the permissible conditions for long-term loads, it is necessary to investigate the mechanical behaviour over a long period and at different temperatures. This also applies to pipes subjected to internal pressure.

Burst pressure test

In the burst pressure test, the pipes are subjected to a rising pressure in a test apparatus until the pipe ruptures. The burst pressure at room temperature is approximately seven times the maximum operating pressure.

Notch impact test

The resistance of the pipes to the effects of impact is tested in a notch impact testing device. A hammer-shaped pendulum strikes the tested pipe under controlled conditions. Pipes made of crosslinked polyethylene have a very high resistance to these severe mechanical effects. The depicted test example (see Figure 4-6) shows a notch impact strength of the pipe without breaking at temperature of -30°C.

Fig. 4-6 Universal pipe RAUTITAN flex in the notch impact testing device

Tensile test

In a tension testing machine, the pipes are pulled longitudinally at high force under controlled conditions until they break. Pipes made of crosslinked polyethylene show an extremely high elongation in comparison to metal pipes. The length of the extended pipe can be several times the original pipe length. The compression sleeve jointing technique must not be pulled out under operating conditions. The pipe is not pulled out of the joint.

Fig. 4-7 Procedure of a tensile test

Long-term test

The use of pipes in domestic installations requires a service life of 50 years or more. To determine the long-term effects, e.g. by temperature fluctuations, pressure and mechanical loads, the pipes are subjected to extreme conditions of temperature and pressure in long-term tests and are tested periodically by the test methods described above. The pipes are then photo-optically examined.

Fig. 4-8 Pipes in a long-term test (under pressure in a water bath)

The necessary parameters were developed on the basis of over 25 years of experience in the laboratory and in practice with numerous trials and extensive tests on pipes made of high-pressure crosslinked polyethylene. The pipes in the background with brown surfaces (see Figure 4-8) have been tested since production began at REHAU in a test bath at 95°C and 10 bars. Other tests are conducted according to the applicable standards and regulations, e.g. these are the measurement of the degree of crosslinking, shrinkage tests, ageing tests, temperature cycling test, pulsing tests and many more.

5. TRANSPORT AND STORAGE

5.1 HANDLING THE PIPES AND SYSTEM COMPONENTS

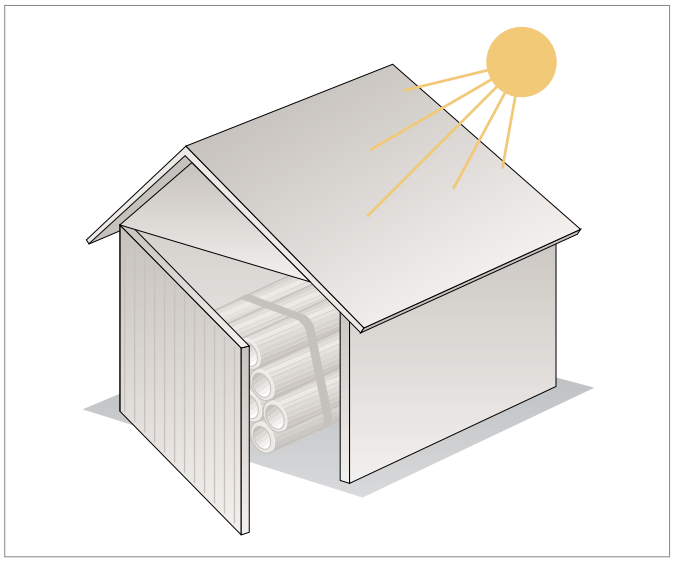


Fig. 5-1 Protect pipes against sunlight

- Store and transport pipes and components protected against UV radiation.
- When laying in areas where UV-radiation (e.g. sunlight, neon light) can occur, cover the piping fully with UV-proof material.

Avoid damaging the pipes and system components:

- Load and unload with due care.
- Only transport in a fashion suitable for the material.
- Do not drag over floors or concrete surfaces.
- Store on a flat surface with no sharp edges.
- Protect against mechanical damage.
- Protect against dirt, drilling dust, mortar, grease, oil, paint, solvents, chemicals, humidity, etc.
- Protect against sunlight, e.g. with an opaque file or similar material.
- Protect against long sunlight exposure during the construction phase.
- Only unpack shortly before laying.
- Note the hygienic requirements (e.g. sealing of pipe ends, protection of the fittings, compliance with VDI 6023 – Hygiene-conscious planning, execution, operation and installation of drinking water systems).

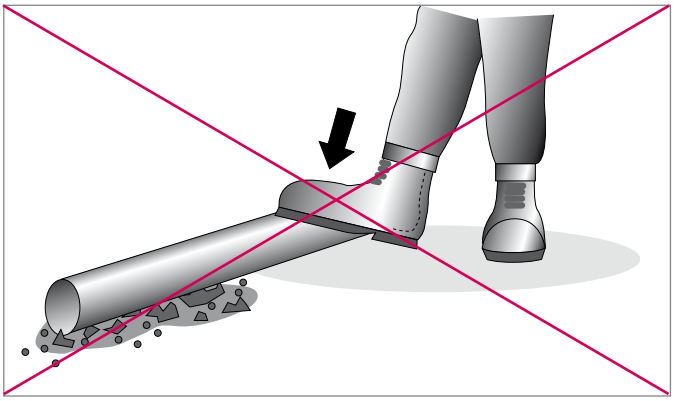


Fig. 5-2 Do not store pipes on sharp-edged surfaces

6. PIPES

6.1 HOT AND COLD WATER PIPE RAUTITAN HIS 311

Fig. 6-1 Hot and cold water pipe RAUTITAN his 311

Delivery Make-up			
d [mm]	s [mm]	Volume [l/m]	Format
16	2.2	0.106	Straight length / coil
20	2.8	0.163	Straight length / coil
25	3.5	0.254	Straight length / coil
32	4.4	0.423	Straight length / coil
40	5.5	0.661	Straight length
50	6.9	1.029	Straight length
63	8.6	1.633	Straight length

Tab. 6-1 Delivery make-up, hot and cold water pipe RAUTITAN his 311

- Pipe made of RAU PE-Xa, with the following structure from the inside-out:
  - Peroxide-crosslinked polyethylene (PE-Xa)
  - Outer black PE layer for UV protection
- Field of application:
  - Drinking water installation

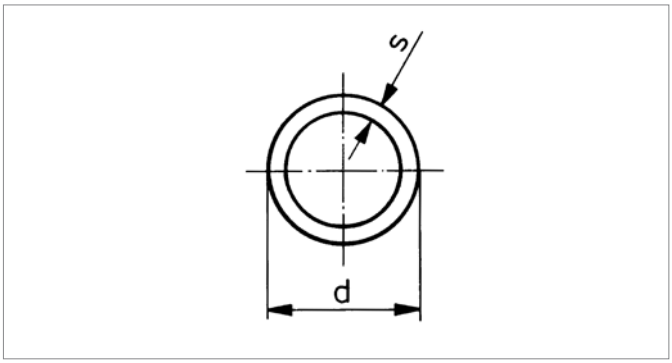


Fig. 6-2 Diameter/Wall thickness

Approvals and quality certifications

- Compliance with ISO 15875 Plastics piping systems for hot and cold water installations - Crosslinked polyethylene (PE-X)
- BS 7291 certification for Thermoplastics pipes and associated fittings for hot and cold water for domestic purposes and heating installations in buildings
- SAI Global Product Certification for sizes 16 – 63 mm (WaterMark LN1413)
- AS 2492 for crosslinked polyethylene (PE-Xa) pipe for hot and cold water application and AS 2537 for mechanical jointing fittings for use with crosslinked polyethylene (PE-Xa) pipes for hot and cold water applications

Local approval

Local approvals may vary. When using the REHAU plumbing installation system, please consult your REHAU Sales Office.

6.2 TECHNICAL DATA OF PIPES

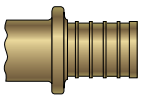
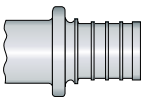
A simultaneous load at the pressure and temperature limits during operation of water services is impermissible.

Technical data	Unit	Pipe Hot and cold water pipe RAUTITAN his 311
Material	-	PE-Xa
Colour (surface)	-	Black
Notch impact strength at 20°C	-	No fracture
Notch impact strength at -20°C	-	No fracture
Average coefficient of expansion When laying with pipe support channel: - Size 16 - 40 - Size 50 - 63	[mm/(mK)]	0.15 0.04 0.1
Thermal conductivity	[W/(mK)]	0.35
Pipe roughness	[mm]	0.007
Operating pressure (maximum)	[bar]	10
Operating temperature - Maximum - Minimum	[°C]	 90 -
Short-term maximum temperature (malfunction)	[°C]	100
Oxygen diffusion (to DIN 4726)	-	-
Material constant C	-	12
Building material class	-	B2
Maximum/minimum laying temperature	[°C]	+45 / -10
Minimum bending radius without tools d = pipe diameter	-	8 x d
Minimum bending radius with spiral spring/tool d = pipe diameter	-	-
Minimum bending radius with pipe bend brackets d = pipe diameter	-	3 – 4 x d
Available sizes	[mm]	16 – 63

Tab. 6-2 Technical data of pipes (approximate values)

7. FITTINGS AND COMPRESSION SLEEVES

7.1 SUITABLE FITTINGS AND COMPRESSION SLEEVES

Areas of application of the fittings and compression sleeves		
Water services	Fitting	Compression sleeve
Hot and cold water pipe RAUTITAN his 311	  	 

Tab. 7-1 Suitable fittings and compression sleeves for RAUTITAN his 311 pipe

Only slide in polymer RAUTITAN PX compression sleeves into polymer RAUTITAN PX fittings.

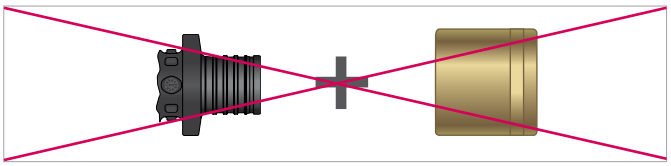


Fig. 7-1 Unapproved combination of RAUTITAN PX fittings with brass compression sleeves

7.2 FITTINGS AND COMPRESSION SLEEVES OF RAUTITAN SYSTEM

Fig. 7-2 RAUTITAN PX fittings made of PPSU

Fig. 7-3 RAUTITAN MX (brass), RAUTITAN RX (gunmetal) and RAUTITAN SX (stainless steel) fittings

Fig. 7-4 RAUTITAN compression sleeves

- For plumbing application
- Compression sleeve jointing technique with permanent sealing in accordance with DIN 1988, DVGW-worksheet W 534, DVGW VP 625 and DVGW VP 626
- Approved for flush-mounted installation in accordance to DIN 18380 (VOB)
- Robust jointing technique, highly suitable for construction site
- Without O-ring (self-sealing pipe material)
- Easy visual inspection
- Can be pressurized immediately
- By expanding the pipe, the internal diameters of the pipes and fittings are hydraulically adjusted to each other
- RAUTITAN MX fittings for drinking water are made of dezincification-resistant brass according to DIN EN 12164, DIN EN 12165 and DIN EN 12168, Grade A (highest requirement category)
- No risk of confusion with universal RAUTITAN PX compression sleeves for water services
  - DVGW registration (all sizes)
  - RAUTITAN pipes for drinking water services
- REHAU compression sleeve jointing technique
- Assemble the compression sleeve joint with RAUTOOL
  - Especially coordinated with RAUTITAN system
  - Development and supervision directly from REHAU

Information on the current drinking water ordinance and on DIN 50930, part 6 can be found in Technical Information RAUTITAN – THE NEW GENERATION.

Sizes of the fittings and compression sleeves for RAUTITAN water services and heating installation:

16 x 2.2	20 x 2.8	25 x 3.5	32 x 4.4
40 x 5.5	50 x 6.9	63 x 8.6	

Material

- The RAUTITAN fittings for water services and heating installation consist of:
  - RAUTITAN PX: PPSU (polyphenyl sulphone)
  - RAUTITAN MX: Special dezincification-resistant brass according to DIN EN 12164, DIN EN 12165, DIN EN 12168 standards, Grade A (highest requirement category)
  - RAUTITAN RX: Gunmetal
  - RAUTITAN SX: Stainless steel
- RAUTITAN SX system adapters and RAUTITAN SX system pressing adapters are manufactured according to DIN EN 10088, part 3 (material designation 1.4404 / 1.4571)
- Special fittings used exclusively in heating installation consist of brass, copper or stainless steel
- RAUTITAN compression sleeves for water services and heating installation consist of:
  - RAUTITAN PX: PVDF (polyvinylidene fluoride)
  - RAUTITAN MX: Thermally annealed brass according to DIN EN 12164, DIN EN 12165 and DIN EN 12168 standards.
- More precise material specifications can be found in the product range

Dezincification resistance

Under the effects of certain types of drinking water, a particular form of corrosion known as dezincification can occur in standard brass alloys, e.g. free-cutting brass.

RAUTITAN MX fittings used in water services are made of special dezincification-resistant brass and are tested for drinking water installation according to DIN ISO 6509. Fittings made of dezincification-resistant brass have been proven in practice and have been in use for decades.

Stress cracking resistance

RAUTITAN MX fitting and RAUTITAN MX compression sleeves for water services satisfy the requirements of stress cracking corrosion resistance in compliance with the DVGW worksheet GW 393/DIN 50916, Part 2.

Erosion/Erosion corrosion

Erosion is the destruction of materials beginning at the surface, caused by excessively high flow velocities.

Erosion corrosion is a process involving erosion and corrosion. RAUTITAN pipes for water services are expanded before jointing. The flow cross-section of the pipe is therefore adjusted to that of the fitting. This hydraulic and corrosion resistance advantage is optimized in RAUTITAN systems for water services, in contrast to systems in which the pipes are not expanded at the joint.

- Only use fittings and compression sleeves of RAUTITAN PX, RAUTITAN MX, RAUTITAN RX or RAUTITAN SX for water services
- Only slide in RAUTITAN PX compression sleeves into RAUTITAN PX fittings
- Do not combine fittings and compression sleeves from different ranges with each other
- Please note the dimension of the fittings and compression sleeves
- You can find the range of connection components in the latest product book

7.2.1 FITTINGS

Contours of RAUTITAN fittings for water services and heating installation

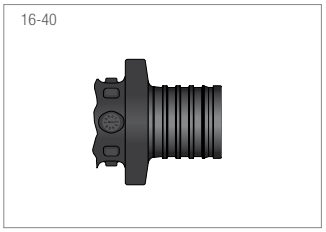


Fig. 7-5 Size 16 - 40, RAUTITAN PX from PPSU

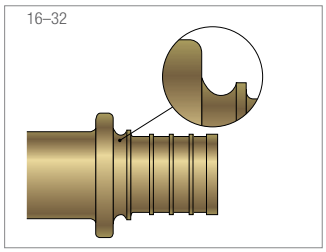


Fig. 7-6 Size 16 - 32, RAUTITAN MX and RAUTITAN RX

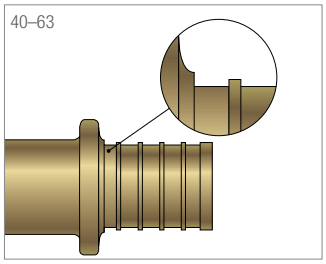


Fig. 7-7 Size 40 - 63, RAUTITAN MX

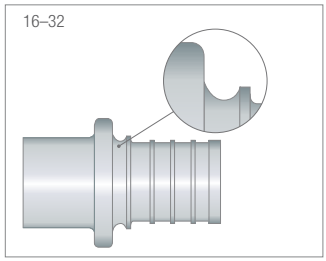


Fig. 7-8 Size 16 - 32, RAUTITAN SX

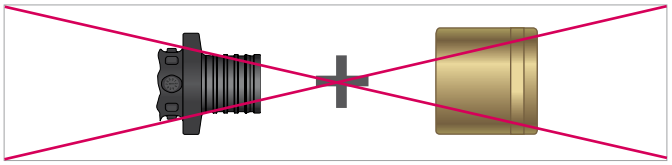


Fig. 7-9 Unapproved combination: RAUTITAN PX fitting with RAUTITAN MX compression sleeve

7.2.2 COMPRESSION SLEEVES

Compression sleeves for RAUTITAN his 311

Fig. 7-10 RAUTITAN PX compression sleeve made of PVDF, size 16 - 40

Fig. 7-11 RAUTITAN MX compression sleeve made of brass, sizes 16 - 25 and 50 - 63

Fig. 7-12 RAUTITAN MX compression sleeve made of brass, size 32 - 40, with encircling knurling

Fig 7-13 RAUTITAN MX compression sleeve made of brass, with collar

	RAUTITAN PX	RAUTITAN MX
Size	16 x 2.2 mm 20 x 2.8 mm 25 x 3.5 mm 32 x 4.4 mm 40 x 5.5 mm	50 x 6.9 mm 63 x 8.6 mm
Material	PVDF	Thermally annealed brass according to: - DIN EN 12164 - DIN EN 12165 - DIN EN 12168
Characteristic features	- Can be slid onto the fitting from both sides - Black	- Can only be slid onto the fitting from one side - Brass finish - Encircling groove

Tab. 7-2 RAUTITAN compression sleeves

- Can be used for all pipes in RAUTITAN his 311
- Compression sleeve jointing technique with permanent sealing
- According to DIN 1988 and DVGW worksheet W 534
- Approved for flush-mounted installation according to DIN 18380 (VOB)
- Existing RAUTITAN brass compression sleeves can still be used with RAUTITAN fittings made of brass, gunmetal or stainless steel

7.3 TRANSITION TO OTHER PIPE MATERIALS

Fig. 7-14 Adapter with RAUTITAN MX male thread and RAUTITAN RX soldering/ pressing adapter

Water piping

- Only make joints after the soldering process.
- Let the solder cool down completely.vvvvv

If repair works or piping network extensions cause necessary system changes to RAUTITAN system, threaded joints must be used as clear division between the different systems and to preserve the guarantee.

An exception to this rule is to use RAUTITAN RX soldering/pressing adapter and RAUTITAN SX system pressing adapter.

For transitions from RAUTITAN system to soldering or metal compression systems (radial compression joints to DVGW worksheet W 534), use RAUTITAN RX soldering/pressing adapter, e.g. transition from copper or mild steel (heating installation).

When using the metal compression systems, ensure that the surfaces of the soldering/compression end are free of grooves and deformations. Observe the instructions of the metal compression system manufacturers.

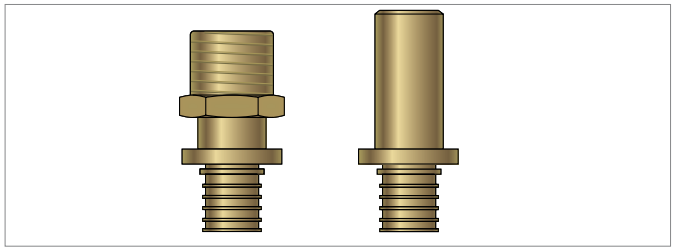


Fig. 7-15 RAUTITAN MX fittings for transitions to other materials

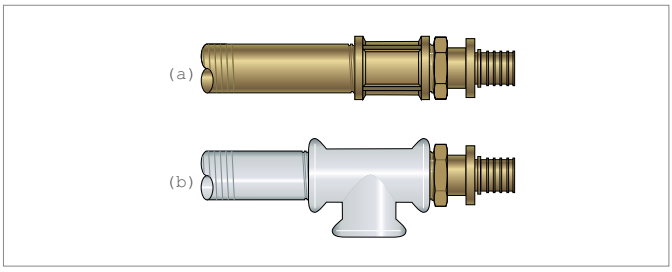


Fig. 7-16 Adapter with RAUTITAN MX male thread fixed into:
(a) Brass fittings
(b) Systems with galvanized steel pipes and fittings

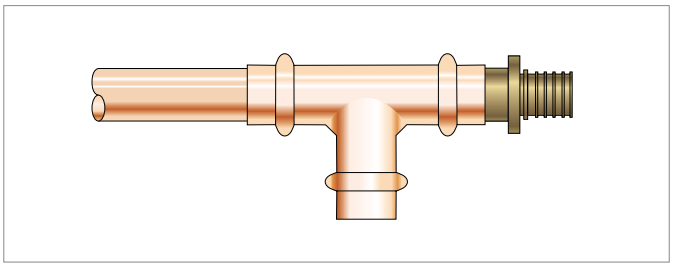


Fig. 7-17 RAUTITAN RX soldering/pressing adapter with copper pressing system

Adapters with RAUTITAN male threads, which also have soldering function (identification L, see latest product book), can be soldered directly into the end of copper pipe.

Use suitable solder and flux for soft-soldering and hard-soldering.

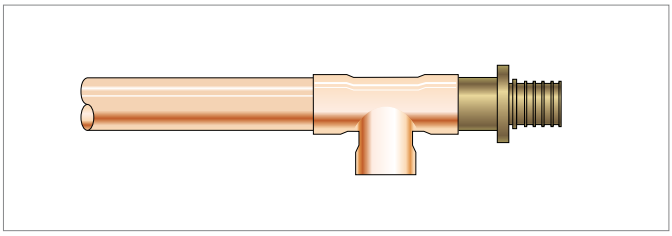


Fig. 7-18 RAUTITAN RX soldering/pressing adapter with copper piping system

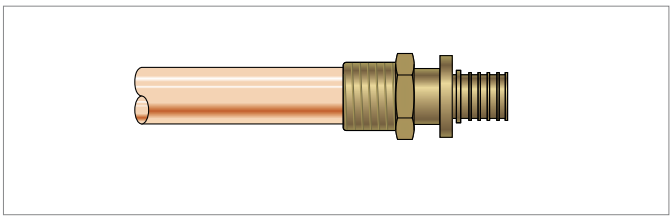


Fig. 7-19 Male threaded RAUTITAN MX adapter soldered into copper pipe system

Transition to stainless steel systems

Fig. 7-20 Male threaded RAUTITAN SX system adapter and RAUTITAN SX system pressing adapter

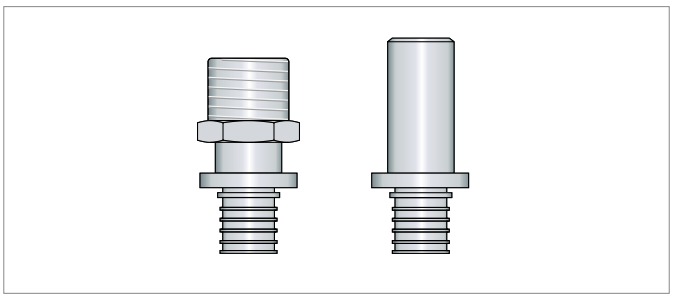


Fig. 7-21 Male threaded RAUTITAN SX system adapter and RAUTITAN SX system pressing adapter

System adapter made of stainless steel

- The direct transition from RAUTITAN system to stainless steel installation systems with brass adapters can lead to leaks or damage to fittings.
- To connect installation systems made of stainless steel, use only RAUTITAN SX system pressing adapters and male threaded RAUTITAN SX system adapters, both made of stainless steel.
- Please note the dimension of the fittings.

Threaded fittings made of stainless steel

- Do not use sealing tape or sealants (e.g. Teflon) which release water-soluble chloride ions.
- Use sealants which do not release water-soluble chloride ions (e.g. hemp).

If RAUTITAN system is connected to other systems made of stainless steel by interconnecting fittings (e.g. flush-mounted valves or water meters), it is not necessary to use RAUTITAN SX adapters.

The material combination of brass with stainless steel has been acknowledged in technical rules for a long time. However, the direct transition point to other systems is not explicitly regulated by the manufacturer's warranty guidelines of stainless steel system suppliers.

To avoid loss of warranty for REHAU system user, uniform material must be used at the system transition to stainless steel systems.

REHAU specifies only the RAUTITAN SX system pressing adapters and male threaded RAUTITAN SX system adapters (both made of stainless steel) for direct system connection to stainless steel installation systems.

The same advice, as RAUTITAN SX system pressing adapters, is applicable to RAUTITAN RX soldering/pressing adapters.

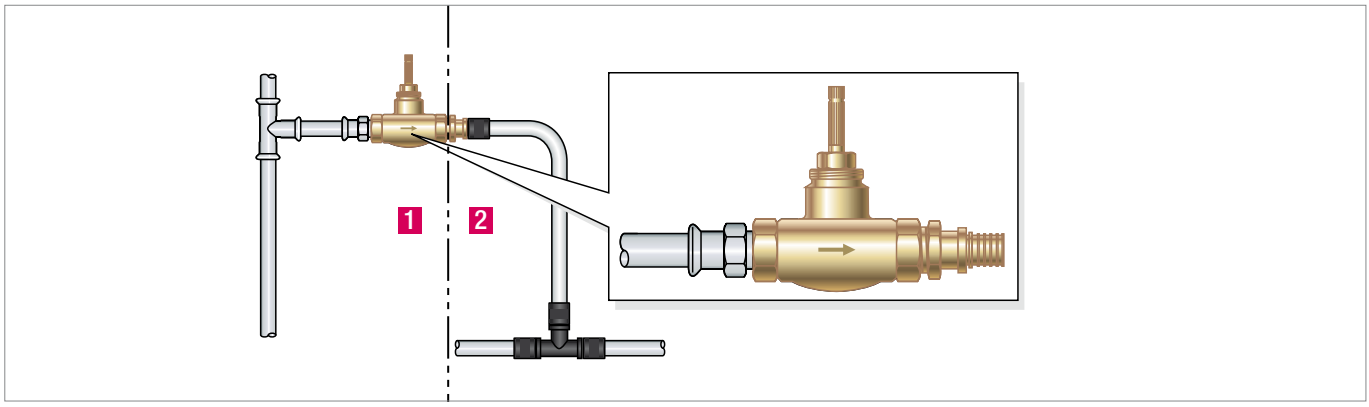


Fig. 7-22 Installation situation of a system adapter to a flush mounted valve (example)
1 *Stainless steel system with flush-mounted valve* 2 *RAUTITAN system with RAUTITAN MX adapters (brass)*

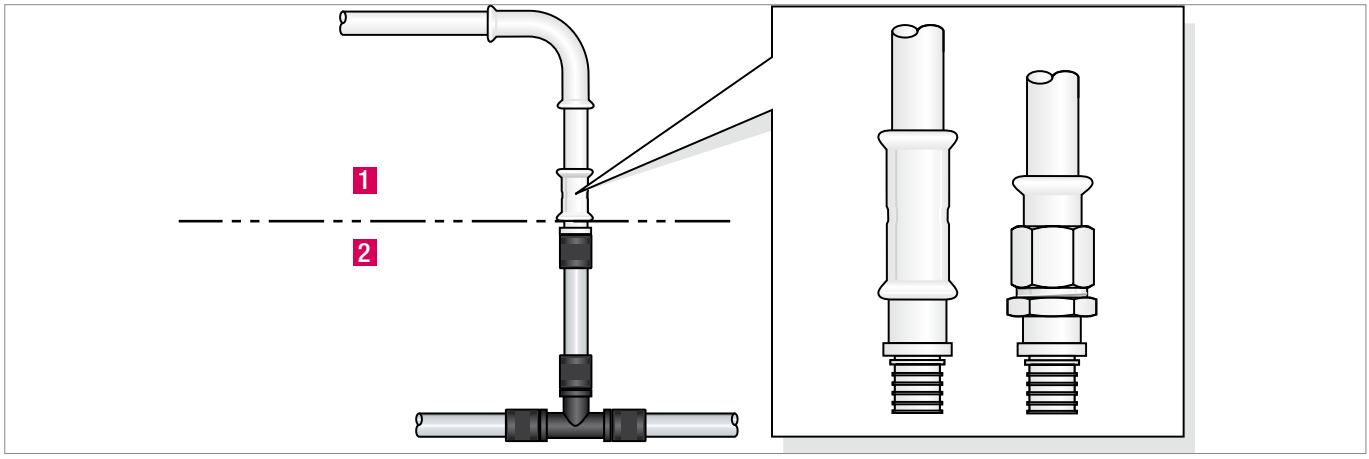


Fig. 7-23 Direct transition from stainless steel systems to RAUTITAN system up to size 32 or with threads up to R1/Rp1 in stainless steel (example)
1 *Stainless steel system* 2 *RAUTITAN system with RAUTITAN SX adapters (stainless steel)*

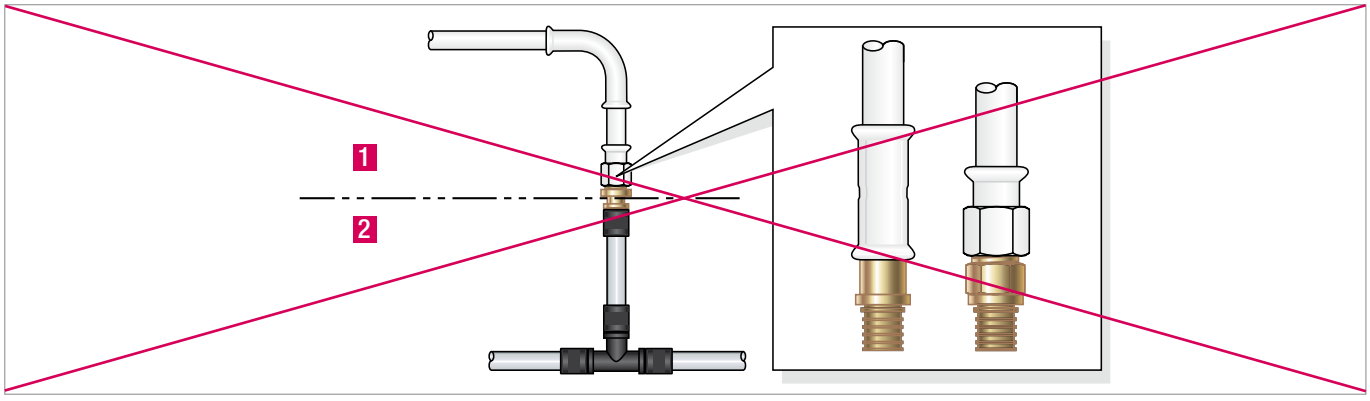


Fig. 7-24 No direct transition from stainless steel system to RAUTITAN system up to size 32 or with threads up to R1/Rp1
1 *Stainless steel system* 2 *RAUTITAN system with RAUTITAN MX adapters (brass)*

7.4 CONNECTION TO FITTINGS

Fig. 7-25 RAUTITAN MX adapter with swivel connector

Equipment and fittings can be easily be connected by using adapters with swivel connectors.

RAUTITAN pipe size	RAUTITAN MX adapter with flat-sealed swivel connector		Fittings with male threads for connection to metal pipe with thread according to DIN 3546, Part 1
	Article no.	Article description	
16	139551-002	16 – G ½	-
16	137144-001	16 – G ¾	G ¾
20	139561-002	20 – G ½	-
20	139571-002	20 – G ¾	G ¾
25	139912-001	25 – G ¾	-
25	139922-001	25 – G 1	G 1
32	139932-001	32 – G 1	-
32	241475-001	32 – G 1 ¼	G 1 ¼
32	137154-001	32 – G 1 ½	-
40	137265-001	40 – G 1 ½	G 1 ½
40	137164-001	40 – G 2	-
50	137275-001	50 – G 1 ¾	G 1 ¾
63	137285-001	63 – G 2 3/8	G 2 3/8

Tab. 7-3 RAUTITAN MX fitting adapter range with swivel connector

7.5 INSTALLATION NOTES FOR CONNECTION COMPONENTS

- Avoid over-tightening threaded joints.
- Use open-end wrenches in the right size. Do not clamp fitting too tightly into the vice.
- Using pipe wrenches can cause damage to the fittings and compression sleeves.
- Do not apply excessive hemp to threaded joints. The thread tips must be visible.
- Do not subject fittings and compression sleeves to plastic deformation, e.g. by hammer blows.
- Only use threads according to ISO 7-1, DIN EN 10226-1 and ISO 228 standards.
  Other thread types are not permitted.
- Make sure that the connection components are free of inadmissible stress during assembly and when in operation. Make sure that the piping has sufficient scope of movement (e.g. from deflection legs).
- Do not use dirty or damaged system components, pipes, fittings, compression sleeves or seals.
- When flat-sealed joints (or similar) are opened, check that the sealing surface is undamaged before reconnecting and insert a new seal if necessary.

Observe the following instructions when installing threaded fittings:
- Only use sealants approved for gas and water installation (e.g. DVGW-certified sealants).
- Do not extend the leverage of installation tools, e.g. with pipes.

- Screw the threaded joints together so that the thread-end remains visible.
- Check that different thread types are capable of being combined (according to ISO 7-1, DIN EN 10226-1 and ISO 228) before screwing them together, e.g. tolerances, free movement.

Other thread types are not permitted.
- If using long threads, ensure the maximum possible screwing depth and sufficient thread depth in opposing parts with inside threads.

The threads of threaded fitting adapters are according to:
- Thread according to ISO 7-1 and DIN EN 10226-1:
  - Rp = cylindrical female thread
  - R = conical male thread
- Thread according to ISO 228:
  - G = cylindrical thread, non-sealing thread

REHAU recommends threaded fittings made of dezincification-resistant brass to supplement the systems.

Installation temperature
- Minimum installation temperature is -10°C
- Maximum installation temperature is +45°C

Aligning the fittings

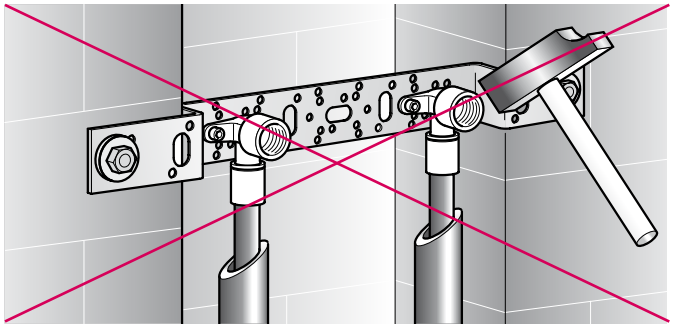


Fig. 7-26 Do not align using a hammer

Only align fittings with suitable tools, e.g. pipe nipples or open-end wrenches.

Protection against corrosion and damage

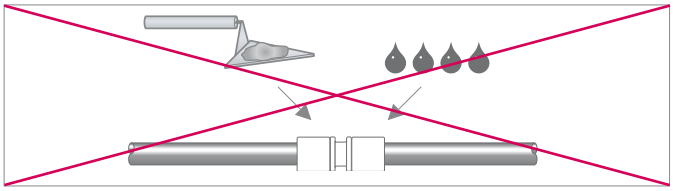


Fig. 7-27 Avoid the risk of corrosion

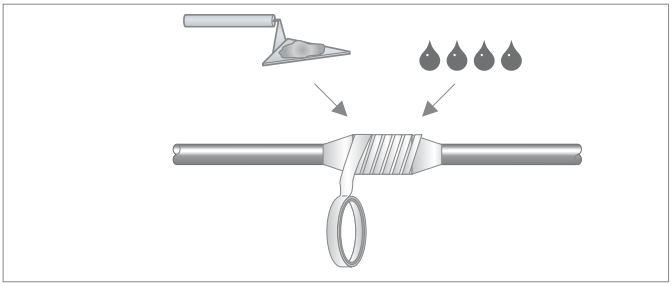


Fig. 7-28 Protect connection components against corrosion

- Use suitable sheathing to protect fittings and compression sleeves against contact with brickwork or with screed, cement, plaster, bonding agents, aggressive media and other materials and substances which can cause corrosion.
- Protect fittings, pipe and compression sleeves against humidity.
- Ensure that the employed sealants, cleaning agents, building foams, etc. do not contain any components which cause stress cracking, e.g. ammonia, ammonia-bearing, aromatic and oxygenated solvents (e.g. ketone and ether), chlorinated hydrocarbons.
- Protect fittings, pipes and compression sleeves against dirt, drilling dust, mortar, grease, oil, paint, lacquers, adhesive/protective primers, solvents, etc.
- In aggressive environments (e.g. farming, encased in concrete, seawater atmosphere, cleaning agents), protect piping and fittings against corrosion adequately and in such a way that they are sealed against diffusion (e.g. to aggressive gasses, fermentation gases).
- Protect fittings, pipes and compression sleeves against humidity.
- Protect systems against damage (e.g. during construction phase, at vehicles area, machines or farming, and from damage caused by animals).

RAUTITAN PX

- Only use leak detection agents (e.g. foaming agents) with current DVGW certification, which were also approved by the respective manufacturer for PPSU and PVDF materials.
- Only use sealants, thread sealants, adhesive tape and flux, which were approved by the respective manufacturer for PPSU and PVDF materials.
- When using the connection components, check the compatibility of materials for the corresponding area of application.
- Contact with aromatic and oxygenated solvents (e.g. ketone and ether) as well as halogenated hydrocarbons (e.g. chlorinated hydrocarbons) is not permitted.
- Contact with water-based acrylic paints and adhesive/protective primers are not permitted.

RAUTITAN SX

- Do not use sealing tape or sealants (e.g. Teflon) which release water-soluble chloride ions.
- Use sealants which do not release water-soluble chloride ions (e.g. hemp).

Water additives

Piping can be damaged if inhibitors, antifreeze agents or other water heater additives are used.

Approval must be obtained from the respective manufacturers and from our Technical Application Department.

In this case, please consult your REHAU Sales Office.

8. INSTALLATION TOOLS: RAUTOOL

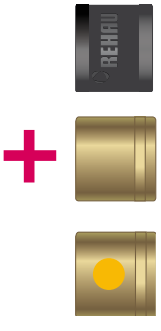
- Before using tools, read and observe the information in the operating instructions completely.
- If these operating instructions are no longer present with the tool or are not longer available, order a copy or download them from the internet.
- Do not use damaged tools or partially functioning tools; send these for repair to your REHAU Sales Office.

Operating instructions can be downloaded online from www.rehau.com.

The scope of delivery of installation tools RAUTOOL can be seen from the product book.

- RAUTOOL installation tools are specially coordinated to work with REHAU programs.
- Development and supervision directly from REHAU.
- RAUTOOL installation tools are continuously improved and further developed.
- Different drive methods of RAUTOOL installation tools can be selected.
- For joint size 16/20, 25/32 and 40:
  - Hydraulic or manual expansion is possible.
- For joint size 16 – 32:
  - Double compression jaws, two pipe sizes can be worked on without refitting the tool.
- Flexible and good tool handling.
  - Compact design.
  - Simple fitting, even in confined spaces (unfavourable fitting situations).
  - Separation of drive unit and clamping tools for hydraulic tools, RAUTOOL H1/H2, E2 and G1.
- No calibration of the pipes is necessary with the compression sleeve jointing technique from REHAU.
- Cutting of the pipes is conducted for all sizes and requires little space and time with REHAU pipe cutters. The use of roller pipe cutters is not necessary.

Notes on the compression jaws size 40

Compression jaws for RAUTITAN PX compression sleeves, size 40					
	Compression jaws, new Ø 40	Compression sleeves Ø 40		Compression jaws, old Ø 40	Compression sleeve RAUTITAN PX Ø 40
Compression jaws set 40 (Black) 201801-001 201803-001			Compression jaws set 40 (Gold-yellow) 137805-001 138223-001		
Compression jaws set M1 40 (Black) 201798-001 201804-001			Compression jaws set M1 40 (Gold-yellow) 137374-001 138333-001		
Compression jaws set G1 40 (Black) 201802-001			Compression jaws set G1 40 (Gold-yellow) 137964-001		

Tab. 8-1 Compression jaws for RAUTITAN PX compression sleeves size 40

RAUTITAN PX compression sleeve size 40 need to be compressed with the new black compression jaws size 40.

Previous compression jaws (gold-yellow) of other sizes, e.g. 16, 20, 25, 32, 50, 63, can still be used **without restriction.**

- Only compress RAUTITAN PX compression sleeve size 40 with the new RAUTOOL compression jaws (black) size 40.
- You can find more information on exchanging your old compression jaws 40 (gold-yellow) for the new ones at your REHAU Sales Office.
- Only make compression sleeve joints with RAUTOOL tools. If other tools are to be used when making the joint, these must be approved by the corresponding manufacturer for use with RAUTITAN system and especially for use with the new RAUTITAN PX fittings and compression sleeves.

Compression sleeve tools: RAUTOOL

- For RAUTITAN system
- For REHAU heating/cooling system
- For special ranges, e.g. REHAU industrial piping system, RAUTHERMEX for district heating
- Various attachment sets and accessories (see product book)

8.1 RAUTOOL M1

Fig. 8-1 RAUTOOL M1

- Manual tool
- Sizes 16 – 40

Only use compression jaws M1 with RAUTOOL M1.

8.2 RAUTOOL H2

Fig. 8-2 RAUTOOL H2

- Mechanical-hydraulic tool
- Sizes 16 – 40
- Drive with foot/hand pump

8.3 RAUTOOL A2

Fig. 8-3 RAUTOOL A2

- Battery-operated hydraulic tool
- Sizes 16 – 40
- The tool cylinder can be used optionally for hydraulic expansion
- Drive with battery-operated hydraulic unit located directly at the tool cylinder

8.4 RAUTOOL A-LIGHT

Fig. 8-4 RAUTOOL A-light

- Battery-operated hydraulic tool
- Sizes 16 – 40
- Drive with battery-operated hydraulic unit located directly at the tool cylinder
- The tool cylinder can be used optionally for hydraulic expansion

The hydraulic tools RAUTOOL H1/H2, RAUTOOL E1/E2 and RAUTOOL A-light are compatible with each other and can be equipped with the same supplementary sets. Expander tool and expander heads of expanding system RO are compatible with each other for all tools up to size 32.

8.5 RAUTOOL E2

Fig. 8-5 RAUTOOL E2

- Electro-hydraulic tool
- Sizes 16 – 40
- Drive with electro-hydraulic power unit connected by an electro-hydraulic hose to the tool cylinder
- The tool cylinder can be used optionally for hydraulic expansion

8.6 RAUTOOL G1

Fig. 8-6 RAUTOOL G1

- Tool for pipe sizes 50 – 63 (optionally available for size 40 x 5.5)
- Drive with electro-hydraulic power unit (optionally with a foot pump)
- The tool cylinder can be used optionally for expansion and clamping

9. PIPE CUTTERS

- Check the blade of the pipe cutters regularly for damage and replace the blade or the cutters as necessary. Damaged or blunt blades can cause burrs or notches on the pipe, which can tear when the pipe is expanded.
- If the pipe was cut improperly, please cut it again to ensure square and burr-free cut.
- If cracks occur at the expanded zone, cut off the damaged pipe end and repeat the expansion procedure.

Spare blades for pipe cutters can be re-ordered (except pipe cutter 25).

When cutting the pipes, observe the following:
- Use the correct pipe cutters for the corresponding pipe type only.
- Cut the pipe square and without burrs.
- Pipe cutters must be in good working condition.

Pipe dimension	to 20	to 25	to 40	40 to 63
Hot & cold water pipe his 311				
	Pipe cutter 16/20 RAUTITAN	Pipe cutter 25	Pipe cutter 40 stabil	Pipe cutter 63

Tab. 9-1 Selection of pipe cutters

9.1 PIPE CUTTERS 16/20 RAUTITAN

To be used exclusively for burr-free cutting of PE-X pipes up to size 20 (see Table 9-1 Selection of pipe cutters).

9.2 PIPE CUTTERS 25

To be used exclusively for burr-free cutting of PE-X pipes up to size 25 (see Table 9-1 Selection of pipe cutters).

9.3 PIPE CUTTERS 40 STABIL

To be used exclusively for burr-free cutting of PE-X pipes up to size 40 and for RAUTITAN stabil/RAUTITAN gas stabil sizes 25 to 40 (see Table 9-1 Selection of pipe cutters).

9.4 PIPE CUTTERS 63

To be used exclusively for burr-free cutting of RAUTITAN pipes or PE-X pipes sizes 40 to 63 (see Table 9-1 Selection of pipe cutters).

10. EXPANDER TOOLS

10.1 EXPANDER HEADS AND EXPANDER BITS FOR PIPES

	Expander heads	Expander bits	Expander head for RAUTOOL G1
Pipe sizes	16/20/25/32	40	40/50/63
Hot and cold water pipe his 311			

Tab. 10-1 Selection of expander tools

Fig. 10-1 Expander set 16/20

The expander set 16/20 can be used in combination with RAUTOOL E2 and RAUTOOL A2/A-light to expand RAUTITAN his 311.

Expander head features

- Expander head for RAUTITAN his 311, RAUTITAN pink, RAUTITAN green and RAUTITAN lilac
  - Blue colour code
  - Silver retaining nut for sizes 16 – 32
  - Expansion segments are not beveled

Notes on dual expander head 16/20

RAUTITAN pipe	Compression sleeve 16 and 20	RAUTITAN pipe	Compression sleeve 16 and 20
RAUTITAN his 311 +		RAUTITAN his 311 +	
Expander head 16 x 2.2 Art. No. 139602-001 **Expander head 20 x 2.8** Art. No. 139612-001		~~**Dual expander head** **16 x 2.2 / 20 x 2.8** Art. No. 247514-001~~	

Tab 10-2 Use of dual expander head with RAUTITAN his 311

Dual expander head 16/20 must not be used to expand RAUTITAN his 311 pipes in combination with RAUTITAN PX compression sleeve.

Information purchase of single expander head can be obtained from REHAU Sales Office.

10.2 EXPANDER BITS

When combined with RAUTOOL H1/H2, E1, E2, A1 and A2, the following expander bits can be used:

- Universal expander bit 25/32 system RO
- Expander bit 40 x 5.5

When combined with RAUTOOL A-light, use the following expander bit:

- Universal expander bit 25/32 system RO

10.3 SAFETY ADVICE ON EXPANDER HEADS

- Do not use defective expander segment or expander heads (e.g. bent, broken off, fractured)
- Ensure that expansion is even over the entire circumference of the pipe
- Discard unevenly expanded pipe ends
- Check the expander head for damage, if necessary carry out expansion test to test the expansion evenness (e.g. no grooves, no local overstretching of pipe material)
- Replace defective expander head
- Do not apply grease or similar materials to the expansion segments
- Apply grease to the cone of the expander tool
- Do not use dirty or damaged expander heads, pipes or connection components
- If cracks occur at the expanded zone or if the pipe ends were not expanded properly, cut off the damaged pipe end and repeat the expansion procedure
- Observe the allocation of expander heads to the respective pipe types and sizes.

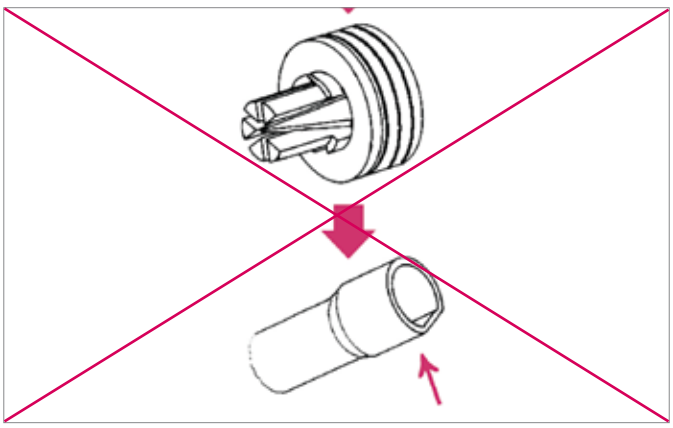


Fig. 10-2 Damage to the pipe material due to defective expander tool

Accessories (brush, lubricating grease, etc.) are included in the tool case.

11. MAKING THE COMPRESSION SLEEVE JOINT

REHAU compression sleeve jointing technology for sizes 16 – 32 mm is described below. Directions for tool handling and making the joint in other pipe sizes are described in the respective operating instructions.

- Only make compression sleeve joints with RAUTOOL. If foreign tools are to be used when making the joint, these must be approved by the corresponding manufacturer for use with RAUTITAN system and especially for use with the new RAUTITAN PX fittings and compression sleeves.
- Only make the joint with the appropriate installation tools.
- Please observe the Technical Information and the corresponding operating instructions and instruction leaflets for information on handling the tools and making joints.
- Do no use dirty or damaged connection components or tools.
- The range of connection components can be found in the latest product book.

Laying temperature

- Do not go below the minimum installation temperature of -10°C.
- Do not exceed the maximum installation temperature of +45°C.

For simpler installation in extremely low temperature (close to the minimum installation temperature), REHAU recommends using hydraulic-based operation RAUTOOL.

Operating instructions can be downloaded from www.rehau.com.

- Universal REHAU compression sleeve jointing technique
- Permanently sealed joint
- Without O-ring (self-sealing pipe material)
- Easy visual inspection
- Can be immediately pressurized
- Pipe does not need to be calibrated or deburred
- Robust jointing technique, highly suitable for construction site

11.1 CUTTING THE PIPE

1. Before beginning work, ensure that the pipe cutters are in good condition.
2. Take note of the pipe type and use the appropriate pipe cutter.
3. Cut the pipe squarely and without burrs.

   Maintain a safe distance between your holding hand and the pipe cutter.

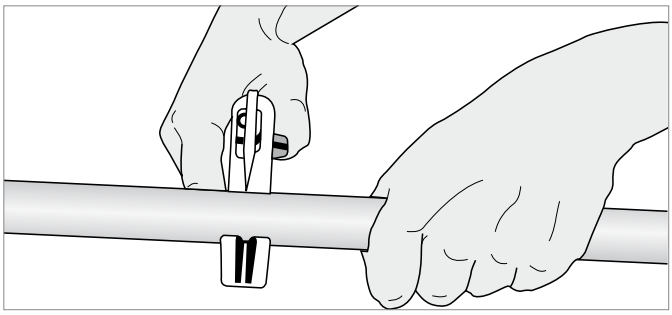


Fig. 11-1 Cut the pipe at right angle

4. Make sure that the jointing and further processing steps are carried out only on a straight pipe section (without bends).

   The straight pipe section must be at least three times the compression sleeve length.

11.2 SLIDING THE COMPRESSION SLEEVE ONTO THE PIPE

Slide the compression sleeve onto the pipe:

- **RAUTITAN PX compression sleeve** can be compressed towards the fitting from both ends, the orientation does not matter.
- **Brass compression sleeve** should be compressed with the chamfered side facing the fitting.

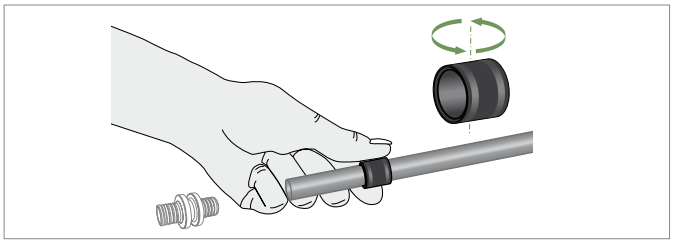


Fig. 11-2 Slide the RAUTITAN PX compression sleeve onto the pipe

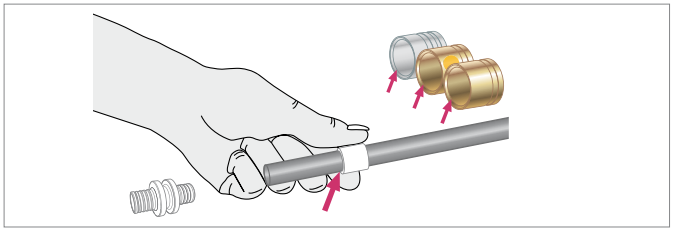


Fig. 11-3 Slide the brass compression sleeve onto the pipe with chamfered side facing the joint

Always slide the brass compression sleeve onto the pipe with the chamfered side facing the joint.

11.3 EXPANDING THE PIPE WITH EXPANDER TOOL

- Follow the safety advice of expander heads.
- Check the expander heads for freedom of movement and dirt, clean if necessary.
- Screw the expander heads fully onto the expansion tool (must not be detached when turning in the pipe).
- Maintain a minimum distance between the pipe end and the compression sleeve (at least twice the length of the compression sleeve).
- Expand the pipe at ambient temperature and insert fitting into the expanded pipe.
- Only insert compression sleeve fitting from REHAU (not other objects) into the expanded pipe end.
- Check the blade of pipe cutter regularly for damage and replace the blade or the pipe cutter if necessary.
- Expand the pipe only with a complete and intact expander head.
- If cracks occur at the expanded zone or if the pipe ends were not expanded properly, cut off the damaged pipe end and repeat the expanding procedure.

The pipe must have an even temperature before expansion. Avoid local heating (e.g. by inspection lights, etc.)

Expand the pipe at ambient temperature and insert the fitting.

1. Slide the compression sleeve onto the pipe, maintain a minimum distance between the pipe end and the compression sleeve of at least twice the compression sleeve length.

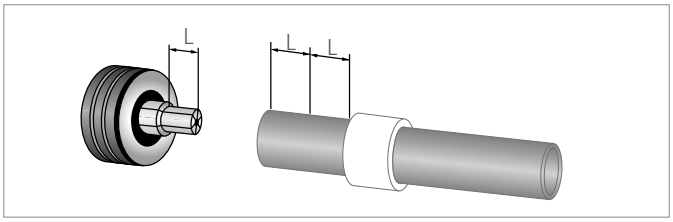


Fig. 11-4 Minimum distance between pipe end and compression sleeve

2. Always insert the segments of the expander head completely into the pipe. Avoid skewing the expander head.
3. Expand the pipe once.

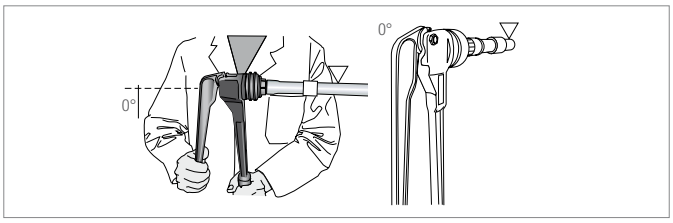


Fig. 11-5 Expand the pipe once

4. Rotate the expander tool by approximately 30°. The pipe remains in position.
5. Expand the pipe once again.

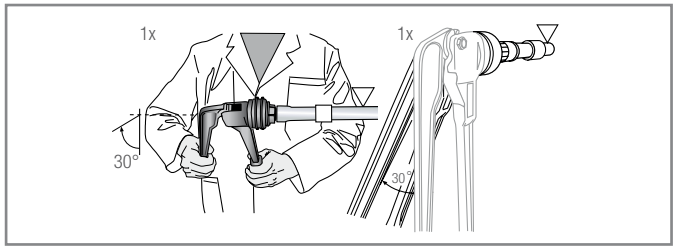


Fig. 11-6 Rotate the expander tool 30° at the same pipe position and expand the pipe once again

11.4 INSERTING THE FITTING INTO THE EXPANDED PIPE

When the pipe has been correctly expanded, the fitting can be inserted into the expanded pipe without difficulties.

After a short time, the fitting is held firmly in the pipe, as the pipe contracts (memory effect).

Handle joints which have not been clamped by the pipe contraction carefully when placing them onto the tool and during compression so that they do not fall apart.

Push the fitting completely (as far as the pre-stop) into the expanded pipe right after expansion.

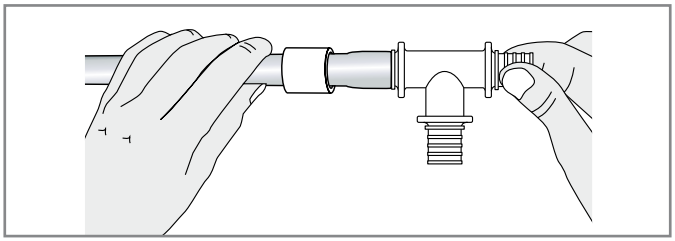
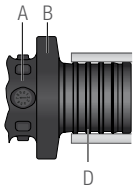
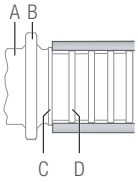
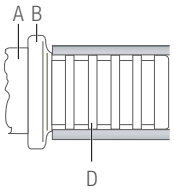


Fig. 11-7 Insert the fitting into the expanded pipe

All sealing ribs must be covered by the pipe as show in Table 11-1.

Pipe size	16 – 32	40	50 – 63
Correct position of the pipe on RAUTITAN PX fitting			
Hot and cold water pipe RAUTITAN his 311			–
Correct position of pipe on RAUTITAN MX, RAUTIAN SX, RAUTITAN RX, RAUTITAN gas fittings and heating/cooling			
Hot and cold water pipe RAUTITAN his 311			

Tab. 11-1 Correct position of pipe on fitting
A=Fitting body B=Fitting collar C=Pre-stop D=Sealing rib

11.5 PLACING THE JOINT INTO THE COMPRESSION TOOL

Place the compression sleeve joint onto the compression tool.

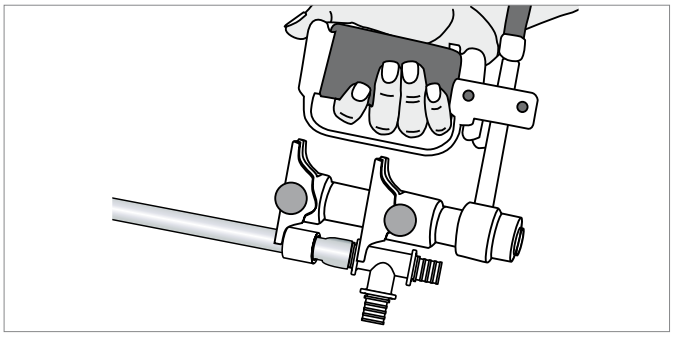


Fig. 11-8 Place the fitting and compression sleeve in between the jaws

Avoid jamming. Place the tool jaw over the entire surface and at right angle.

Bulging of the compression sleeve does not impair the quality of the joint and usually occurs when older expander heads are used.

When older expander heads are used with RAUTITAN his 311, the pipe material may pull together during compression. In this case, stop pushing the brass compression sleeve shortly before bulge (approximately 2 mm distance from the fitting collar).

11.6 COMPRESS THE COMPRESSION SLEEVE UP TO THE FITTING COLLAR

Only perform jointing on a straight pipe section (not on pipe bend). The straight pipe section must at least three times the compression sleeve length.

- Do not jam joints which are not clamped properly after placing them into the tool jaws and always maintain full contact with the tool jaws.
- Compress the compression sleeve fully up to the fitting collar.
- Do not use lubricants, water, etc. when making the compression sleeve joint.

1. Operate the pressure switch or pedal of the tool.
2. Push the compression sleeve fully up to the fitting collar.
3. Carry out visual inspection on the joint for damages and incomplete compression of the compression sleeve.

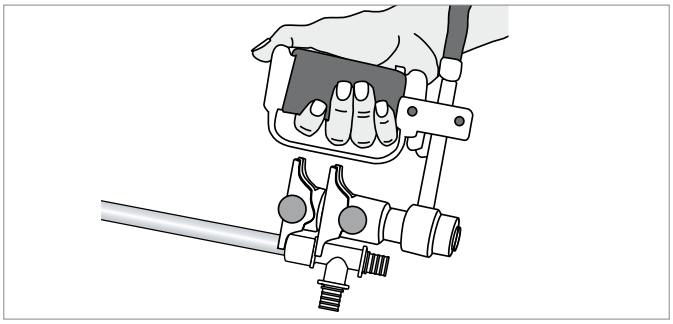


Fig. 11-9 Compress the compression sleeve

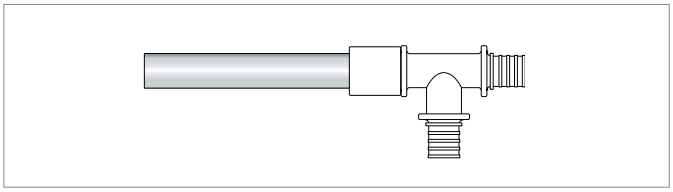


Fig. 11-10 Complete compression sleeve joint

- Clean and lubricate the tool after use.
- Store the tool in a dry place.

12. DETACHING THE COMPRESSION SLEEVE JOINT

REHAU will not accept liability if these instructions are not followed (e.g. when heating up the compression sleeve joint when attached).

12.1 CUTTING OUT JOINT

Cut the joint to be detached completely from the existing piping using the pipe cutter. Maintain a safe distance between the holding hand and the pipe cutter.

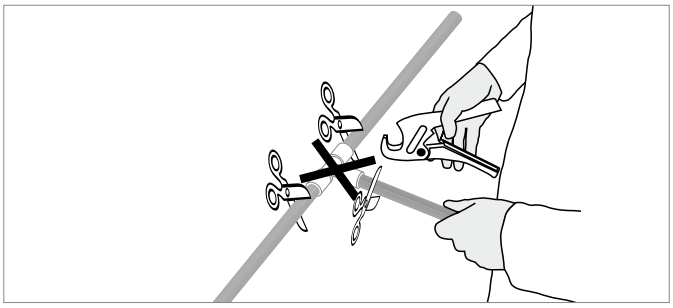
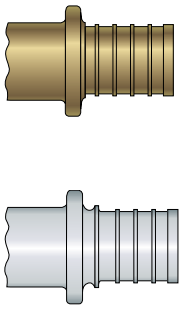
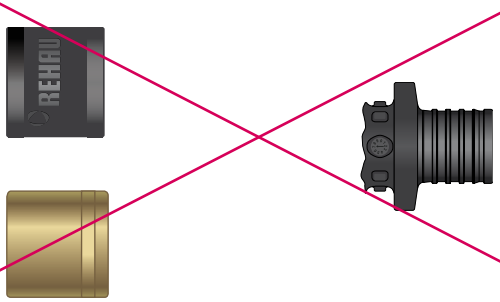


Fig. 12-1 Cutting out the joint

12.2 USABILITY OF CUT-OUT JOINTS

Usability of the parts of a detached compression sleeve joint	
Reusable	**Not reusable** Dispose of together with all cut-out pipe parts
RAUTITAN system	Compression sleeves RAUTITAN PX Fittings
	

Tab. 12-1 Usability of detached compression sleeve joints

Removed metal fittings from water installations

- Dispose used RAUTITAN PX fittings and RAUTITAN PX compression sleeves.
- Only reuse removed metal fittings in perfect condition within the same application type, from which they were removed from.
- Dispose detached compression sleeves with the detached pipe sections.

12.3 DETACHING THE CUT-OUT JOINT FROM WATER SERVICES INSTALLATION

12.3.1 HEATING THE JOINT TO BE DETACHED

Heating up the RAUTITAN PX compression sleeve to over 200°C or direct flame exposure can lead to build-up of toxic gases.

- Do not heat RAUTITAN PX compression sleeve to over 200°C.
- It is not permitted to burn or apply a flame to RAUTITAN PX compression sleeves.

1. Heat up the cut-out metal fitting with hot air blower.

   Observe the safety advice in the operating instructions of the hot air blower.
2. On reaching the temperature of approximately 135°C, remove the compression sleeve from the fitting body (e.g. with pliers).

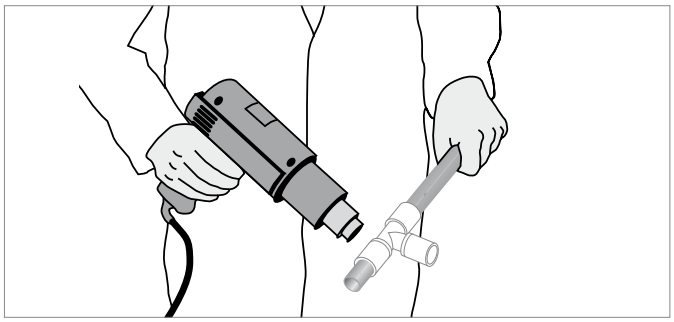


Fig. 12-2 Heating up the joint which is to be detached

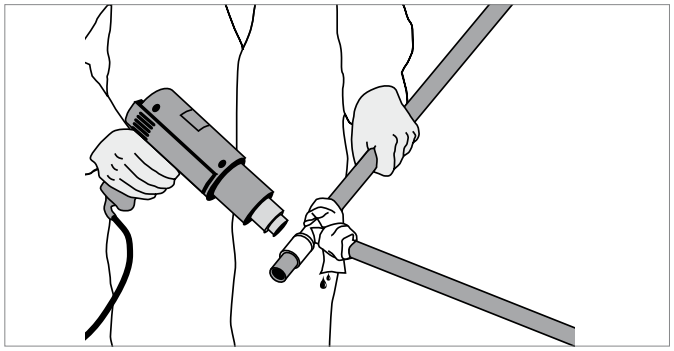


Fig. 12-3 Not permissible heating up procedure

When the joint to be detached is heated, all joints of the heated fitting are no longer sealed.

Always separate the fitting to be heated completely from the piping.

12.3.2 PULLING OFF THE COMPRESSION SLEEVES

1. Remove pipe from fitting body.
2. Clean dirt from fitting.
   - When in perfect condition and cooled, the metal fitting can be reused.
   - Do not reuse detached compression sleeves and pipe sections.
3. Dispose the compression sleeves with the detached pipe sections.

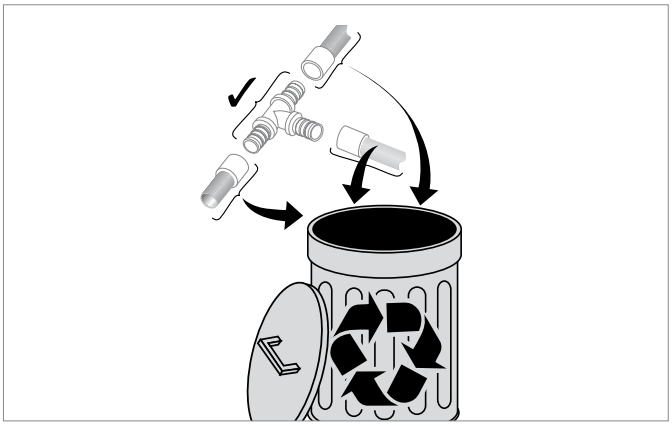


Fig. 12-4 Disposing cut out pipe sections and compression sleeves

13. BENDING THE PIPES

13.1 BENDING RAUTITAN HIS 311 PIPE

Fig. 13-1 Pipe bend bracket for plumbing (3-4 x d), 90° and 45° for sizes 16 – 32

Fig. 13-2 Pipe bend bracket for plumbing (5 x d), 90° and 45° for sizes 16 – 25

Fig. 13-3 Pipe bend bracket for plumbing (4 x d) 90° and pipe bend bracket for plumbing (5 x d) 90°, each in size 32

Elbow fitting is not always required for sizes 16 to 32. With pipe bend brackets, 90° and 45° bend can be formed at ambient temperature quickly and easily.

For pipe size 40 to 63, we recommend using elbow fittings.

Minimum bending radius

When manual bending by hand is done, the minimum bending radius is eight times the outer pipe diameter.

When installing with pipe bend brackets, the minimum bending radius in plumbing installations is three times the outer pipe diameter, and for heating installations is five times the outer pipe diameter.

The minimum bending radius is with measured respect to the centre of the pipe.

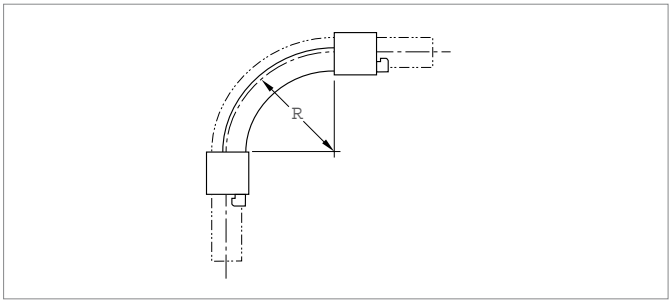


Fig. 13-4 Pipe bend bracket for plumbing 90° for size 16 – 32 and pipe bend bracket for plumbing (5 x d) 90° for size 32.
R = Bending radius

Pipe	Drinking water installation with pipe bend bracket for plumbing 90° approximately 3-4 x d		Drinking water and heating installation with pipe bend bracket for plumbing/heating 90° 5 x d		Bent by hand (90°) 8 x d	
RAUTITAN his 311	Hot & cold water pipe		Hot & cold water pipe		Hot & cold water pipe	
Pipe size	Bending radius R	Arc B	Bending radius R	Arc B	Bending radius R	Arc B
16	48	75	80	126	128	201
20	60	94	100	157	160	251
25	75	118	125	196	200	314
32	112	176	160	251	256	402

Tab. 13-1 Minimum bending radius for RAUTITAN his 311 pipes

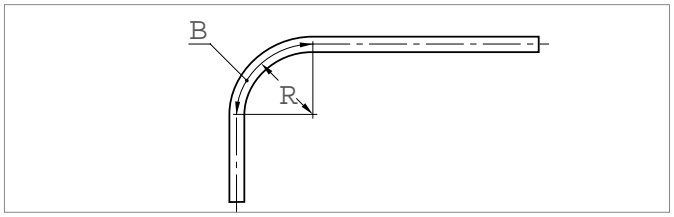


Fig. 13-5 R = Bending radius
B = Arc

14. REHAU SUPPORT CHANNEL

14.1 BENEFITS OF USING REHAU SUPPORT CHANNEL

- Reduces thermal expansion length
- Clip effect increases the axial retaining force
- Stabilizes the pipes against sagging and sideways bending
- Increases rigidity
- Increases the pipe clamp interval to 2 m regardless of the pipe size
- Visually appealing installations in exposed areas with RAUTITAN his 311 pipes
- Simple assembly
- Self-supporting
  - Clipped onto the pipe
  - No additional fastenings required (e.g. cable ties, insulating tapes)
- Cut-offs of the pipe support channel can still be used

14.2 FUNCTIONALITY

The REHAU support channel covers the pipe by about 60% and is shaped to closely encase the pipe without additional fastenings. This strong clamping effect prevents the pipe from bending and reduces thermal expansion in length.

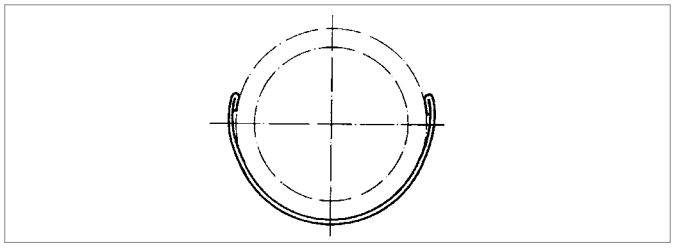


Fig. 14-1 Cross-section of pipe support channel

14.3 ASSEMBLY OF REHAU SUPPORT CHANNEL

Do not fit support channel or pipe fasteners close to the deflection legs so the pipe can still bend.

Pipe cover

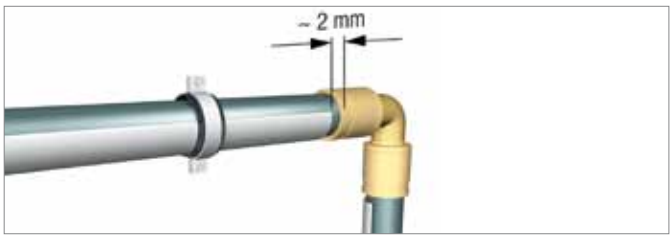


Fig. 14-2 Let the REHAU support channel end approximately 2 mm before the compression sleeve

The support channel must be fitted over the entire length of the piping up to 2 mm before the compression sleeve, as only this ensures reduction of the thermal expansion length.

Pipe clamp intervals

Fig. 14-3 Maximum pipe clamp intervals

The maximum pipe clamp interval when using the support channel is 2 m for all sizes. The distance from the pipe end, or when changing direction, to the first pipe bracket may not exceed 0.5 m. This way, pipe brackets for pipe routing or in cellars can be attached in a uniform and effective manner.

Fitting cover

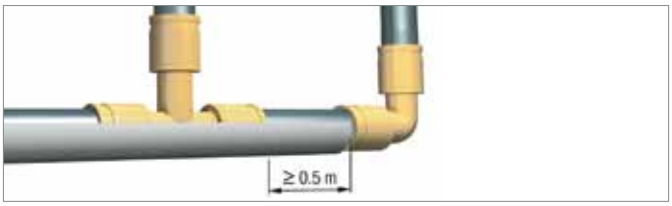


Fig. 14-4 Minimum overlapping of 0.5 m

Fittings with brass compression sleeve sizes 50 and 63 can be clipped by the support channel if the pipe support channel projects at least 0.5 m beyond the compression sleeve. With this kind of installation, cutting off the support channel at the fitting is not necessary.

When using RAUTITAN PX compression sleeves, clipping over the fitting is not possible.

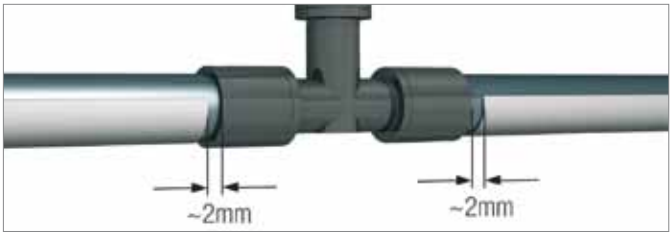


Fig. 14-5 Do not clip over RAUTITAN PX compression sleeve

Assembly of the REHAU support channels

Reduced retaining force of the support channel can cause greater thermal expansion of the pipe.

Do not lessen the retaining force of the pipe support channels by storing or assembling them improperly.

1. Cut off the support channel with a metal saw (see Figure 14-6). Maintain a safe distance between the holding hand and the cutting tool. Saw pipe support channels from the rear side, not the open side so that they are not bent open at their bordered ends.

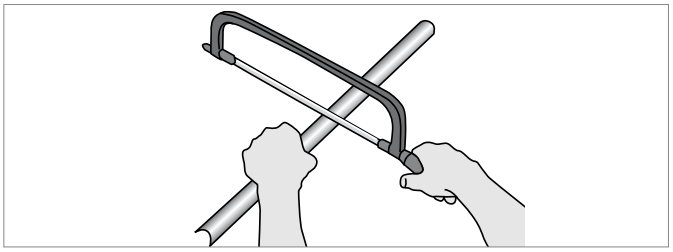


Fig. 14-6 Cutting off pipe support channel

2. If the support channel has been bent inwards or outwards when it was cut to length, bend the pipe support channel back to its original shape.
3. Deburr the ends of the pipe support channel.

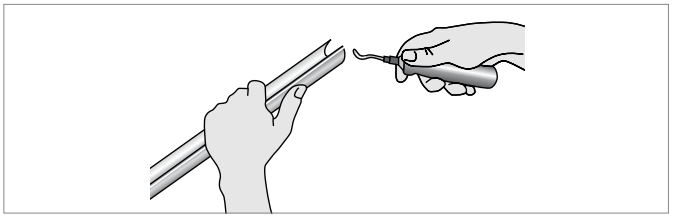


Fig. 14-7 Deburring of pipe support channel

4. Clip the pipe support channel onto the pipe (by hand or using a pliers or pipe wrench with plastic jaws).

   Do not overlap the ends of support channels.

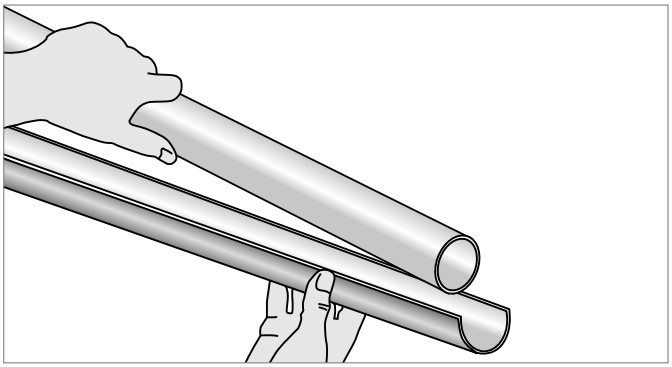


Fig. 14-8 Clipping in pipe support channel

5. To join support channels together, use cut-offs clipped over both ends.

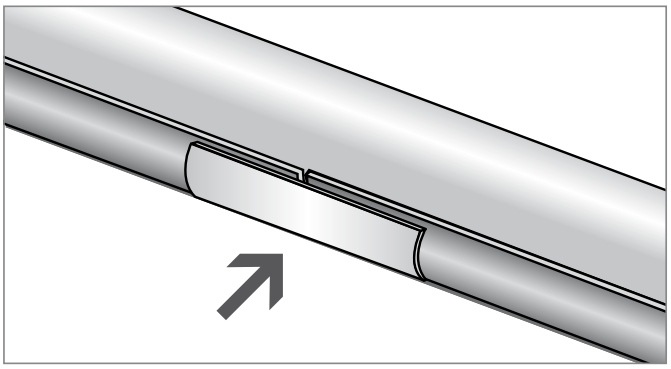


Fig. 14-9 Joining two pipe support channels

Even short cut-offs of support channel can be used for clipping over joints, ensuring an almost waste-free installation.

15. PLANNING AND DESIGN

15.1 STANDARDS AND GUIDELINES

RAUTITAN system for water services must be planned, calculated, installed and operated according to national water services installation standards/regulations and other relevant standards.

RAUTITAN plumbing system

RAUTITAN his 311 plumbing system must be installed according to national water services installation standards/regulations. It can be used for hot and cold water services with normal operating temperature of 70°C and can also temporarily withstand temperature of up to 100°C. It can also be operated at a pressure of up to 2.0 MPa for PN20 system.

The complete RAUTITAN his 311 system is designed for installation in new buildings, and for carrying out renovations and repairs. It is suitable for drinking water systems in buildings for residential, industrial and commercial use such as hospitals, schools, kindergartens, sports halls, churches, aged care facilities, supermarkets and services stations, as well as industrial premises, etc.

15.2 APPROVAL AND CERTIFICATIONS

The complete range of RAUTITAN pipes and fittings comply with international and national standards and fully certified:

- RAUTITAN his 311 system complies with ISO 15875 Plastic piping systems for hot and cold water installations – Crosslinked polyethylene (PE-X).
- RAUTITAN his 311 system complies with BS 7291 Thermoplastics pipes and associated fittings for hot and cold water for domestic purposes and heating installations in buildings.
- SAI Global Product Certification for sizes 16 - 63 mm (WaterMark LN 1413)
- AS 2492 for crosslinked polyethylene (PE-Xa) pipe for hot and cold water application and AS 2537 for mechanical jointing fittings for use with crosslinked polyethylene (PE-Xa) pipe for hot and cold water applications.

15.3 OPERATING PARAMETERS

For continuous operation, the following parameters must not be exceeded.

Continuous operating temperature	Maximum 70°C
Continuous operating pressure	Maximum 10 bars
Minimum designed service life	50 years

Tab. 15-1 Parameters for continuous operation

For operating parameters higher than specified in Table 15-1, please consult your REHAU Sales Office.

15.4 REQUIREMENTS OF DRINKING WATER

The drinking water must comply with the currently valid limits of the following standards:

- DIN 2000
- German drinking water ordinance[1)]
- Council directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption

In locations with highly corrosive water composition, e.g. in volcanic areas, installations using bore/well water etc., the suitability of RAUTITAN pipe system must be checked with REHAU. In some cases, the available water quality may void the REHAU warranty unless appropriate water treatment is provided.

With its RAUTITAN MX fittings made of dezincification-resistant brass, REHAU satisfies the highest requirements category according to DIN EN 12164, DIN EN 12165, and DIN EN 12168 and continues to develope these further in order to meet the increasing quality demands.

Nonetheless, there is no fundamentally ideal material for every application. Thus, different influential factors can lead to corrosion in drinking water installation, regardless of the materials used.

In some specific cases, corrosion can happen even with water qualities within the permitted range of the drinking water ordinance.

The chloride concentration and the hydrogen carbonate concentration of the water have considerable influence on how aggressive the corrosion is. High chloride concentration combined with low hydrogen carbonate concentration can negatively influence the corrosion behaviour.

However, the interaction under the following factors, according to DIN EN 12502-1:2005 (D), also influence the corrosion resistance:

- Material properties (chemical composition, surface integrity)
- Water quality (physical and chemical properties, solid matter)
- Planning and execution (geometry, mix installation, connections)
- Leak testing and initial start-up (purging, drainage, disinfection)
- Operating conditions (temperature, temperature changes, flow conditions)

The application of water after-treatment (e.g. water softening), in principle, changes the corrosive-chemical behaviour of the water. To avoid corrosion damage as a result of incorrect use and operation of a water treatment system, we explicitly recommend that you have your individual situation examined before hand by an expert or the system manufacturer.

The most practical way of evaluating the likelihood of corrosion due to water quality is to test the water which is to be distributed to the area.

It is the responsibility of the system designer that the above-mentioned factors and parameters are taken into account when it comes to corrosion protection and sediment formation in actual application.

Our Technical Application Department for RAUTITAN application area provides support when needed.

If the drinking water quality is outside the limits of the drinking water guidelines, evaluation and approval is definitely required from our Technical Application Department if the RAUTITAN system is intended to be used.

In this case, please contact your REHAU Sales Office.

1) The limit values for maximum disinfection agent concentrations detailed in the drinking water ordinance are not to be interpreted as permanent, lasting application concentrations. They represent the temporary maximum values defined under hygienic and toxicological aspects. Top priority of the drinking water ordinance is the principle of minimization, that is, nothing should be mixed into the water. Only if a chemical additive is required due to contamination may the minimum amount required be mixed in.

15.5 DISINFECTION

REHAU pipes intended for drinking water together with the compression sleeve jointing technique without O-ring help to keep the hygiene level of drinking water installation. They correspond to the KTW guidelines of the German Federal Environment Agency and satisfy the requirements of the DVGW worksheet W 270. Thus, they are suitable for fields of application with special hygiene requirements when it comes to drinking water. It has been proven that RAUTITAN pipes for water services and heating installation do not cause any multiplication of micro-organisms and thus do not support microbial contamination or legionella growth.

Due to **errors made during planning, construction and operation, during stagnation or substandard water quality** (e.g. wastewater, floodwater, maintenance works on the piping network) contamination can occur. Furthermore, damage to the piping network, e.g. a supply line with external water inflow, can be the cause of possible contamination.

The disinfection of drinking water installation is only necessary in exceptional cases (in the case of contamination) and all operational and structural engineered system deficiencies are to be rectified first.

Repeated or constant bacterial exposure of domestic water installation is often caused by the installation method (e.g. stubs) or by the operation method (e.g. long stagnation periods), as such that continuous disinfection is not justifiable.

15.5.1 THERMAL DISINFECTION IN CASE OF CONTAMINATION

For drinking water installations in compliance with the latest technical standards (no stubs, etc.), removal of dirt can be done by thorough water rinsing as long as the dirt is water-soluble or remains soluble in water.

If contamination is suspected, an additional thermal disinfection as per DVGW worksheet W 551 is possible as a sensible and urgent measure. According to the latest technological standards, for water with temperature of at least 70°C, it is very likely that germs and bacteria, including legionella which is found freely in water will be killed off. **It is important that the appropriate measures have to be taken to avoid scalding to people.**

All RAUTITAN piping system for water services and heating installation are suitable **for multiple thermal disinfections according to DVGW worksheet W 551 at 70°C**. It must be ensured that the allowable operating pressure is not exceeded during thermal disinfection.

15.5.2 CHEMICAL DISINFECTION IN THE CASE OF CONTAMINATION

Alongside with thermal disinfection, chemical disinfection is being used more and more. Chemical and thermal disinfection measures always strain the materials used in water services installation. According to today's level of awareness, some disinfection measures are not suitable for standard materials in installation technology. This also applies to materials, for which it was previously assumed that they were sufficiently corrosion-resistant, e.g. stainless steel, copper and some synthetic materials.

Before introducing these types of process measures, it needs to be ensured that all parts of the installation system are thermally and chemically suited for the corresponding measure. This is regulated by DVGW worksheet 551. If necessary, please have the suitability of the disinfectant approved by the disinfectant's manufacturer for all system parts of the installation.

15.5.2.1 CHEMICAL "POSTRINSE DISINFECTION"

For short-term chemical disinfection (postrinse disinfections), only special active ingredients may be used which are specified in corresponding rules and standards.

Carrying out the disinfection measures according to the specifications of DVGW worksheet W 291 can be done without impairing the functionality of REHAU drinking water installation if the active ingredients, concentrations, application duration and maximum temperatures are observed (as listed in Table 15-2)

It should be noted that combining thermal-chemical disinfection at temperatures of higher than 25°C, as well as permanent or regular disinfection cycles (e.g. monthly), are not permitted. In relation to the lifespan of the piping, the total number of disinfection cycles is limited to five "postrinse disinfections". Otherwise, it cannot be guaranteed that the specified lifespan will be reached.

The person carrying this out must guarantee that the water is not used for human consumption (e.g. as drinking water) at any time during the disinfection phase, including the subsequent rinsing phase.

Description	Commercial size and packing	Storage	Safety advice [1]	Max. application concentration [2] Application duration and temperature in the piping
Hydrogen peroxide **H_2O_2**	Hydrous solution in various concentrations	Light-protected, cool, avoid contamination at all costs	With >5% solutions, protective equipment necessary	150 mg/l H_2O_2 Max. 12h Tmax ≤ 25 °C
Sodium hypochlorite **NaOCl**	Hydrous solution with maximum 150g/l chlorine	Light-protected, cool, sealed and in a collecting reservoir	Alkaline, corrosive, toxic, protective equipment necessary	50 mg/l chlorine Max. 12h Tmax ≤ 25 °C
Calcium hypochlorite **$Ca(OCl)_2$**	Granules or tablets approx. 70% $Ca(OCl)_2$	Cool, dry and sealed	Alkaline, corrosive, toxic, protective equipment necessary	50 mg/l chlorine Max. 12h Tmax ≤ 25 °C
Chlorine dioxide **ClO_2**	Two components (Sodium chloride, sodium peroxide sulphate)	Light-protected, cool and sealed	Oxidizing effect, do not inhale chlorine dioxide, protective equipment necessary	6 mg/l ClO_2 Max. 12h Tmax ≤ 25 °C

Tab. 15-2 Chemical postrinse disinfections, active ingredients and concentrations according to DVGW W 291

[1] The corresponding notes in the safety data sheets of the manufacturer must be adhered to.

[2] REHAU approval: this value may not be exceeded at any stage of the entire application duration of the installation.

15.5.2.2 CONTINUOUS CHEMICAL DISINFECTION

We **cannot** recommend using **indefinite chemical disinfection** in domestic installation, especially as a preventive measure for legionella prophylaxis, due to the possible occurrence of material damages to installation components. We cannot provide any guarantees in these cases.

In some cases, it may be the case that chemical disinfection may be necessary for a long time, but finite period of time, until structural decontamination has been completed. These disinfection measures may only be carried out if the permitted method is used. The parameters listed in Table 15-3 must be monitored and documented for the full duration of the disinfection measure, immediately after the dosing point. If the active ingredients, concentrations, application durations and maximum temperatures as listed in Table 15-3 are adhered to, execution without impairing the functionality of REHAU drinking water installation is possible.

Description[1)]	Max. application concentration[2)]	Max. application duration in the piping[3)]	Application temperature in the piping
Chlorine Cl_2	Max. 0.3 mg/l Free chlorine	4 months	60°C
Calcium hypochlorite $Ca(OCl)_2$	Max. 0.3 mg/l Free chlorine	4 months	60°C
Chlorine dioxide ClO_2	Max. 0.2 mg/l ClO_2	4 months	60°C

Tab. 15-3 Chemical disinfection with finite period according to drinking water ordinance 2001

1) The corresponding notes in the safety data sheets of the manufacturer must be adhered to.

2) REHAU approval: this value may not be exceeded at any stage of the entire application duration of the installation.

3) Maximum application duration is an accumulation of the entire system lifespan.

In relation to the lifespan of the pipe, the full application duration is limited to four months. Otherwise, it cannot be guaranteed that the specified lifespan will be reached.

We generally exclude other non-listed disinfectant from being used, especially strong oxidants (e.g. ozone).

Erroneously listed chemical and thermal disinfection measures can lead to permanent damage to drinking water installation components.

Before introducing these types of methodological measures, it needs to be ensured that all parts of the installation system are thermally and chemically suitable for the corresponding measure. If necessary, please have this approved by the disinfectant's manufacturer.

With thermal disinfection, it is important that the appropriate measures be taken to avoid scalding to people.

When carrying out chemical "postrinse disinfection" it must be guaranteed that water is not used for human consumption (e.g. as drinking water) at any time during the disinfection phase, including the subsequent rinsing phase.

The safety advice from the disinfectant manufacturer must be observed.

15.6 IMPORTANT ADDITIONAL INFORMATION ON THE CURRENT DRINKING WATER ORDINANCE AND DIN 50930 PART 6

A new drinking water ordinance was issued based on the drinking water directive 98/83/EC. This came into force on 1 January 2003.

In August 2001, DIN 50930 (Corrosion of metals – corrosion of metallic materials under corrosion load by water inside of tubes, tanks and apparatus) was supplemented by Part 6 – Influence of the properties of drinking water.

The notes below provide you with additional information on the new guidelines:
- New drinking water ordinance dated 21 May 2001
- DIN 50930 Part 6, August 2001

Notes on the new drinking water ordinance dated 21 May 2001

Basis: EU drinking water directive 98/83/EC dated 3 Nov 1998 Implementation in German law with the revised drinking water ordinance on 21 May 2001.

Significant revisions for piping and fitting materials:
- The limits for lead emission and nickel to the drinking water were substantially reduced.
- The recommendation for copper was replaced by an explicit limit.
- The requirements no longer apply only up to domestic mains connection as in the past, but also to the entire domestic installation.
- Compliance with the values (drinking water ordinance) for water supply system in public facilities (schools, hospitals, public houses, etc.) will be monitored by the health authorities.

Notes on DIN 50930 Part 6 dated August 2001

Piping materials

REHAU piping made of crosslinked polyethylene

RAUTITAN pipes for water services and heating installation have been tested continuously for years by a neutral institute with regard to the changes in water properties for the purpose of DVGW registration. There is still no restriction for these pipes to be used in drinking water application with regard to the quality of drinking water.

Copper piping

For bright copper pipes, usage at pH values under 7.4 with a simultaneously high content of organically bonded carbon (TOC, particularly in certain regions of northern Germany) is not permitted without individual tests, i.e. the use of copper must be verified by the installer.

Fittings in drinking water systems

With respect to the current drinking water ordinance, the maximum lead content of the raw materials for fittings made of dezincification-resistant brass was restricted to a maximum of 2.2% and a maximum of 3% for gunmetal.

These revisions in the raw materials are applicable since the drinking water ordinance was introduced on 1 January 2003.

Fittings from RAUTITAN system for water services and heating installation
The current fittings for RAUTITAN system for water services and heating installation correspond to the latest requirements.

Nickel-plated fittings

Fittings with nickel-plated surfaces have been defined as generally unsuitable. As the “technical rules” must be fulfilled on behalf of the client within the premises of work contracts, the use of nickel-plated fittings in drinking water installation should be avoided.

Conclusion

With the publishing of DIN 50930 in August 2001, it has become a part of the “generally acknowledged technical rules”. As these must be fulfilled on behalf of the client within the premises of work contracts, failure to observe them may become critical and expensive for the installer.

Apart from the drinking water ordinance and Part 6 of DIN 50930, further stringency must be anticipated due to the ever decreasing water quality (mixing of water and, among others, the risk of corrosion).

Consult your REHAU Sales Office if you have any enquiries.

15.7 WATER HAMMER

The low elastic modulus of PE-Xa pipes and their ability to expand quickly and contract slowly enables the pipes to absorb water hammer effectively. In cold water service installations, the water hammer effect can be reduced by up to 75% compared to metal pipe installations.

15.8 PIPE SIZING

- Because of its unique jointing system, RAUTITAN system can achieve satisfactory performance levels at small bore sizes.
- The excellent corrosion and incrustation resistance of PE-X pipe ensures the bore size is maintained even after years of service. This means no extra allowance for pipe size is required.
- The final performance will strongly depend on the available mains pressure, the location (e.g. on top of a hill) and overall size of the building and how many bathrooms and outlets the pipe system has to supply.

To avoid unnecessary large pipe sizes, REHAU recommends carrying out pipe sizing based on REHAU pressure loss tables (available in Appendix A).

16. INSULATION

16.1 THERMAL INSULATION

Thermal insulation may be required to reduce heat loss through the pipe.

In cold water installations, the likelihood of pipe damage due to freezing can be reduced. It is, however, not possible to prevent static water from freezing completely. For longer periods during which freezing is likely to occur, pump warm water periodically through the pipe system. Alternatively, the complete system could also be drained.

Table 16-1 may be used to aid heat loss calculation.

Insulation	None		9 mm		25 mm	
Dimension mm	PE-X W/m	Copper W/m	PE-X W/m	Copper W/m	PE-X W/m	Copper W/m
16 x 2.2	31.3		11.2		7.1	
12.7 x 0.91		27.2		10.0		6.5
20 x 2.8	36.8		12.9		8.0	
19.05 x 1.02		38.3		13.0		8.0
25 x 3.5	43.3		14.9		9.0	
25.4 x 1.22		48.9		15.9		9.4
32 x 4.4	51.8		17.7		10.4	
31.75 x 1.22		59.2		18.7		10.7
40 x 5.5	60.2		20.8		12.0	
38.1 x 1.22		69.2		21.5		12.0
50 x 6.9	69.8		24.5		13.7	
50.8 x 1.22		88.6		27.0		14.6
63 x 8.6	80.9		29.1		16.1	

Tab. 16-1 Heat losses per meter of PE-X and copper pipes

The heat losses are calculated based on:

- ISO 12241 (Thermal insulation for building equipment and industrial installations – calculation rules)
- Horizontal pipe installation indoors in still air
- Laminar air flow over pipe/insulation
- Internal heat transfer coefficient larger than 1000 W/m^{2}K
- Water temperature of 65°C
- Ambient temperature of 20°C
- Emissivity of:
  - 0.77 for copper (strongly oxidized)
  - 0.93 for polymer piping
  - 0.90 for insulation
- Thermal conductivity of:
  - 380 W/mK for copper pipes
  - 0.35 W/mk for PE-X pipes
  - 0.04 W/mK for insulation

Although PE-Xa pipe is polymeric in nature and its thermal conductivity is more than 100 times lower compared to metallic pipes, it cannot be automatically assumed that no insulation is required.

16.2 ACOUSTIC INSULATION

Sound is conducted through the pipe wall as well as through the flowing water itself. The sound is then transmitted into the building fabric through the pipe, brackets and clips. Walls, ceilings, etc. start to vibrate and emit sound themselves.

Compared to metal pipe, PE-Xa pipes transmit significantly less impact sound. To obtain independent test results, REHAU commissioned the Acoustic Division of the Fraunhofer Institute for Structural Physics, Stuttgart to conduct a study of the sound level differences of PE-Xa, copper and galvanized steel pipes.

Three common pipe diameters were compared under identical conditions such as flow pressure and flow rate.

Overall, the report established that PE-Xa pipes generate up to four times less noise (sound level difference LA = 12.7 dBA) than the metal pipes (see Figure 6-1). A complete copy of the report is available on request from REHAU.

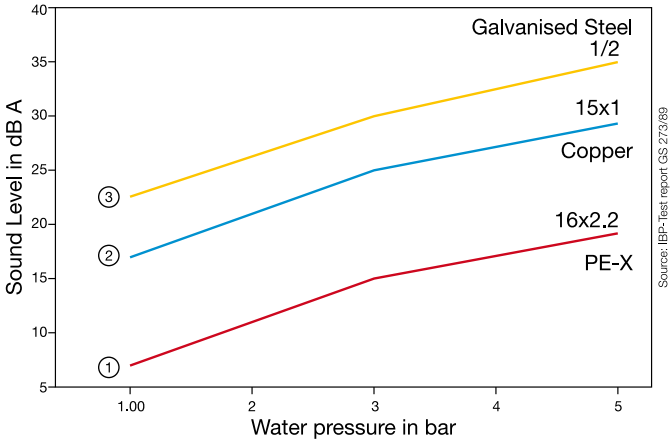


Fig. 16-1 Result of acoustics report from Acoustics Division of the Fraunhofer Institute of Structural Physics

17. PIPE SUPPORT AND FIXING

17.1 PIPE BRACKETS AND CLIPS

Use only pipe brackets and clips with the following properties:

- Suitable for plastic pipes
- Improved acoustic properties through rubber lining
- Correct size (to allow easy gliding of pipe without pulling the rubber lining out)
- Free of burrs

17.2 ANCHOR POINTS

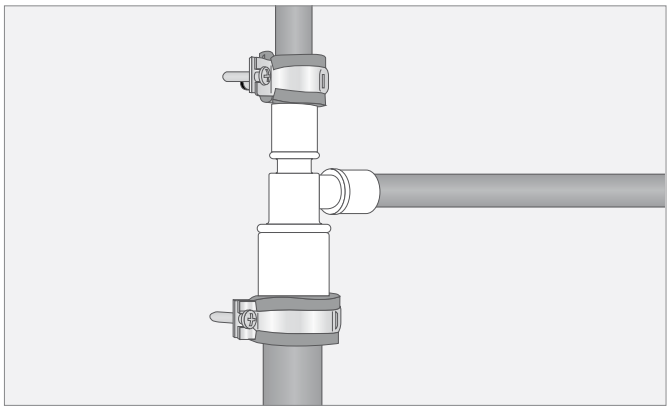
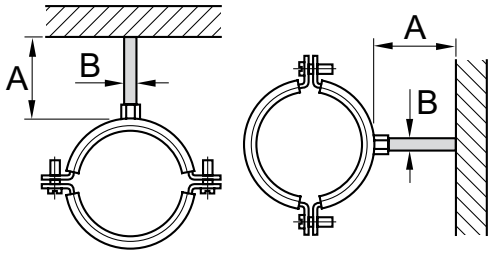


Fig. 17-1 Anchor point made by pipe clamps

- Observe the instruction and guideline from the pipe bracket/clip manufacturer.
- Adapt the guideline values for design and installation of pipe brackets and clip (as per Table 17-1) to the building requirements and bracket/clip manufacturer's recommendations.
- Anchor points can be used to restrict the thermal linear expansion into one direction.
- Long pipe run can be divided into several sections by adding several anchor points.
- Anchor points can be fixed at tees, elbows or connectors. Anchor points can be fixed by installing a pipe bracket directly before each compression sleeve of the fitting.

Do not install pipe brackets on the compression sleeves.

Pipe size [mm]	**B** Thread diameter or pipe nipple diameter	**A** Maximum distance of wall/ceiling to the pipe clamp [mm]
		
16	M8	100
	M10	150
	M12	200
	M16	300
20	M10	100
	M12	150
	M16	250
25	M12	100
	M16	200
32	M16	100
	R ½	150
40	R ½	100
	R¾	150
	R1	220
50	R¾	100
	R1	200
63	R1	150

Tab. 17-1 Guideline values for fixing parameters of anchor points

17.3 SPACING OF BRACKETS AND CLIPS

Choose the correct pipe spacing intervals according to the guideline values (see Table 17-2) for installation with or without pipe support channels.

17.4 EXPOSED INSTALLATION

When installing pipe at exposed areas or installing long piping without change in direction, we recommend using pipe support channel for RAUTITAN his 311 pipes.

- For installation without pipe support channel, install anchor points at 6 m intervals.
- Ensure that there is sufficient space for piping to expand.

For installation of RAUTITAN his 311 pipes without pipe support channel, pipe sagging is to be anticipated.

Pipe	Size	l = Maximum pipe bracket distance (m)	
	(mm)	Without support channel	With support channel
RAUTITAN his 311	16	1	2
	20	1	2
	25	1.2	2
	32	1.4	2
	40	1.5	2
	50	1.5	2
	63	1.5	2

Tab. 17-2 Recommended spacings of pipe bracket/clip for RAUTITAN his 311 pipes

18. THERMAL LENGTH CHANGES

18.1 GUIDELINES

Due to physical laws, all piping materials expand when heated and contract when cooled. This effect, which occurs regardless of the piping material, must be taken into account in the installation of water services, heating installation and gas piping. This also applies to RAUTITAN piping systems.

The thermal expansion and contraction occur mainly due to the different installation, ambient and operating temperatures. During installation, appropriate pipe routing with provisions for movement (e.g. at changes of direction) and corresponding space for piping expansion must always be taken into account. Additional deflection legs e.g. U-expansion bends or lyre loops are usually only necessary for larger changes in length.

18.2 BENEFITS

- Low thermal expansion/contraction when installing with:
- RAUTITAN his 311 pipes with REHAU support channel
- Short deflection legs is possible with flexible RAUTITAN his 311 pipes
- Simple installation of REHAU support channel

18.3 CALCULATION OF LINEAR THERMAL EXPANSION

The thermal change in length is calculated with the following equation:

ΔL = Length change in mm

α = Coefficient of linear thermal expansion in $\frac{mm}{m.K}$

L = Length of piping in m

ΔT = Temperature difference in K

The coefficient of linear thermal expansion must be selected according to the installed pipe type and if REHAU pipe support channel is installed.

Determining the pipe length

The pipe length L is the actual installed pipe length on site between anchor points, expansion bends or loops. Sometimes it may be necessary to divide the pipe run into several sections by adding anchor points or expansion bends and loops to keep the thermal expansion low.

Determining the temperature difference

In determining the temperature difference , the installation temperature as well as the minimum and maximum temperatures of the pipe wall during operation (e.g. thermal disinfection) and when the system is out of service must be taken into account in the calculation.

Pipe type	Size	Coefficient of linear thermal expansion α $[\frac{mm}{m.K}]$	Material constant C
		$\Delta L = \alpha \cdot L \cdot \Delta T$	$L_{BS} = C \cdot \sqrt{d_a \cdot \Delta L}$
RAUTITAN his 311	16 – 63 without REHAU support channel	0.15	12
	16 – 40 with REHAU support channel	0.04	-
	50 – 63 with REHAU support channel	0.1	-

Tab. 18-1 Coefficient of linear thermal expansion (approximate values) and material constants for deflection leg calculation (approximate values)

19. DEFLECTION LEGS

Thermal length changes can be accommodated by deflection legs. RAUTITAN his 311 pipes are particularly suitable for this due to their flexibility.

A deflection leg is the freely moveable pipe length, which can take up the required thermal length changes. The length of the deflection leg is influenced mainly by the material (material constant C).

Deflection legs result mostly from changes in direction of the piping. For long piping lengths, additional deflection legs must be installed in the piping to compensate the thermal length changes.

Do not fit pipe support channels or pipe brackets close to the deflection legs so it will not be prevented from bending.

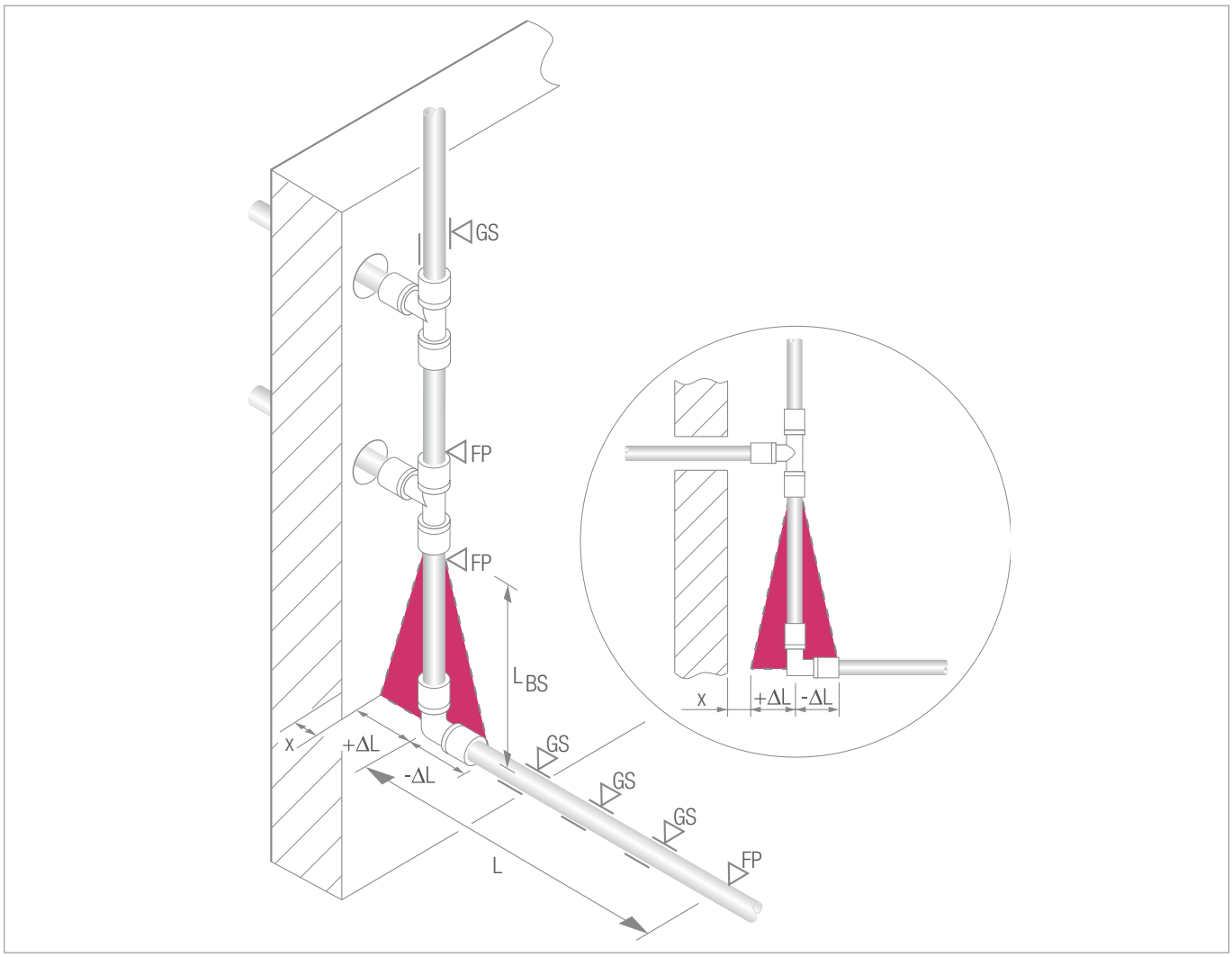


Fig. 19-1 Deflection legs

L_{BS}	Length of deflection leg	x	Minimum distance of the pipe from the wall
ΔL	Thermal length change	FP	Anchor point
L	Pipe length	GS	Sliding point

19.1 CALCULATION OF DEFLECTION LEG LENGTH

The minimum length of deflection length (BS) is calculated by the following formula:

$L_{BS} = C \cdot \sqrt{d_a \cdot \Delta L}$

L_{BS} = Length of deflection leg

d_a = Outside pipe diameter in mm

ΔL = Length change in mm

C = Material constant of piping material

For approximate values for material constant C, see Table 19-1.

Do not fit pipe support channels or pipe brackets close to the deflection legs so it will not be prevented from bending.

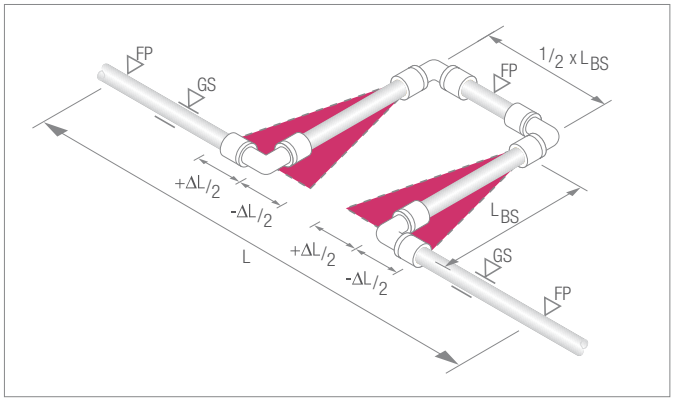


Fig. 19-2 U expansion bends

L_{BS} = Length of deflection leg

ΔL = Thermal length change

L = Pipe length

FP = Anchor point

GS = Sliding point

19.2 CALCULATION EXAMPLES

The pipe length L, for which the thermal length change is to be accommodated at a deflection length, is 7 m.

The temperature difference between the minimum and maximum values (installation temperature and subsequent operating temperature) is 50 K. The installed pipe outer diameter is 25 mm.

What length of deflection leg is required for RAUTITAN his 311 pipe?

Calculation of deflection leg length with RAUTITAN his 311 pipes mounted with REHAU support channel

$\Delta L = \alpha \cdot L \cdot \Delta T$

$\Delta L = 0.04 \frac{mm}{m.K} \cdot 7m \cdot 50L$

$\Delta L = 14mm$

$L_{BS} = C \cdot \sqrt{d_a \cdot \Delta L}$

$L_{BS} = 12 \cdot \sqrt{25mm \cdot 14mm}$

$L_{BS} = 224$ mm

Assessment of the results

The required deflection leg length for RAUTITAN his 311 is shorter due to the flexible pipe material.

For metallic pipe materials, a substantially larger deflection leg is required for the same operating parameters during installation, due to the significantly higher material constant (C), than for other RAUTITAN pipes system.

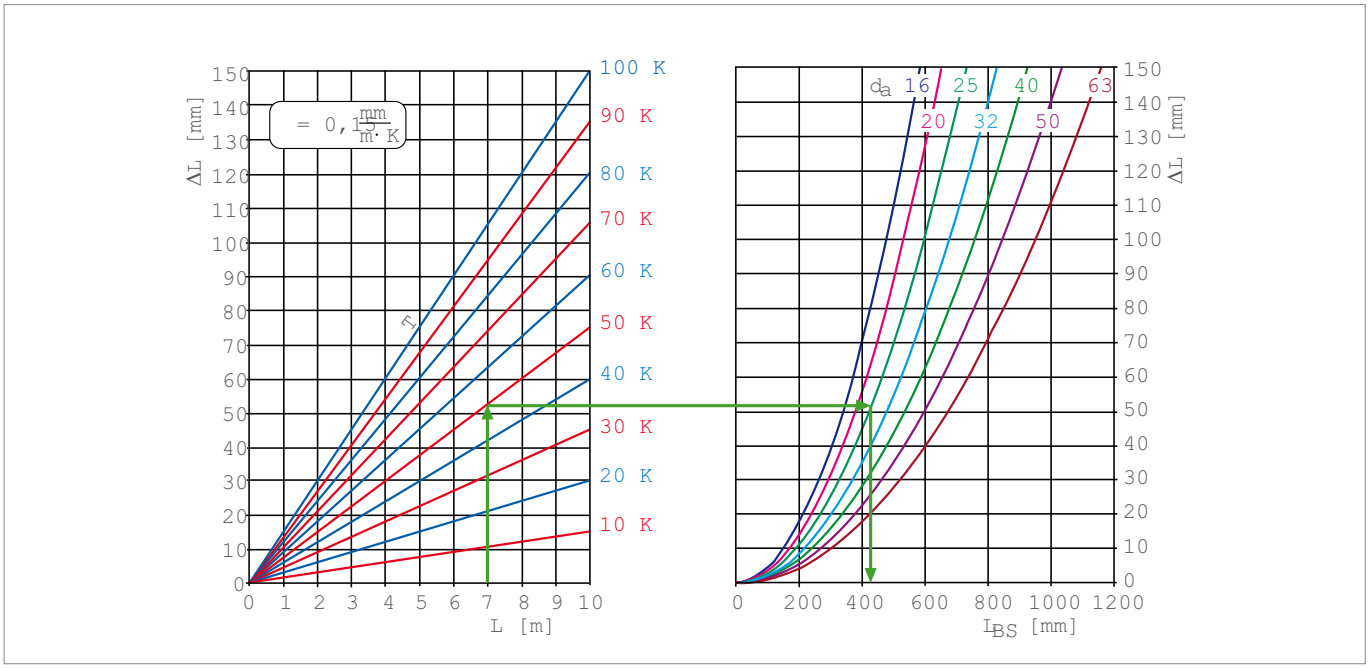


Fig.19-3 Linear expansion and deflection leg length of RAUTITAN PE-Xa pipes size 16 - 63 mm without support channel

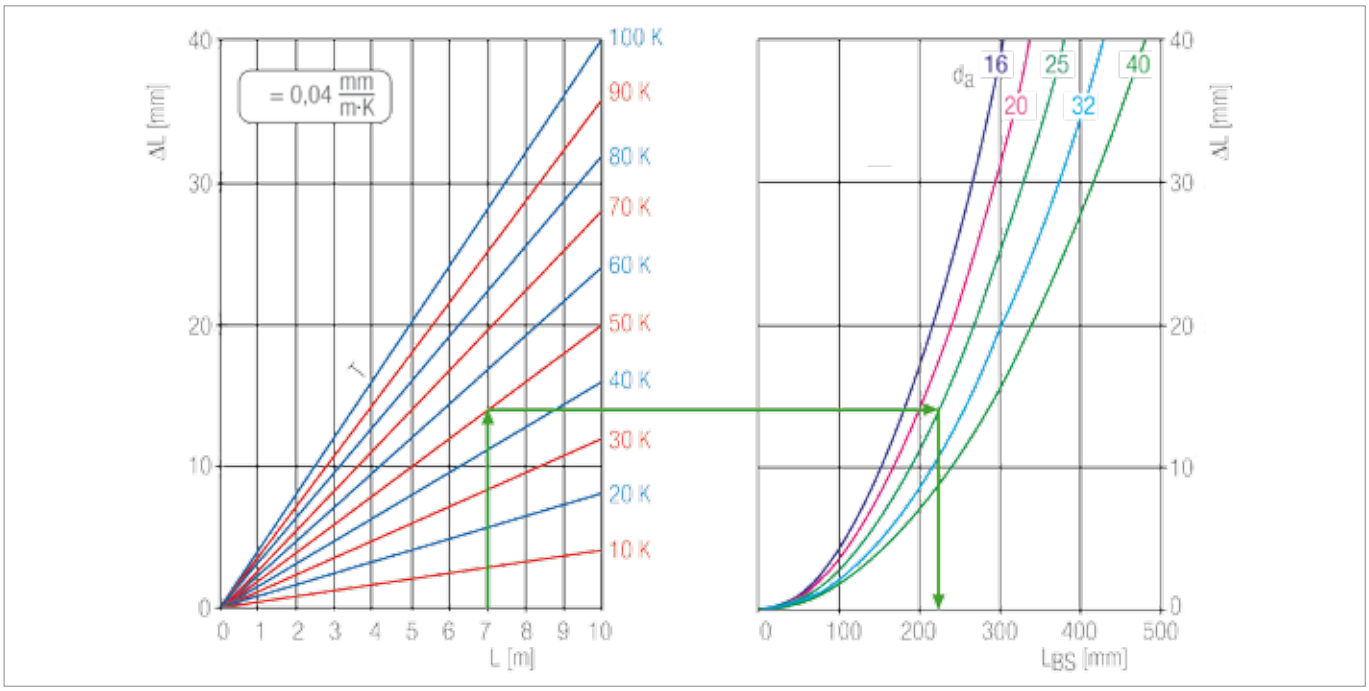


Fig. 19-4 Linear expansion and deflection leg length of RAUTITAN PE-Xa pipes size 16 - 40 mm with support channel

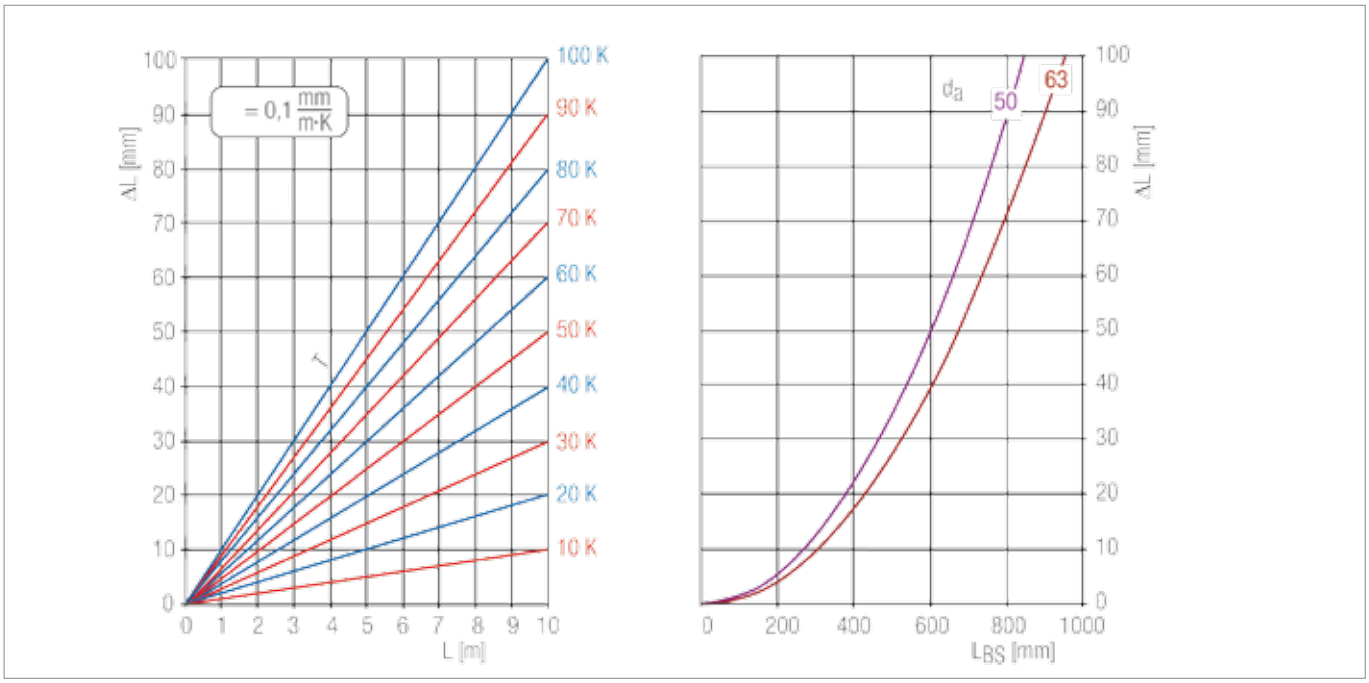


Fig. 19-5 Linear expansion and deflection leg length of RAUTITAN PE-Xa pipes size 50 - 63 mm with support channel

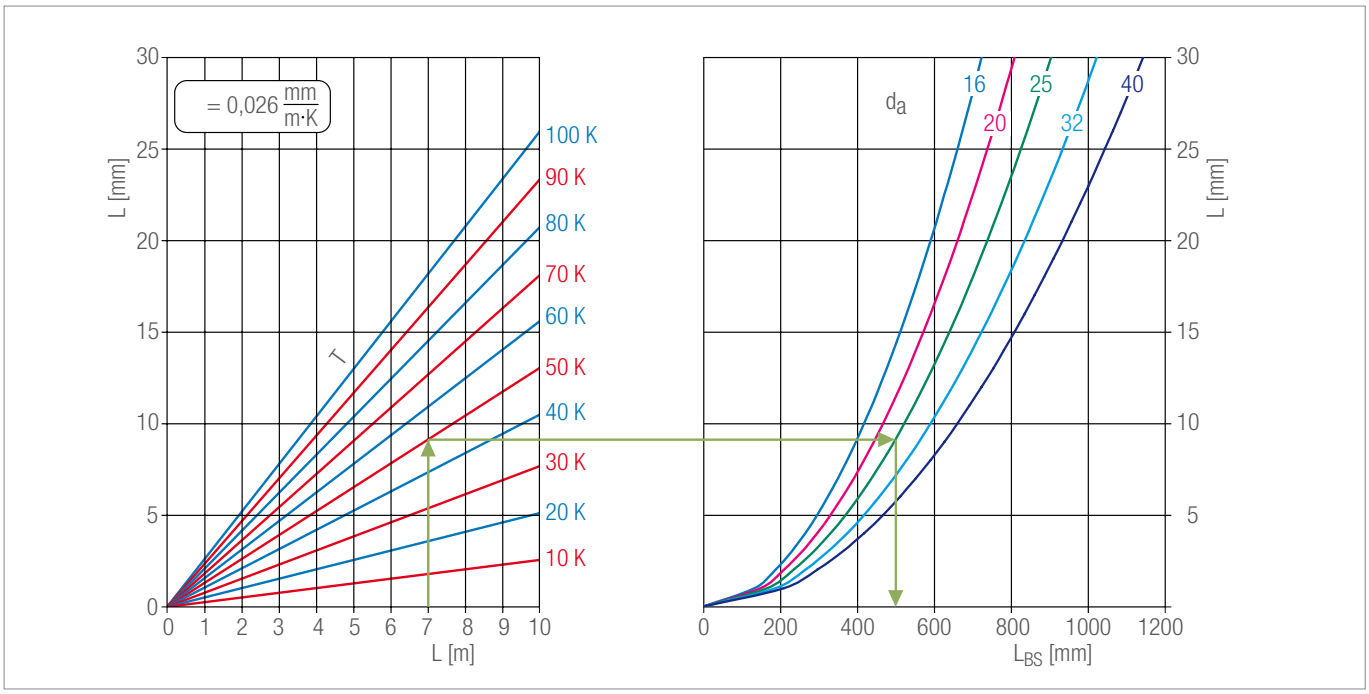


Fig. 19-6 Linear expansion and deflection leg length of RAUTITAN multilayer pipes size 16 - 40 mm

20. FIRE SAFETY

Every service penetration reacts differently in the event of fire. Because of this test results are only applicable to the tested wall or floor construction, installed pipes and the applied fire stops. A fire safety engineer responsible for a particular building can at his discretion accept test results from a different test setup, if he deems the construction in question to be achieving a better fire rating than the one that was tested.

REHAU recommends to only using the fire protection methods which have been specifically tested with the RAUTITAN pipe system. REHAU cannot accept responsibility or liability for the correct manufacture or installation of fire protection systems.

Detailed test results of fire resistance ratings of RAUTITAN pipes together with retrofit UniCollars from Promat's Promaseal are available upon request. The test was done accordingly to AS 1530.4 and might not be suitable for every country.

21. INSTALLATION ADVICES

21.1 EXPOSURE TO EXCESSIVE HEAT

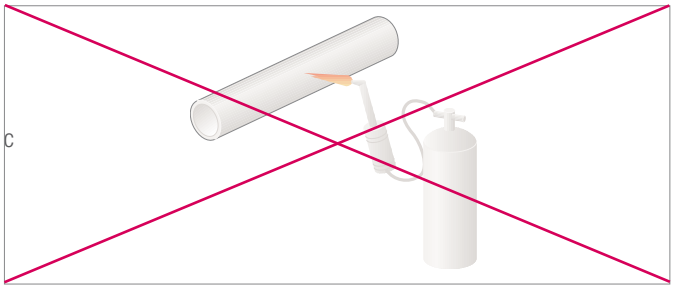


Fig. 21-1 Protect piping against exposure to excessive heat

During construction, maintenance or repair work in close proximity care must be taken not to expose RAUTITAN pipe systems to a naked flame (soldering), flood lights or other localized heat sources, as this can result in permanent damage or a significant reduction in performance life.

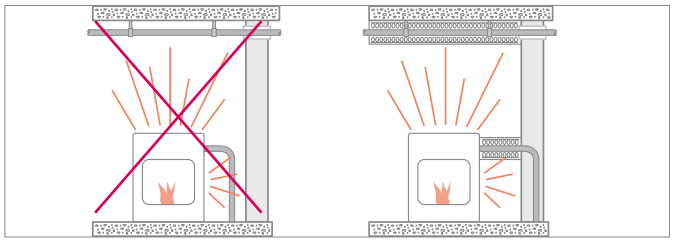


Fig. 21-2 Protection against temperature-induced stress

Piping close to devices with high temperature emissions must be insulated sufficiently and permanently protected against inadmissible heating.

Adhere to the maximum allowable operating parameters (e.g. operating temperature, pressure and duration).

21.2 EXTERNAL INSTALLATION

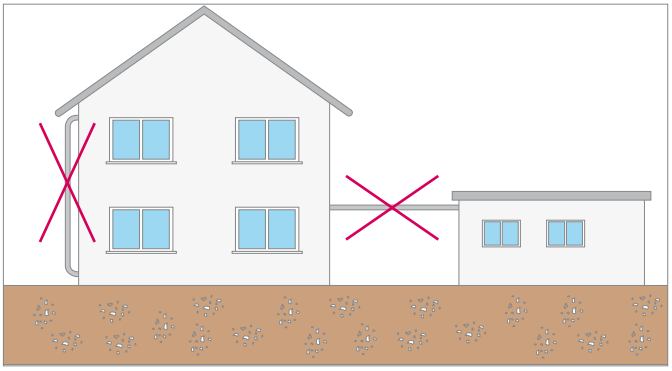


Fig. 21-3 External installation prohibited

All external installations, in-ground and above ground, shall follow the applicable national plumbing installation standards and must be protected as required by these codes.

RAUTITAN his 311 system is an indoor system, which must not be installed externally, except for the below installations:

- In-ground installations after water meter of the building premises
- Short pipe length after connection from water meter before going below the ground
- Connection to an externally located water heater
- Connection to garden taps within the premises

➔ For each of the excepted external installation, adequate protection is required.

21.2.1 EXCEPTION FOR EXTERNAL INSTALLATION BELOW GROUND

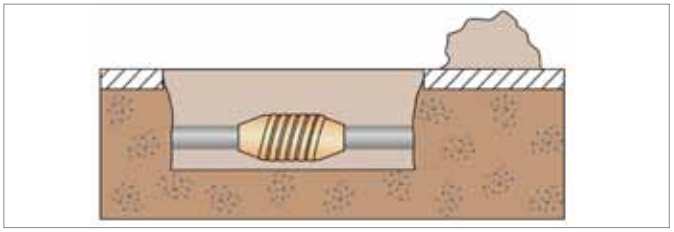


Fig. 21-4 Installation of RAUTITAN system below ground with fittings wrapped with corrosion protection system

RAUTITAN his 311 pipe can be installed in the ground without protection. Adequate protection is to be provided if the pipe is in risk of:

- Mechanical damage
- Chemical damage
- Contamination

In-ground installations of RAUTITAN his 311, system with jointings must be protected against:

- Mechanical damage
- Corrosion
- Chemical damage
- Contamination

For below ground installation of RAUTITAN his 311 system, proper bedding and backfill materials have to be observed. To lay RAUTITAN his 311 system below ground, please ensure the following:

- The pipe bedding, compacted pipe overlay and compacted pipe side support materials are compacted sand or fine-grain soil with no hard object and sharp edges.
- The pipe bedding, compacted pipe overlay and compacted pipe side support materials are at least 75 mm deep and are without any hard object and sharp edges.
- The backfill material is free from builder's waste, concrete pieces, rocks, or hard matters larger than 25 mm and broken up so that it contains no soil lumps larger than 75 mm.
- The depth of cover is suitable according to the ground loading.

Proper corrosion protection of the fittings can be achieved by using a recognized corrosion protection system, such as the butyl-tape based DEKOTEC N15/PE5 system or equivalent.

RAUTITAN his 311 pipes with RAUTITAN PX fittings and compression sleeves only need to be protected against mechanical damage

Chemical damage

If chemical damage is likely to occur, the RAUTITAN his 311 system must be adequately protected using a suitable conduit, e.g. PVC pipes or equivalent.

When using a Corrosion Protection System, always ensure the following:

- The corrosion protection system is chemically compatible with all RAUTITAN his 311 system components, RAUTITAN MX fitting and compression sleeve, RAUTITAN PX fittings and compression sleeve.
- It's fully suitable for the given ground conditions, e.g. damp soil.
- The system includes an approved cavity filler/mastique which can be applied to profile the joint, allowing smooth application of the protection tape without any cavities between the tape and fitting.
- Mechanical protection is provided to avoid any damage to the corrosion protection tape e.g. by backfill material.
- In addition to complete coverage of the joint itself, the corrosion protection system has to cover at least 150 mm of the pipe on each side of the brass fitting.
- Confirmation from manufacturer that the corrosion protection system is suitable for the intended application.

21.2.2 INSTALLATION PROCEDURE OF CORROSION PROTECTION SYSTEM

Incorrect application of the system components can compromise its performance and result in fitting corrosion. Corroded components can cause joint failure and lead to leakage.

- For more detailed information on correct handling and application, carefully read the individual instruction leaflets supplied with each component of the Corrosion Protection System prior to use.

- REHAU requires a minimum protection extension of 150 mm to each side of the joint. This minimum requirement overrules some of the manufacturers' instruction.

The procedure of corrosion protection system given below is only an example specific to DEKOTEC N15/PE5 system. Other equivalent corrosion protection systems may have different procedure and tape colours. Please follow the procedures given by corrosion protection systems' manufacturers.

21.2.2.1 SURFACE PREPARATION OF PROTECTION AREA

- Clean the protection area, ensure that it is dry and free from grease and dust.

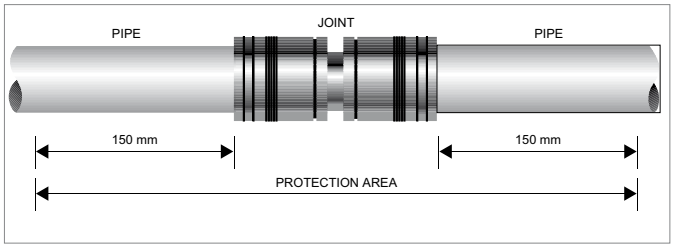


Fig. 21-5 Protection area for corrosion protection system

- Completely remove any contamination which might act as a release agent (e.g. grease, oil, coupling agents, paint, cement, varnish, etc.) prior to tape application.
- Roughen the cleaned pipe surface 150 mm on each side of the joint using coarse emery cloth. Remove any grinding dust afterwards.

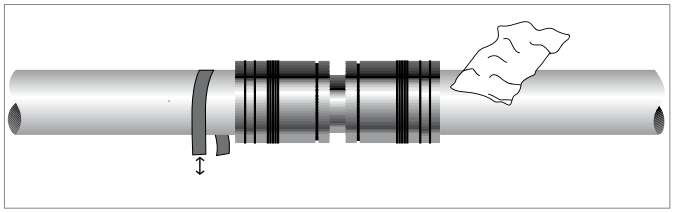


Fig. 21-6 Roughen the pipe surface and clean the grinding dust after the roughening process

21.2.2.2 PRIMING THE PROTECTION AREA

- Thoroughly stir the corrosion protection primer in original container to ensure uniformity prior to application.
- Using a brush or roller apply an even coating of primer to the cleaned and dried surface over the entire protection area. Surfaces have to be uniformly coated and cover must extend for a minimum of 150 mm on each side of the fitting (complete protection area).
- After use immediately seal the primer container.
- Clean the brush or roller with suitable solvent (e.g. white spirit).

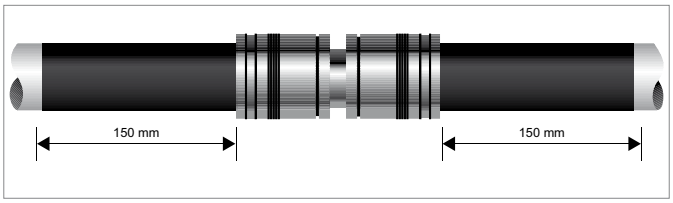


Fig. 21-7 Primed protection area surface

- Let primer coating dry until it is tack free and all solvents have evaporated.
- The drying time depends on ambient temperature and air movement.
- The primed surface should be wrapped within 8 hours. Otherwise or in case of contamination (e.g. dust) the primer coating has to be renewed.

21.2.2.3 PROFILING THE PROTECTION AREA

- Gaps and voids between pipe/fitting and the corrosion protection tape must be avoided to ensure proper protection.
- The fitting has to be contoured to ensure full contact between the corrosion protection tape and the substrate being protected. Corrosion protection mastique is to be used for profiling as part of the corrosion protection system.

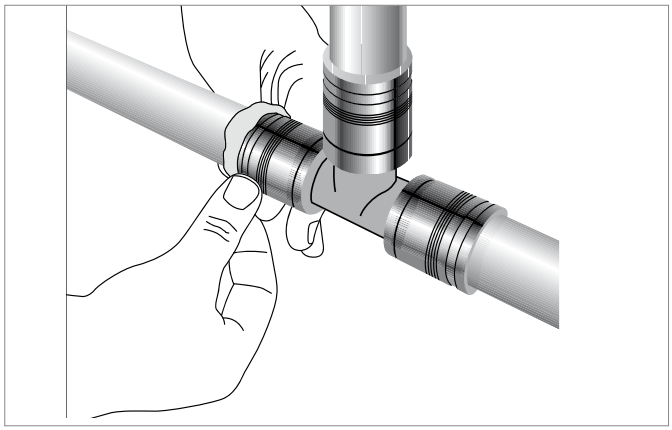


Fig. 21-8 Filling the gaps between fitting and pipe with mastique

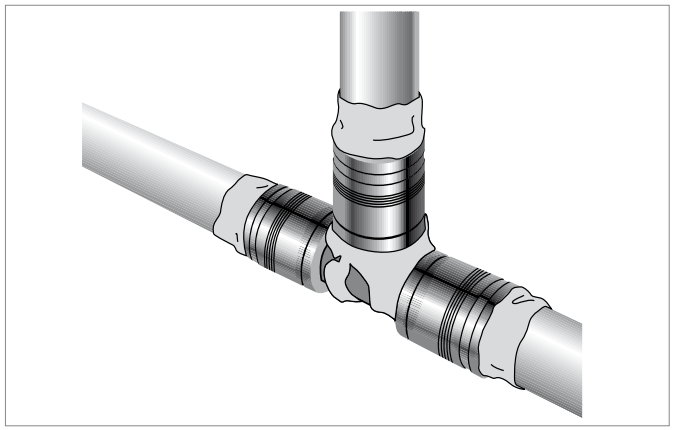


Fig. 21-9 Profiled protection area

21.2.2.4 FIRST WRAP OF THE PROTECTION AREA

- Starting at one end of the protection area (minimum 150 mm from compression sleeve) apply the inner tape (grey colour) with one circumferential wrap and continue wrapping it spirally with minimum 50% overlap across the complete protection area.

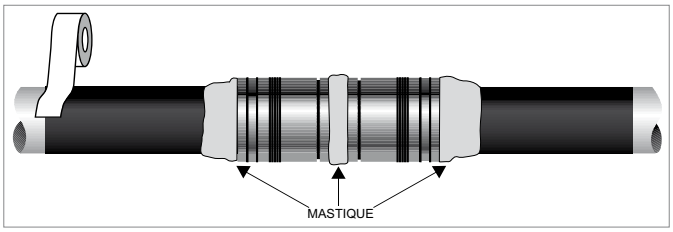


Fig. 21-10 Wrapping the protection area with the first tape (grey colour)

- Apply slight pressure while wrapping to ensure good bonding to the substrate.
- Keep the tape under tension to avoid any kinks and creases. A good indicator for sufficient tension is if the tape's width is narrowed by approximately 1% during application. Remove the separating foil.
- The tape wrapping shall cover the complete jointing and extend by at least 150 mm beyond the protected joint onto the pipe (protection area).

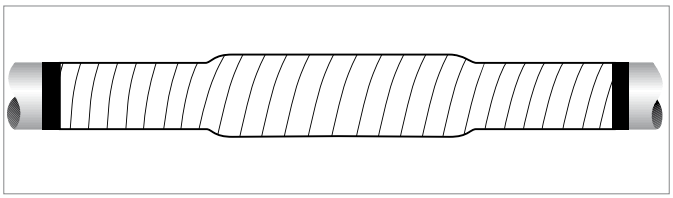


Fig. 21-11 First tape wrapping of complete protection area

21.2.2.5 FINAL WRAP OF PROTECTION AREA

- The outer wrap (black/grey tape) must at least fully cover the first wrap. Position the black/grey tape at one end of the protection area with half of it covering the inner wrap and the grey surface facing the inner wrap, the black side facing outward.

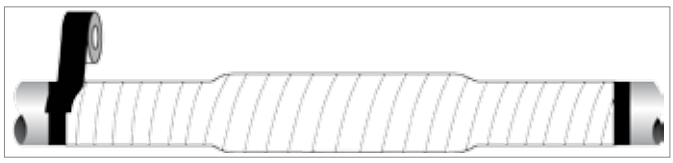


Fig. 21-12 Wrapping the protection area with black/grey tape

- Apply one circumferential wrap and continue wrapping it spirally with minimum 50% overlap across the complete protection area.
- Keep the tape under tension to avoid any kinks and creases. A good indicator for sufficient tension is if the tape's width is narrowed by approximately 1% during application.
- The tape wrapping should cover the complete pipe and extend by at least 150 mm beyond the protected joint (protection area).

Fig. 21-13 Fully protected joint with corrosion protection system.

No wrinkles, creases or kinks are allowed in the finished wrapping on visual testing.

21.3 INSTALLATION IN AREAS EXPOSED TO UV-RADIATION

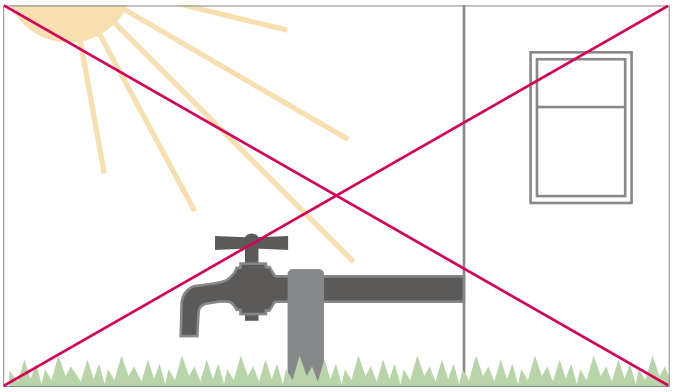


Fig. 21-14 Unprotected installation in areas exposed to UV-radiation is not permitted, example: outdoors

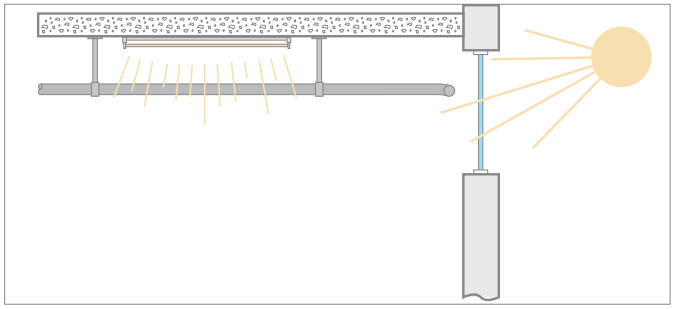


Fig. 21-15 Unprotected installation in areas exposed to UV-radiation is not permitted, example: indoors

- Store and transport pipes with protection against UV-radiation.
- Protect piping from UV-rays in areas where UV radiation can occur (e.g. sunlight, neon light).

21.4 INSTALLATION IN COMBINATION WITH BITUMEN AND SHEETS AND COATINGS

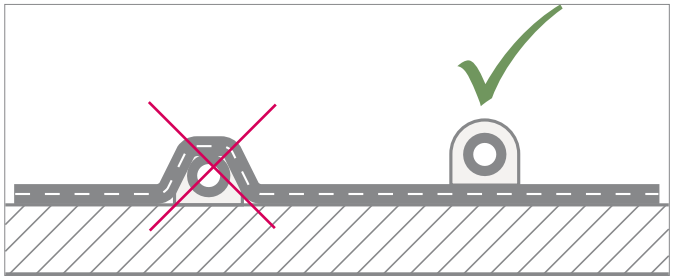


Fig. 21-16 Only install pipes on top of bitumen sheet

Do not lay pipes under bitumen sheeting.

Installation under bitumen sheeting can lead to damage to the piping or to the bitumen sheeting.

- Allow the bitumen sheets or bituminous coatings that contain solvents to dry completely before laying the pipes.
- Adhere to the setting time specified by the manufacturer.
- Before laying the pipes, ensure that the pipes nor the drinking water are not adversely affected.
- Protect the pipe adequately from heating while laying the pipes near flaming bitumen sheets.

21.5 HEAT TRACE SYSTEM

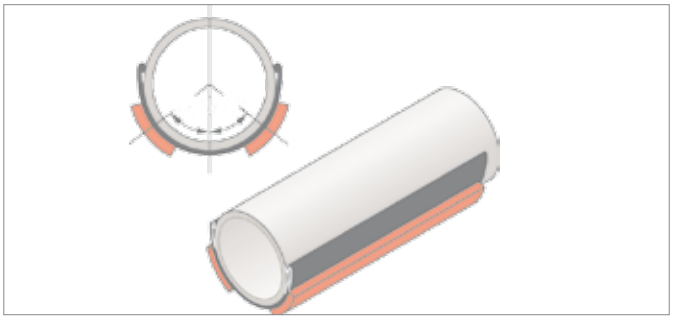


Fig. 21-17 Example of trace heating fitted to RAUTITAN pipe with support channel

- If pipes are installed with REHAU support channel, the heating strip must be attached to the outside of the support channel.
- Take the appropriate measures to ensure that the piping and connection components do not, at any point, exceed 70°C.
- When installing heating trace strips on pipes, observe the installation instructions of the heat trace manufacturer.

21.6 INSTALLATION IN AREAS WITH ASPHALT SCREED

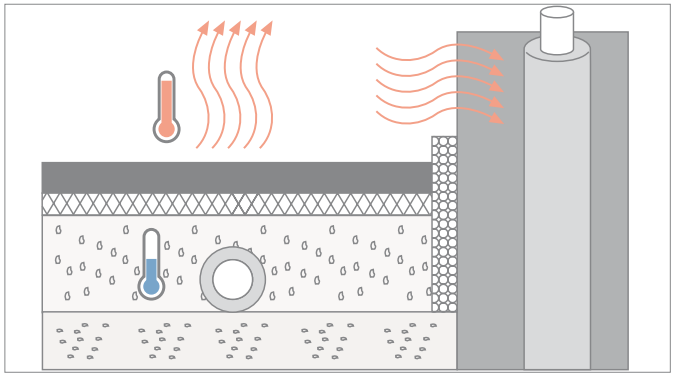


Fig. 21-18 Installation under hot asphalt screed

Hot asphalt screeds are laid at a temperature of approximately 250°C. To protect the piping from overheating, proper steps need to be taken.

Since these depend on the structural condition and cannot be influence by REHAU, these must be coordinated with and approved by the planner.

The following measures must at least be taken to protect the piping (e.g. pipes, fittings, compression sleeves, joints) from exposure to high temperatures. At any point, none of the piping insulation shall exceed 100°C:

- Lay pipes directly onto subfloor.
- Embed pipes completely in insulation granules.

Use insulation granules made from volcanic pearlite (this material can also be used for leveling purposes and has good acoustic and thermal insulation properties).

There is no limit on the maximum thickness for the layer of insulation granules:

- Cover the pipes with at least 10 mm of compacted material.
- For layers of 40 mm thickness and more, mechanically compact the material manually before placing the thermal insulation cover on top.

Always agree with the contractor laying the hot asphalt screed on the suitable insulation and protective measures to prevent any damage to the pipes due to excessive heat.

21.7 POTENTIAL EQUALIZATION

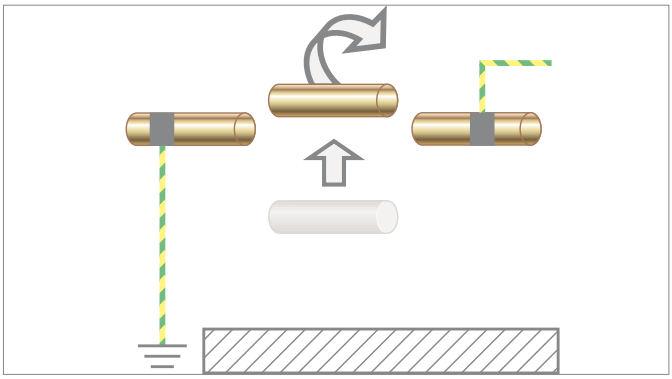


Fig. 21-19 Potential equalization while replacing pipes

RAUTITAN piping must not be used as an earthing conductor for electrical units.

After replacement of existing metallic pipe with RAUTITAN system, the function of potential equalization and the effectiveness of the electrical safety devices must be verified by an electrician.

22. CONNECTION TO WATER HEATERS

22.1 ELECTRICAL INSTANTANEOUS WATER HEATERS

The listed electrical instantaneous water heaters (see Table 22-1) can be combined with RAUTITAN his 311 system according to the manufacturer's specifications. Please observe the operating parameter limits set by respective water heater's manufacturer (maximum pressure and maximum temperature during operation as well as in case of malfunction) and the maximum operating parameters of the RAUTITAN his 311 system.

Manufacturer	Model	Capacity (kW)					Regulation
AEG	DDLE XX*	-	18	21	24	27	Electronic
AEG	DDLT XX*	12	18	21	24	27	Hydraulic
Buderus	BDE XX*	-	18	21	24	-	Electronic
CLAGE	DBX	-	18	21	24	27	Electronic
CLAGE	DCX	-	18	21	24	-	Electronic
CLAGE	DEX	-	18	21	24	27	Electronic
CLAGE	DSX	-	18	21	24	27	Electronic
Junkers	ED XX*-1 HE	-	18	21	24	-	Electronic
Junkers	ED XX*-2 S	-	18	21	24	-	Hydraulic
Siemens	Typ DE XX* 410	-	18	21	24	-	Electronic
Siemens	Typ DE XX* 415	-	18	21	24	27	Electronic
Siemens	Typ DE XX* 515	-	18	21	24	27	Electronic
Siemens	Typ DE XX* 555	-	18	21	24	27	Electronic
Siemens	Typ DH XX* 400	12	18	21	24	-	Hydraulic
Siemens	Typ DH XX* 401	12	-	-	-	-	Hydraulic
Stiebel Eltron	DEL XX* SL	-	18	21	24	27	Electronic
Stiebel Eltron	DHE XX* SL	-	18	21	24	27	Electronic
Vaillant	VED E XX*/5	-	18	21	24	27	Electronic
Vaillant	VED E XX*/6 C	-	18	21	24	27	Electronic
Vaillant	VED E XX*/6 E	-	18	21	24	27	Electronic

Tab. 22-1 Certified electrical water heaters (as of November 2008) for RAUTITAN pipes

XX* = The product model is indicated by its capacity.

22.2 INSTANTANEOUS GAS WATER HEATERS

Not all gas instantaneous water heaters are suitable for direct connection to plastic pipes. With these units, inadmissibly high pressures and temperatures can arise if malfunction occurs.

Always observe the manufacturer's specification of the equipment.

Approval for connection of instantaneous gas water heaters to RAUTITAN his 311 system can only be issued by the equipment manufacturer.

22.3 HOT WATER TANKS

RAUTITAN his 311 system for drinking water can be used for hot water tanks with a maximum water temperature of 70°C in continuous operation.

Electrical instantaneous water heaters, instantaneous gas water heaters and other water heaters which are not approved in this Technical Information for use with RAUTITAN his 311 system, must be approved by the respective manufacturer. The installed pipe type and its field of application must be observed.

22.4 SOLAR WATER HEATERS

RAUTITAN his 311 system can be used together with solar water heater systems that have a maximum water temperature of 70°C in continuous operation.

Suitable measures must be taken (e.g. mixer for regulating hot water temperature) to ensure that the hot water temperature does not exceed 70°C.

For this reason, RAUTITAN his 311 system is only suitable for distribution of regulated hot water temperature (maximum 70°C) from the mixer outlet.

22.5 UNCONTROLLED HEAT SOURCES

RAUTITAN his 311 pipes must not be used together with uncontrolled heat sources. Installation of a tempering valve is required.

Should there be any doubt on the suitability of the instantaneous water heaters to RAUTITAN his 311 system, please contact your nearest REHAU Sales Office for further advice.

23. PRESSURE TESTING AND PURGING OF DRINKING WATER PIPES

Pressure testing of water services installation system has to be done according to applicable national water services installation standards.

23.1 GUIDELINES FOR PRESSURE TESTING

The successful execution and documentation of a pressure test is a prerequisite for any warranty claims from REHAU guarantee and the liability agreement with the German Central Association for Plumbing, Heating and Air Conditioning (ZVSHK).

According to DIN 1988, a pressure test must be conducted after completion of piping installation but before the concealing phase. For smaller system components (e.g. distribution and connecting pipes in wet rooms), DIN 1988 only requires a preliminary test with water.

Statements on the system's leak-tightness derived from the pressure test (constant, decreasing, increasing) can only be asserted in a limited capacity.

- The leak-tightness of the system can only checked by performing a visual inspection of unconcealed lines.
- Micro leaks can only be detected by performing a visual inspection (water outlet or leak detection agent) at high pressure.
- Subdividing the piping system into smaller test sections increases the inspection accuracy.

Leak detection agents

Only use leak detection agents (e.g. foaming agents) with current DVGW certification, which were also approved by the respective manufacturers for PPSU and PVDF materials.

Important information on testing with pressurized air and inert gas:

- Small leaks can only be detected by using leak detection agents at high test pressures (load test) or with a supplementary pressure test with water and the applicable visual inspection.
- Temperature fluctuation can impair the test result (pressure loss or increase).
- Pressurized air and inert gas are compressed gases. This means the piping volume has big influence on the shown pressure result. A high piping volume reduces the determination of small leaks using pressure reduction.

23.2 WATER PRESSURE TEST

23.2.1 PREPARATION OF WATER PRESSURE TEST

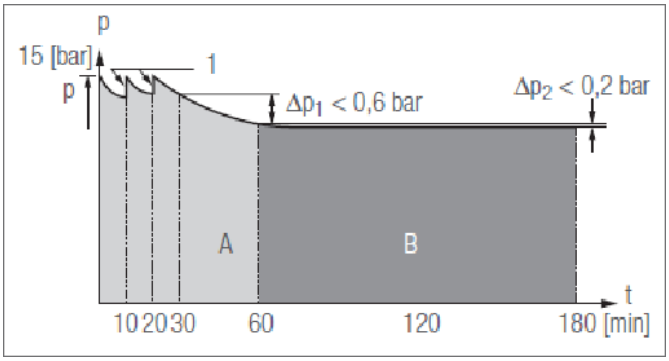


Fig. 23-1 Pressure testing diagram according to DIN 1988

1 - Topping up
A - Pre-test
B - Main test
p - Test pressure
t - Time

1. Piping needs to be accessible and cannot be concealed.
2. Dismount safety devices and meters as necessary safely and replace with pipes of pipe stoppers.
3. Fill the piping at the lowest point of the system with filtered water until all air is purged out.
4. Vent the extraction points until water is purged without air.
5. Connect the pressure testing device to the lowest point of water service installation.

6. Close all extraction points carefully.
7. Ensure that the temperature remains as constant as possible during the pressure test.
8. Prepare the pressure test record and note the system data.

The pressure test can be heavily influenced by temperature fluctuations in the piping system, e.g. a temperature change of 10 K can cause a pressure change of 0.5 bar to 1 bar.

Due to the pipe material properties (e.g. pipe elongation when there is increased pressurization), the pressure loss (Δp_1 and Δp_2) during the pressure test (pre-testing and main test) can deviate from standard values.

The test pressure and the pressure progression which occur during testing do not permit any sufficient conclusions as to the leak-tightness of the system. For this reason, the entire water service installation, as required in the standards, must be visually checked for leaks.

23.2.2 PRE-TESTING WITH WATER

1. Build up pressure of 15 bars in the water services installation.
2. After 10 minutes and 20 minutes, read and write down the test pressure and pressurize it back to 15 bars.
3. Perform visual inspection for leaks on the entire water service installation, especially on the jointings.
4. After an additional test period of 30 minutes, note the test pressure in the pressure test record.

If the test pressure has fallen by more than 0.6 bars (Δp_1):
1. Repeat a thorough visual inspection of the piping, extraction points and joints.
2. If no leak is found during visual inspection, the main test can be started.
3. After resolving the cause of the drop in pressure, repeat the pre-testing.

23.2.3 MAIN WATER PRESSURE TEST

The main test is conducted immediately after a successful pre-testing and takes about two hours:
1. Read the test pressure after the pre-testing and note it in the pressure test form.
2. After two hours, read the test pressure and note it down in the pressure test form.
3. Check the entire water service installation, particularly the joints for leaks by visual inspection.

If no leak is found during the visual inspection, the pressure test is deemed satisfactory.

If, after two hours, the test pressure has dropped by more than 0.2 bars (Δp_2):
1. Repeat a thorough visual inspection on the piping, extraction points and joints.
2. If no leak is found during the visual inspection, the pressure test is deemed satisfactory.
3. After resolving the cause of the drop in pressure, repeat the pre-testing and main test.

23.2.4 COMPLETION OF WATER PRESSURE TEST

After completion of the main test:
1. Confirm the pressure test in the pressure test form with the contractor and client.
2. Disassemble the pressure test unit.
3. After the pressure test, thoroughly rinse out the water service pipe installation for hygiene purpose.
4. Reinstall all removed safety devices and water meters.

23.3 PURGING OF WATER SERVICES PIPES

To remove dirt from the storage and construction phase, open all extraction point for several minutes and thereby purge contaminants from water services installation.

Time-consuming purging of the piping with a mixture of air and water required by DIN 1988, Part 2 to protect metallic piping against corrosion is not necessary for RAUTITAN pipes.

We recommend that drinking water system should be fully drained if it is not put into immediate operation for hygienic reason and to avoid frost formation.

Purge the drained system thoroughly before commissioning.

24. STANDARDS, REGULATIONS AND GUIDELINES

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Observe the applicable national and international laying, installation, accident prevention and safety regulations when installing piping systems, as well as the instructions in this Technical Information.

Also observe the applicable laws, standards, guidelines and regulations (e.g. DIN, EN, ISO, DVGW, TRGI, VDE and VDI) as well as regulations on environmental protection, provisions of professional associations and regulations of the local public utility companies.

Areas of application not contained in this Technical Information (special applications) require consultation with our Applications Department. For extensive advice, consult your REHAU sales office.

The planning and installation instructions are directly connected with the respective REHAU product. References are made to excerpts from generally applicable standards and regulations.

Observe the respectively valid issues of the guidelines, standards and regulations.

Further standards, regulations and guidelines with regard to the planning, installation and operation of drinking water, heating and building technology systems must also be taken into account but are not a part of this Technical Information.

The following standards, regulations and guidelines are referred to in the Technical Information (the current version is always valid):

BS 7291
Thermoplastics pipes and associated fittings for hot and cold water for domestic purposes and heating installations in buildings

DIN 1045
Concrete structures

DIN 1055
Action on structures

DIN 1186
Building plasters

DIN 15018
Cranes

DIN 16892
Crosslinked polyethylene (PE-X) pipes - General requirements, testing

DIN 16893
Crosslinked polyethylene (PE-X) pipes - Dimensions

DIN 18180
Gypsum plasterboards

DIN 18181
Gypsum plasterboards for building construction

DIN 18182
Accessories for use with gypsum plasterboards

DIN 18195
Water-proofing of buildings

DIN 18202
Tolerances in building construction

DIN 18350
German Construction Contract Procedures (VOB) - Part C:
General Technical Specifications for Building Works - Plaster and stucco works

DIN 18380
German Construction Contract Procedures (VOB) - Part C:
General Technical Specifications for Building Works - Systems for heating and central water heating

DIN 18380 (VOB)
German Construction Contract Procedures (VOB) - Part C:
General Technical Specifications for Building Works - Systems for heating and central water heating

DIN 18557
Works mortar

DIN 18560
Floor screeds in building construction

DIN 1988
Codes of practice for drinking water installations (TRWI)

DIN 2000
Central drinking water supply - Guidelines regarding requirements for drinking water, planning, construction, operation and maintenance of plants

DIN 3546
Stop-valves for domestic water supply

DIN 3586
Thermally activated shutting-off devices for gas - Requirements and testing

DIN 4102
Fire behaviour of building materials and components

DIN 4108
Thermal insulation in buildings

DIN 4109
Sound insulation in buildings

DIN 4725
Warm water surface heating systems - Systems and components

DIN 4726
Warm water surface heating systems and radiator connecting systems - Plastic piping systems

DIN 49019
Conduits for electrical installation

DIN 49073
Metal boxes and boxes of insulating material for recessed mounting for accommodation of accessories and socket outlets

DIN 50916-2
Testing of copper alloys; stress corrosion and cracking test using ammonia; testing of components

DIN 50930-6
Corrosion of metals – Corrosion of metallic under corrosion load by water inside of tubes, tanks and apparatus - Part 6: Influence of the composition of drinking water.

DIN 68 800
Protection of timber used in buildings

DIN EN 10088
Stainless steels

DIN EN 10226
Pipe threads where pressure - Tight joints are made on the threads

DIN EN 12164
Copper and copper alloys - Rod for free machining purposes

DIN EN 12165
Copper and copper alloys - Wrought and unwrought forging stock

DIN EN 12168
Copper and copper alloys - Hollow rod for free machining purposes

DIN EN 12502-1
Protection of metallic materials against corrosion – Guidance on the assessment of corrosion likelihood in water distribution and storage systems

DIN EN 1264
Floor heating

DIN EN 12828
Heating systems in buildings – Design of water-based heating systems

DIN EN 12831
Heating systems in buildings

DIN EN 12831 Supplementary sheet 1
Heating systems in buildings - Method for calculation of the design heat load

DIN EN 13163
Thermal insulation products for buildings

DIN EN 13163 to DIN EN 13171
Thermal insulation products for buildings

DIN EN 13501
Fire classification of construction products and building elements

DIN EN 14037
Ceiling mounted radiant panels supplied with water at temperature below 120 °C

DIN EN 14240
Ventilation for buildings - Chilled ceilings

DIN EN 14291
Foam producing solutions for leak detection on gas installations

DIN EN 14336
Heating systems in buildings

DIN EN 15377
Heating systems in buildings

DIN EN 442
Radiators and convectors

DIN EN 520
Gypsum plasterboards

DIN EN 60529
Degrees of protection provided by enclosures

DIN EN 806
Codes of practice for drinking water installations

DIN EN ISO 15875
Plastic piping systems for hot and cold water installations - Crosslinked polyethylene (PE-X)

DIN EN ISO 6509
Corrosion of metals and alloys - Determination of dezincification resistance of brass

DIN EN ISO 7730
Ergonomics of the thermal environment

DIN V 4108-6
Thermal protection and energy-economy in buildings

DIN VDE 0100
(Summary)
Electrical systems in building
Setting up high-voltage current systems
Setting up low-voltage current systems

DIN VDE 0100-701
Low-voltage electrical installations - Requirements for special installations or locations - Part 701: Locations containing a bath or shower

DIN VDE 0298-4
Application of cables and cords in power installations

DIN VDE 0604-3
Trunking mounted on walls and ceilings for electrical installations; skirting board ducts

DVGW G 459-1
Gas service pipes for pressures up to 4 bars; Design and construction

DVGW G 260
Gas quality

DVGW G 465-4
Gas leak detection and gas concentration measuring devices for leakage survey on gas supply systems

DVGW G 600 / DVGW-TRGI 2008
Technical rules for gas installations

DVGW G 617
Calculation guidelines for dimensioning of the piping system of gas installations

DVGW GW 393
Extensions (pipe connectors) from copper materials for gas and drinking water installations - Requirements and testing

DVGW VP 305-1
Gas flow monitors for the gas installation

DVGW VP 625
Pipe connectors and connections for internal gas lines from multi-layer connector pipes according to DVGW-VP 632 - Requirements and testing

DVGW VP 626
Pipe connectors and connections for internal gas lines from crosslinked polyethylene (PE-X) according to DVGW-VP 624 - Requirements and testing

DVGW W 270
Reproduction of micro-organisms on materials for the drinking water area

DVGW W 291
Cleaning and disinfection of water distribution systems

DVGW W 534
Pipe connectors and connections in the drinking water installation

DVGW W 551
Drinking water heating and drinking water pipe systems

EnEV
German Energy Saving Ordinance

Council directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption

Council directive relating to machinery (89/392/EEC) including amendments

ISO 228
Pipe threads where pressure-tight joints are not made on the threads

ISO 7
Pipe threads where pressure-tight joints are not made on the threads

LBO
Regional building laws of the states of the Federal Republic of Germany

MBO
German Building Code for the states of the Federal Republic of Germany

MLAR
Sample Line Systems Guidelines

Muster-Feu-VO
Sample firing equipment regulation

TRF
Technical regulations on liquid gas installations

TrinkwV
Drinking Water Ordinance

VDI 2035
Prevention of damage in water heating installations

VDI 2078
Cooling load calculation of air-conditioned rooms

VDI 4100
Noise control in dwellings

VDI 6023
Hygiene for drinking water supply systems

APPENDIX A

PRESSURE LOSS TABLES FOR RAUTITAN HIS 311

Cold water at 25°C

Peak Flow Rate Qs (l/s) (0.01 to 0.50)	PN 20 16 x 2.2 D_o (mm) = 16.00 D_i (mm) = 11.60		PN 20 20 x 2.8 D_o (mm) = 20. 00 D_i (mm) = 14.40		PN 20 25 x 3.5 D_o (mm) = 25.00 D_i (mm) = 18.00		PN 20 32 x 4.4 D_o (mm) = 32.00 D_i (mm) = 23.20	
	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)
0.01	~~0.0226~~	0.095	~~0.0082~~	0.061	~~0.0029~~	0.039	~~0.0009~~	0.024
0.02	~~0.0720~~	0.189	~~0.0261~~	0.123	~~0.0092~~	0.079	~~0.0028~~	0.047
0.03	~~0.1437~~	0.284	~~0.0518~~	0.184	~~0.0181~~	0.118	~~0.0055~~	0.071
0.04	0.2355	0.378	~~0.0846~~	0.246	~~0.0295~~	0.157	~~0.0090~~	0.095
0.05	0.3464	0.473	0.1241	0.307	~~0.0432~~	0.196	~~0.0131~~	0.118
0.06	0.4755	0.568	0.1701	0.368	0.0591	0.236	~~0.0178~~	0.142
0.07	0.6224	0.662	0.2222	0.430	0.0771	0.275	0.0232	0.166
0.08	0.7864	0.757	0.2802	0.491	0.0970	0.314	0.0292	0.189
0.09	0.9674	0.852	0.3442	0.553	0.1190	0.354	0.0357	0.213
0.10	1.1648	0.946	0.4139	0.614	0.1429	0.393	0.0429	0.237
0.11	1.3786	1.041	0.4892	0.675	0.1687	0.432	0.0505	0.260
0.12	1.6085	1.135	0.5700	0.737	0.1964	0.472	0.0588	0.284
0.13	1.8542	1.230	0.6563	0.798	0.2259	0.511	0.0675	0.308
0.14	2.1156	1.325	0.7480	0.860	0.2572	0.550	0.0768	0.331
0.15	2.3926	1.419	0.8451	0.921	0.2903	0.589	0.0866	0.355
0.16	2.6850	1.514	0.9474	0.982	0.3252	0.629	0.0969	0.378
0.17	2.9927	1.609	1.0549	1.044	0.3618	0.668	0.1077	0.402
0.18	3.3156	1.703	1.1677	1.105	0.4002	0.707	0.1191	0.426
0.19	3.6536	1.798	1.2856	1.167	0.4402	0.747	0.1309	0.449
0.20	4.0066	1.892	1.4086	1.228	0.4820	0.786	0.1432	0.473
0.21	4.3745	1.987	1.5367	1.289	0.5254	0.825	0.1560	0.497
0.22	4.7572	2.082	1.6698	1.351	0.5705	0.865	0.1693	0.520
0.23	5.1548	2.176	1.8079	1.412	0.6173	0.904	0.1831	0.544
0.24	5.5670	2.271	1.9510	1.474	0.6658	0.943	0.1973	0.568
0.25	5.9939	2.366	2.0991	1.535	0.7158	0.982	0.2120	0.591
0.26	6.4354	2.460	2.2521	1.596	0.7675	1.022	0.2272	0.615
0.27	6.8915	2.555	2.4101	1.658	0.8209	1.061	0.2429	0.639
0.28	7.3620	2.649	2.5729	1.719	0.8758	1.100	0.2590	0.662
0.29	7.8470	2.744	2.7406	1.781	0.9324	1.140	0.2755	0.686
0.30	8.3464	2.839	2.9131	1.842	0.9905	1.179	0.2926	0.710
0.31	8.8602	2.933	3.0905	1.903	1.0503	1.218	0.3101	0.733
0.32	9.3883	3.028	3.2727	1.965	1.1116	1.258	0.3280	0.757
0.33	9.9307	3.123	3.4597	2.026	1.1745	1.297	0.3464	0.781
0.34	10.4873	3.217	3.6515	2.088	1.2390	1.336	0.3652	0.804
0.35	11.0582	3.312	3.8481	2.149	1.3050	1.375	0.3845	0.828
0.36	11.6433	3.406	4.0494	2.210	1.3726	1.415	0.4043	0.852
0.37	12.2426	3.501	4.2555	2.272	1.4418	1.454	0.4244	0.875
0.38	12.8560	3.596	4.4663	2.333	1.5125	1.493	0.4451	0.899
0.39	13.4836	3.690	4.6819	2.395	1.5848	1.533	0.4661	0.923
0.40	14.1252	3.785	4.9021	2.456	1.6586	1.572	0.4876	0.946
0.41	14.7810	3.880	5.1271	2.517	1.7339	1.611	0.5096	0.970
0.42	15.4507	3.974	5.3567	2.579	1.8108	1.650	0.5319	0.994
0.43			5.5911	2.640	1.8892	1.690	0.5547	1.017
0.44			5.8301	2.702	1.9691	1.729	0.5780	1.041
0.45			6.0737	2.763	2.0505	1.768	0.6016	1.065
0.46			6.3221	2.825	2.1335	1.808	0.6257	1.088
0.47			6.5750	2.886	2.2180	1.847	0.6502	1.112
0.48			6.8326	2.947	2.3039	1.886	0.6752	1.135
0.49			7.0949	3.009	2.3914	1.926	0.7006	1.159
0.50			7.3617	3.070	2.4804	1.965	0.7264	1.183

Cold water at 25°C

Peak Flow Rate Qs (l/s) (0.05 to 2.50)	PN 20 32 x 4.4 D_o (mm) = 32.00 D_i (mm) = 23.20		PN 20 40 x 5.5 D_o (mm) = 40.00 D_i (mm) = 29.00		PN 20 50 x 6.9 D_o (mm) = 50.00 D_i (mm) = 36.20		PN 20 63 x 8.6 D_o (mm) = 63.00 D_i (mm) = 45.80	
	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)
0.05	~~0.0131~~	0.118	~~0.0046~~	0.076	~~0.0016~~	0.049	~~0.0005~~	0.030
0.10	0.0429	0.237	0.0149	0.151	~~0.0052~~	0.097	~~0.0017~~	0.061
0.15	0.0866	0.355	0.0300	0.227	0.0105	0.146	0.0035	0.091
0.20	0.1432	0.473	0.0495	0.303	0.0173	0.194	0.0057	0.121
0.25	0.2120	0.591	0.0731	0.378	0.0254	0.243	0.0083	0.152
0.30	0.2926	0.710	0.1006	0.454	0.0350	0.291	0.0114	0.182
0.35	0.3845	0.828	0.1320	0.530	0.0458	0.340	0.0150	0.212
0.40	0.4876	0.946	0.1671	0.606	0.0579	0.389	0.0189	0.243
0.45	0.6016	1.065	0.2059	0.681	0.0713	0.437	0.0232	0.273
0.50	0.7264	1.183	0.2483	0.757	0.0858	0.486	0.0279	0.303
0.55	0.8617	1.301	0.2942	0.833	0.1016	0.534	0.0330	0.334
0.60	1.0075	1.419	0.3435	0.908	0.1185	0.583	0.0385	0.364
0.65	1.1637	1.538	0.3963	0.984	0.1366	0.632	0.0443	0.395
0.70	1.3301	1.656	0.4525	1.060	0.1558	0.680	0.0505	0.425
0.75	1.5067	1.774	0.5120	1.135	0.1761	0.729	0.0571	0.455
0.80	1.6933	1.892	0.5749	1.211	0.1976	0.777	0.0640	0.486
0.85	1.8900	2.011	0.6411	1.287	0.2202	0.826	0.0712	0.516
0.90	2.0966	2.129	0.7105	1.363	0.2438	0.874	0.0788	0.546
0.95	2.3132	2.247	0.7832	1.438	0.2686	0.923	0.0868	0.577
1.00	2.5396	2.366	0.8592	1.514	0.2944	0.972	0.0951	0.607
1.05	2.7758	2.484	0.9383	1.590	0.3214	1.020	0.1037	0.637
1.10	3.0218	2.602	1.0207	1.665	0.3493	1.069	0.1126	0.668
1.15	3.2775	2.720	1.1062	1.741	0.3784	1.117	0.1219	0.698
1.20	3.5429	2.839	1.1949	1.817	0.4084	1.166	0.1316	0.728
1.25	3.8179	2.957	1.2867	1.892	0.4396	1.215	0.1415	0.759
1.30	4.1025	3.075	1.3817	1.968	0.4717	1.263	0.1518	0.789
1.35	4.3968	3.194	1.4798	2.044	0.5049	1.312	0.1624	0.819
1.40	4.7006	3.312	1.5810	2.120	0.5392	1.360	0.1733	0.850
1.45	5.0140	3.430	1.6853	2.195	0.5744	1.409	0.1846	0.880
1.50	5.3369	3.548	1.7927	2.271	0.6107	1.457	0.1961	0.910
1.55	5.6692	3.667	1.9031	2.347	0.6480	1.506	0.2080	0.941
1.60	6.0111	3.785	2.0167	2.422	0.6863	1.555	0.2202	0.971
1.65	6.3624	3.903	2.1333	2.498	0.7257	1.603	0.2327	1.002
1.70	6.7231	4.021	2.2529	2.574	0.7660	1.652	0.2456	1.032
1.75			2.3756	2.649	0.8073	1.700	0.2587	1.062
1.80			2.5014	2.725	0.8497	1.749	0.2722	1.093
1.85			2.6301	2.801	0.8930	1.797	0.2859	1.123
1.90			2.7619	2.877	0.9373	1.846	0.3000	1.153
1.95			2.8967	2.952	0.9826	1.895	0.3144	1.184
2.00			3.0345	3.028	1.0289	1.943	0.3291	1.214
2.05			3.1754	3.104	1.0762	1.992	0.3441	1.244
2.10			3.3192	3.179	1.1245	2.040	0.3594	1.275
2.15			3.4660	3.255	1.1738	2.089	0.3750	1.305
2.20			3.6158	3.331	1.2240	2.138	0.3909	1.335
2.25			3.7686	3.406	1.2752	2.186	0.4071	1.366
2.30			3.9244	3.482	1.3274	2.235	0.4236	1.396
2.35			4.0831	3.558	1.3806	2.283	0.4404	1.426
2.40			4.2448	3.634	1.4347	2.332	0.4576	1.457
2.45			4.4095	3.709	1.4898	2.380	0.4750	1.487
2.50			4.5771	3.785	1.5458	2.429	0.4927	1.517

Cold water at 25°C

Peak Flow Rate Qs (l/s) (0.51 to 1)	PN 20 20 x 2.8 D_o (mm) = 20.00 D_i (mm) = 14.40		PN 20 25 x 3.5 D_o (mm) = 25.00 D_i (mm) = 18.00		PN 20 32 x 4.4 D_o (mm) = 32.00 D_i (mm) = 23.20		PN 20 40 x 5.5 D_o (mm) = 40.00 D_i (mm) = 29.00	
	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)
0.51	7.6332	3.132	2.5709	2.004	0.7526	1.206	0.2572	0.772
0.52	7.9093	3.193	2.6628	2.043	0.7792	1.230	0.2662	0.787
0.53	8.1900	3.254	2.7563	2.083	0.8063	1.254	0.2754	0.802
0.54	8.4752	3.316	2.8513	2.122	0.8338	1.277	0.2847	0.818
0.55	8.7651	3.377	2.9477	2.161	0.8617	1.301	0.2942	0.833
0.56	9.0596	3.439	3.0457	2.201	0.8900	1.325	0.3037	0.848
0.57	9.3586	3.500	3.1451	2.240	0.9188	1.348	0.3135	0.863
0.58	9.6622	3.561	3.2460	2.279	0.9479	1.372	0.3234	0.878
0.59	9.9704	3.623	3.3484	2.319	0.9775	1.396	0.3334	0.893
0.60	10.2831	3.684	3.4522	2.358	1.0075	1.419	0.3435	0.908
0.61	10.6004	3.746	3.5575	2.397	1.0379	1.443	0.3538	0.924
0.62	10.9223	3.807	3.6643	2.436	1.0687	1.467	0.3642	0.939
0.63	11.2487	3.868	3.7726	2.476	1.1000	1.490	0.3748	0.954
0.64	11.5796	3.930	3.8823	2.515	1.1316	1.514	0.3855	0.969
0.65	11.9151	3.991	3.9935	2.554	1.1637	1.538	0.3963	0.984
0.66	12.2551	4.053	4.1062	2.594	1.1961	1.561	0.4073	0.999
0.67			4.2203	2.633	1.2290	1.585	0.4184	1.014
0.68			4.3358	2.672	1.2623	1.609	0.4296	1.029
0.69			4.4529	2.712	1.2960	1.632	0.4410	1.045
0.70			4.5714	2.751	1.3301	1.656	0.4525	1.060
0.71			4.6913	2.790	1.3646	1.680	0.4641	1.075
0.72			4.8127	2.829	1.3995	1.703	0.4759	1.090
0.73			4.9355	2.869	1.4348	1.727	0.4878	1.105
0.74			5.0598	2.908	1.4705	1.751	0.4999	1.120
0.75			5.1856	2.947	1.5067	1.774	0.5120	1.135
0.76			5.3127	2.987	1.5432	1.798	0.5243	1.151
0.77			5.4414	3.026	1.5801	1.821	0.5368	1.166
0.78			5.5714	3.065	1.6174	1.845	0.5494	1.181
0.79			5.7029	3.105	1.6552	1.869	0.5621	1.196
0.80			5.8359	3.144	1.6933	1.892	0.5749	1.211
0.81			5.9703	3.183	1.7319	1.916	0.5879	1.226
0.82			6.1061	3.222	1.7708	1.940	0.6010	1.241
0.83			6.2434	3.262	1.8101	1.963	0.6142	1.257
0.84			6.3821	3.301	1.8499	1.987	0.6276	1.272
0.85			6.5222	3.340	1.8900	2.011	0.6411	1.287
0.86			6.6637	3.380	1.9305	2.034	0.6547	1.302
0.87			6.8067	3.419	1.9715	2.058	0.6685	1.317
0.88			6.9511	3.458	2.0128	2.082	0.6824	1.332
0.89			7.0970	3.497	2.0545	2.105	0.6964	1.347
0.90			7.2443	3.537	2.0966	2.129	0.7105	1.363
0.91			7.3930	3.576	2.1392	2.153	0.7248	1.378
0.92			7.5431	3.615	2.1821	2.176	0.7392	1.393
0.93			7.6946	3.655	2.2254	2.200	0.7538	1.408
0.94			7.8476	3.694	2.2691	2.224	0.7684	1.423
0.95			8.0020	3.733	2.3132	2.247	0.7832	1.438
0.96			8.1578	3.773	2.3577	2.271	0.7982	1.453
0.97			8.3151	3.812	2.4026	2.295	0.8132	1.469
0.98			8.4737	3.851	2.4479	2.318	0.8284	1.484
0.99			8.6338	3.890	2.4935	2.342	0.8437	1.499
1.00			8.7953	3.930	2.5396	2.366	0.8592	1.514

Cold water at 25°C

Peak Flow Rate Qs (l/s) (2.60 to 7.50)	PN 20 50 x 6.9 D_o (mm) = 50.00 D_i (mm) = 36.20		PN 20 63 x 8.6 D_o (mm) = 63.00 D_i (mm) = 45.80	
	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)
2.60	1.6609	2.526	0.5290	1.578
2.70	1.7797	2.623	0.5665	1.639
2.80	1.9025	2.721	0.6052	1.700
2.90	2.0290	2.818	0.6451	1.760
3.00	2.1593	2.915	0.6861	1.821
3.10	2.2935	3.012	0.7283	1.882
3.20	2.4314	3.109	0.7717	1.942
3.30	2.5732	3.206	0.8162	2.003
3.40	2.7187	3.303	0.8619	2.064
3.50	2.8679	3.401	0.9088	2.124
3.60	3.0210	3.498	0.9568	2.185
3.70	3.1777	3.595	1.0059	2.246
3.80	3.3383	3.692	1.0562	2.307
3.90	3.5025	3.789	1.1076	2.367
4.00	3.6705	3.886	1.1602	2.428
4.10	3.8423	3.984	1.2139	2.489
4.20	4.0177	4.081	1.2688	2.549
4.30			1.3247	2.610
4.40			1.3818	2.671
4.50			1.4401	2.731
4.60			1.4994	2.792
4.70			1.5599	2.853
4.80			1.6215	2.914
4.90			1.6842	2.974
5.00			1.7481	3.035
5.10			1.8130	3.096
5.20			1.8791	3.156
5.30			1.9463	3.217
5.40			2.0146	3.278
5.50			2.0840	3.338
5.60			2.1545	3.399
5.70			2.2261	3.460
5.80			2.2989	3.521
5.90			2.3727	3.581
6.00			2.4476	3.642
6.10			2.5237	3.703
6.20			2.6008	3.763
6.30			2.6790	3.824
6.40			2.7584	3.885
6.50			2.8388	3.945
6.60			2.9203	4.006
6.70			3.0029	4.067
6.80			3.0867	4.128
6.90			3.1715	4.188
7.00			3.2574	4.249
7.10			3.3444	4.310
7.20			3.4324	4.370
7.30			3.5216	4.431
7.40			3.6119	4.492
7.50			3.7032	4.552

Hot water at 60°C

Peak Flow Rate Qs (l/s) (0.01 to 0.50)	PN 20 16 x 2.2 D_o (mm) = 16.00 D_i (mm) = 11.60		PN 20 20 x 2.8 D_o (mm) = 20.00 D_i (mm) = 14.40		PN 20 25 x 3.5 D_o (mm) = 25.00 D_i (mm) = 18.00		PN 20 32 x 4.4 D_o (mm) = 32.00 D_i (mm) = 23.20	
	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)
0.01	~~0.0181~~	0.095	~~0.0066~~	0.061	~~0.0023~~	0.039	~~0.0007~~	0.024
0.02	0.0590	0.189	~~0.0212~~	0.123	~~0.0074~~	0.079	~~0.0023~~	0.047
0.03	0.1191	0.284	0.0426	0.184	0.0148	0.118	~~0.0045~~	0.071
0.04	0.1968	0.378	0.0702	0.246	0.0243	0.157	0.0073	0.095
0.05	0.2913	0.473	0.1036	0.307	0.0358	0.196	0.0107	0.118
0.06	0.4020	0.568	0.1426	0.368	0.0492	0.236	0.0147	0.142
0.07	0.5286	0.662	0.1871	0.430	0.0644	0.275	0.0192	0.166
0.08	0.6705	0.757	0.2368	0.491	0.0814	0.314	0.0243	0.189
0.09	0.8277	0.852	0.2918	0.553	0.1001	0.354	0.0298	0.213
0.10	0.9999	0.946	0.3519	0.614	0.1205	0.393	0.0358	0.237
0.11	1.1869	1.041	0.4170	0.675	0.1426	0.432	0.0424	0.260
0.12	1.3885	1.135	0.4871	0.737	0.1664	0.472	0.0494	0.284
0.13	1.6047	1.230	0.5622	0.798	0.1918	0.511	0.0568	0.308
0.14	1.8353	1.325	0.6421	0.860	0.2188	0.550	0.0648	0.331
0.15	2.0802	1.419	0.7269	0.921	0.2474	0.589	0.0731	0.355
0.16	2.3394	1.514	0.8165	0.982	0.2776	0.629	0.0820	0.378
0.17	2.6127	1.609	0.9108	1.044	0.3094	0.668	0.0913	0.402
0.18	2.9001	1.703	1.0099	1.105	0.3427	0.707	0.1010	0.426
0.19	3.2016	1.798	1.1136	1.167	0.3775	0.747	0.1112	0.449
0.20	3.5171	1.892	1.2221	1.228	0.4139	0.786	0.1218	0.473
0.21	3.8464	1.987	1.3352	1.289	0.4519	0.825	0.1329	0.497
0.22	4.1897	2.082	1.4530	1.351	0.4913	0.865	0.1444	0.520
0.23	4.5468	2.176	1.5754	1.412	0.5323	0.904	0.1563	0.544
0.24	4.9178	2.271	1.7024	1.474	0.5747	0.943	0.1686	0.568
0.25	5.3025	2.366	1.8340	1.535	0.6186	0.982	0.1814	0.591
0.26	5.7009	2.460	1.9701	1.596	0.6641	1.022	0.1946	0.615
0.27	6.1131	2.555	2.1109	1.658	0.7110	1.061	0.2082	0.639
0.28	6.5390	2.649	2.2561	1.719	0.7594	1.100	0.2222	0.662
0.29	6.9785	2.744	2.4059	1.781	0.8092	1.140	0.2366	0.686
0.30	7.4317	2.839	2.5602	1.842	0.8606	1.179	0.2514	0.710
0.31	7.8985	2.933	2.7191	1.903	0.9134	1.218	0.2667	0.733
0.32	8.3789	3.028	2.8824	1.965	0.9676	1.258	0.2824	0.757
0.33	8.8729	3.123	3.0502	2.026	1.0233	1.297	0.2984	0.781
0.34	9.3805	3.217	3.2225	2.088	1.0804	1.336	0.3149	0.804
0.35	9.9016	3.312	3.3993	2.149	1.1390	1.375	0.3318	0.828
0.36	10.4362	3.406	3.5806	2.210	1.1990	1.415	0.3491	0.852
0.37	10.9844	3.501	3.7663	2.272	1.2605	1.454	0.3668	0.875
0.38	11.5461	3.596	3.9564	2.333	1.3234	1.493	0.3849	0.899
0.39	12.1213	3.690	4.1510	2.395	1.3877	1.533	0.4034	0.923
0.40	12.7100	3.785	4.3501	2.456	1.4535	1.572	0.4223	0.946
0.41	13.3121	3.880	4.5536	2.517	1.5207	1.611	0.4416	0.970
0.42	13.9277	3.974	4.7615	2.579	1.5893	1.650	0.4613	0.994
0.43	14.5568	4.069	4.9738	2.640	1.6593	1.690	0.4813	1.017
0.44			5.1906	2.702	1.7307	1.729	0.5018	1.041
0.45			5.4117	2.763	1.8036	1.768	0.5227	1.065
0.46			5.6373	2.825	1.8778	1.808	0.5440	1.088
0.47			5.8673	2.886	1.9535	1.847	0.5656	1.112
0.48			6.1017	2.947	2.0306	1.886	0.5877	1.135
0.49			6.3404	3.009	2.1091	1.926	0.6101	1.159
0.50			6.5836	3.070	2.1890	1.965	0.6329	1.183

Hot water at 60°C

Peak Flow Rate Qs (l/s) (0.05 to 2.50)	PN 20 32 x 4.4 D_o (mm) = 32.00 D_i (mm) = 23.20		PN 20 40 x 5.5 D_o (mm) = 40.00 D_i (mm) = 29.00		PN 20 50 x 6.9 D_o (mm) = 50.00 D_i (mm) = 36.20		PN 20 63 x 8.6 D_o (mm) = 63.00 D_i (mm) = 45.80	
	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)
0.05	0.0107	0.118	0.0037	0.076	0.0013	0.049	0.0004	0.030
0.10	0.0358	0.237	0.0124	0.151	0.0043	0.097	0.0014	0.061
0.15	0.0731	0.355	0.0252	0.227	0.0088	0.146	0.0029	0.091
0.20	0.1218	0.473	0.0418	0.303	0.0145	0.194	0.0047	0.121
0.25	0.1814	0.591	0.0620	0.378	0.0215	0.243	0.0070	0.152
0.30	0.2514	0.710	0.0858	0.454	0.0296	0.291	0.0096	0.182
0.35	0.3318	0.828	0.1130	0.530	0.0389	0.340	0.0126	0.212
0.40	0.4223	0.946	0.1435	0.606	0.0494	0.389	0.0160	0.243
0.45	0.5227	1.065	0.1773	0.681	0.0609	0.437	0.0197	0.273
0.50	0.6329	1.183	0.2143	0.757	0.0735	0.486	0.0238	0.303
0.55	0.7529	1.301	0.2546	0.833	0.0872	0.534	0.0281	0.334
0.60	0.8825	1.419	0.2979	0.908	0.1019	0.583	0.0329	0.364
0.65	1.0216	1.538	0.3444	0.984	0.1177	0.632	0.0379	0.395
0.70	1.1703	1.656	0.3941	1.060	0.1345	0.680	0.0433	0.425
0.75	1.3284	1.774	0.4467	1.135	0.1523	0.729	0.0490	0.455
0.80	1.4960	1.892	0.5025	1.211	0.1712	0.777	0.0550	0.486
0.85	1.6728	2.011	0.5612	1.287	0.1910	0.826	0.0613	0.516
0.90	1.8590	2.129	0.6230	1.363	0.2118	0.874	0.0679	0.546
0.95	2.0545	2.247	0.6878	1.438	0.2337	0.923	0.0749	0.577
1.00	2.2593	2.366	0.7556	1.514	0.2565	0.972	0.0821	0.607
1.05	2.4733	2.484	0.8263	1.590	0.2803	1.020	0.0897	0.637
1.10	2.6965	2.602	0.9001	1.665	0.3050	1.069	0.0975	0.668
1.15	2.9289	2.720	0.9767	1.741	0.3307	1.117	0.1057	0.698
1.20	3.1704	2.839	1.0564	1.817	0.3574	1.166	0.1141	0.728
1.25	3.4211	2.957	1.1389	1.892	0.3851	1.215	0.1229	0.759
1.30	3.6810	3.075	1.2244	1.968	0.4137	1.263	0.1319	0.789
1.35	3.9499	3.194	1.3128	2.044	0.4433	1.312	0.1412	0.819
1.40	4.2280	3.312	1.4041	2.120	0.4738	1.360	0.1509	0.850
1.45	4.5151	3.430	1.4984	2.195	0.5052	1.409	0.1608	0.880
1.50	4.8113	3.548	1.5955	2.271	0.5376	1.457	0.1710	0.910
1.55	5.1166	3.667	1.6955	2.347	0.5710	1.506	0.1815	0.941
1.60	5.4310	3.785	1.7984	2.422	0.6053	1.555	0.1923	0.971
1.65	5.7543	3.903	1.9042	2.498	0.6405	1.603	0.2034	1.002
1.70	6.0868	4.021	2.0129	2.574	0.6767	1.652	0.2148	1.032
1.75			2.1245	2.649	0.7137	1.700	0.2264	1.062
1.80			2.2389	2.725	0.7518	1.749	0.2384	1.093
1.85			2.3562	2.801	0.7907	1.797	0.2506	1.123
1.90			2.4764	2.877	0.8306	1.846	0.2631	1.153
1.95			2.5994	2.952	0.8714	1.895	0.2759	1.184
2.00			2.7253	3.028	0.9131	1.943	0.2890	1.214
2.05			2.8540	3.104	0.9558	1.992	0.3023	1.244
2.10			2.9856	3.179	0.9993	2.040	0.3160	1.275
2.15			3.1200	3.255	1.0438	2.089	0.3299	1.305
2.20			3.2573	3.331	1.0892	2.138	0.3441	1.335
2.25			3.3974	3.406	1.1356	2.186	0.3585	1.366
2.30			3.5404	3.482	1.1828	2.235	0.3733	1.396
2.35			3.6861	3.558	1.2310	2.283	0.3883	1.426
2.40			3.8348	3.634	1.2800	2.332	0.4037	1.457
2.45			3.9862	3.709	1.3300	2.380	0.4192	1.487
2.50			4.1405	3.785	1.3809	2.429	0.4351	1.517

Hot water at 60°C

Peak Flow Rate Qs (l/s) (0.51 to 1.00)	PN 20 20 x 2.8 D_o (mm) = 20.00 D_i (mm) = 14.40		PN 20 25 x 3.5 D_o (mm) = 25.00 D_i (mm) = 18.00		PN 20 32 x 4.4 D_o (mm) = 32.00 D_i (mm) = 23.20		PN 20 40 x 5.5 D_o (mm) = 40.00 D_i (mm) = 29.00	
	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)
0.51	6.8312	3.132	2.2703	2.004	0.6561	1.206	0.2221	0.772
0.52	7.0831	3.193	2.3530	2.043	0.6797	1.230	0.2300	0.787
0.53	7.3394	3.254	2.4371	2.083	0.7037	1.254	0.2381	0.802
0.54	7.6001	3.316	2.5225	2.122	0.7281	1.277	0.2463	0.818
0.55	7.8652	3.377	2.6094	2.161	0.7529	1.301	0.2546	0.833
0.56	8.1346	3.439	2.6977	2.201	0.7780	1.325	0.2630	0.848
0.57	8.4084	3.500	2.7874	2.240	0.8036	1.348	0.2715	0.863
0.58	8.6866	3.561	2.8784	2.279	0.8295	1.372	0.2802	0.878
0.59	8.9691	3.623	2.9709	2.319	0.8558	1.396	0.2890	0.893
0.60	9.2560	3.684	3.0647	2.358	0.8825	1.419	0.2979	0.908
0.61	9.5473	3.746	3.1600	2.397	0.9095	1.443	0.3070	0.924
0.62	9.8429	3.807	3.2566	2.436	0.9370	1.467	0.3162	0.939
0.63	10.1429	3.868	3.3546	2.476	0.9648	1.490	0.3255	0.954
0.64	10.4472	3.930	3.4539	2.515	0.9930	1.514	0.3349	0.969
0.65	10.7559	3.991	3.5547	2.554	1.0216	1.538	0.3444	0.984
0.66	11.0689	4.053	3.6568	2.594	1.0506	1.561	0.3541	0.999
0.67			3.7604	2.633	1.0800	1.585	0.3639	1.014
0.68			3.8653	2.672	1.1097	1.609	0.3738	1.029
0.69			3.9716	2.712	1.1398	1.632	0.3839	1.045
0.70			4.0792	2.751	1.1703	1.656	0.3941	1.060
0.71			4.1882	2.790	1.2012	1.680	0.4043	1.075
0.72			4.2987	2.829	1.2324	1.703	0.4148	1.090
0.73			4.4104	2.869	1.2641	1.727	0.4253	1.105
0.74			4.5236	2.908	1.2961	1.751	0.4360	1.120
0.75			4.6381	2.947	1.3284	1.774	0.4467	1.135
0.76			4.7540	2.987	1.3612	1.798	0.4576	1.151
0.77			4.8713	3.026	1.3943	1.821	0.4687	1.166
0.78			4.9899	3.065	1.4278	1.845	0.4798	1.181
0.79			5.1099	3.105	1.4617	1.869	0.4911	1.196
0.80			5.2313	3.144	1.4960	1.892	0.5025	1.211
0.81			5.3541	3.183	1.5306	1.916	0.5140	1.226
0.82			5.4782	3.222	1.5656	1.940	0.5256	1.241
0.83			5.6037	3.262	1.6010	1.963	0.5374	1.257
0.84			5.7305	3.301	1.6367	1.987	0.5492	1.272
0.85			5.8587	3.340	1.6728	2.011	0.5612	1.287
0.86			5.9883	3.380	1.7093	2.034	0.5733	1.302
0.87			6.1192	3.419	1.7462	2.058	0.5856	1.317
0.88			6.2515	3.458	1.7834	2.082	0.5979	1.332
0.89			6.3852	3.497	1.8211	2.105	0.6104	1.347
0.90			6.5202	3.537	1.8590	2.129	0.6230	1.363
0.91			6.6566	3.576	1.8974	2.153	0.6357	1.378
0.92			6.7944	3.615	1.9361	2.176	0.6486	1.393
0.93			6.9335	3.655	1.9752	2.200	0.6615	1.408
0.94			7.0740	3.694	2.0147	2.224	0.6746	1.423
0.95			7.2158	3.733	2.0545	2.247	0.6878	1.438
0.96			7.3590	3.773	2.0947	2.271	0.7011	1.453
0.97			7.5035	3.812	2.1353	2.295	0.7146	1.469
0.98			7.6494	3.851	2.1763	2.318	0.7281	1.484
0.99			7.7967	3.890	2.2176	2.342	0.7418	1.499
1.00			7.9453	3.930	2.2593	2.366	0.7556	1.514

Hot water at 60°C

Peak Flow Rate Qs (l/s) (2.60 to 7.50)	PN 20 50 x 6.9 D_o (mm) = 50.00 D_i (mm) = 36.20		PN 20 63 x 8.6 D_o (mm) = 63.00 D_i (mm) = 45.80	
	Head loss (kPa/m)	Velocity (m/s)	Head loss (kPa/m)	Velocity (m/s)
2.60	1.4854	2.526	0.4677	1.578
2.70	1.5935	2.623	0.5013	1.639
2.80	1.7053	2.721	0.5361	1.700
2.90	1.8207	2.818	0.5720	1.760
3.00	1.9397	2.915	0.6089	1.821
3.10	2.0623	3.012	0.6470	1.882
3.20	2.1885	3.109	0.6861	1.942
3.30	2.3183	3.206	0.7263	2.003
3.40	2.4517	3.303	0.7676	2.064
3.50	2.5887	3.401	0.8100	2.124
3.60	2.7292	3.498	0.8535	2.185
3.70	2.8734	3.595	0.8980	2.246
3.80	3.0211	3.692	0.9436	2.307
3.90	3.1724	3.789	0.9903	2.367
4.00	3.3272	3.886	1.0381	2.428
4.10	3.4857	3.984	1.0869	2.489
4.20	3.6477	4.081	1.1369	2.549
4.30			1.1878	2.610
4.40			1.2399	2.671
4.50			1.2930	2.731
4.60			1.3472	2.792
4.70			1.4024	2.853
4.80			1.4587	2.914
4.90			1.5161	2.974
5.00			1.5745	3.035
5.10			1.6340	3.096
5.20			1.6945	3.156
5.30			1.7561	3.217
5.40			1.8188	3.278
5.50			1.8825	3.338
5.60			1.9473	3.399
5.70			2.0131	3.460
5.80			2.0800	3.521
5.90			2.1479	3.581
6.00			2.2169	3.642
6.10			2.2870	3.703
6.20			2.3580	3.763
6.30			2.4302	3.824
6.40			2.5034	3.885
6.50			2.5776	3.945
6.60			2.6529	4.006
6.70			2.7293	4.067
6.80			2.8067	4.128
6.90			2.8851	4.188
7.00			2.9646	4.249
7.10			3.0451	4.310
7.20			3.1267	4.370
7.30			3.2093	4.431
7.40			3.2930	4.492
7.50			3.3777	4.552

Construction

Automotive

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