5 Planning and design

5.1 Installation

Prerequisites for a professionally designed pipe system are in principle good technical knowledge in combination with many years of experience in application and production techniques. Customers nowadays expect that both the engineering (planning) firm and construction company has the appropriate theoretical basis and the correspondingly qualified professional personnel. In addition, they must be able to offer an environmentally friendly, low-maintenance, economical and long-lasting pipe system, properties that a plastic system can provide in.

The references to corresponding chapters of the Specification Manual indicated in the figures will serve as guide to passages in which the relevant subjects are discussed in detail and should facilitate the use of this Specification Manual in specific applications.

5.1.1 Classification criteria

In the project planning and installation of thermoplastic pipe systems, consideration must always be given to material specific properties. The applicability of general principles to specific applications is only possible when material variables and behaviours display similarities (to the requirements of the given situation). In the age of the PC, computer programs are used to design reliable pipe systems, and graphical planning occurs with the support of modern CAD applications. But these are not sufficient to guarantee the operational reliability of pipes, which still depends on the professional processing and use of plastic.

The following instructions should be used, especially in planning, as a guide for the design and construction of water supply systems. A general distinction in the classification of drinking water installations is based on the method of installation. In general, there are 4 main groups, see illustration 5.1.

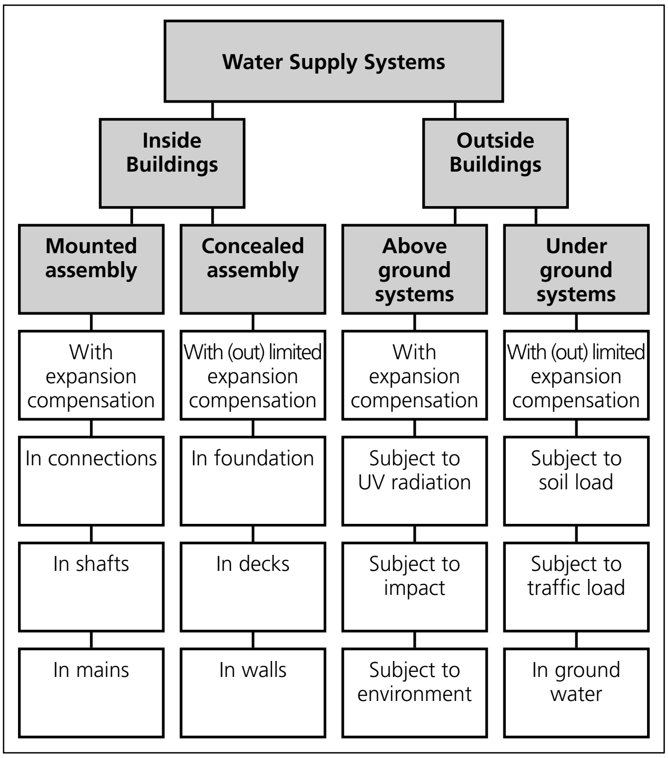


Illustration 5.1

Group 1: Inside buildings mounted systems with expansion compensation

These systems require an expansion compensation construction with brackets and are predominantly found in mains, shafts and hot water circulation systems. They generally require the largest project outlays. Planning aids and influential factors for these pipe systems can be seen in illustration 5.2.

Group 2: Inside buildings concealed systems without (or limited) expansion compensation

Longitudinal expansion does not necessarily have to be taken into account with concealed laying. In an insulated system the insulation will absorb the longitudinal expansion without any problem. Problems resulting from longitudinal expansion generally do not arise. Pipes can be laid in floor topping or concrete, or buried beneath plaster when clamped appropriately. Concealed systems' accessibility for maintenance is limited. Planning aids and influential factors for these pipe systems can be seen in figure 5.3.

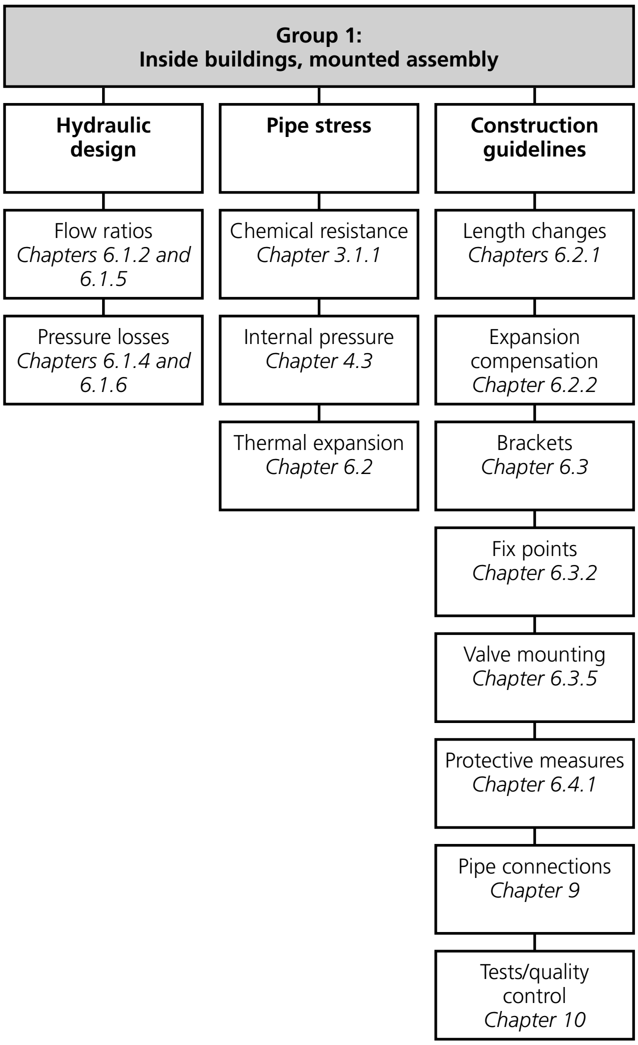
Group 3: Outside buildings above ground systems with expansion compensation

Fundamentally it will always be possible to lay a pipe network in an open and visible manner with high requirements on the optical aspects in general. As a result of its high dimensional stability and reduced longitudinal expansion Wefatherm stabi pipework is specially suitable for exposed systems. Optically acceptable pipework requires expansion compensation construction with brackets. Planning aids and influential factors for these pipe systems can be seen in illustration 5.4.

Group 4: Outside buildings under ground systems

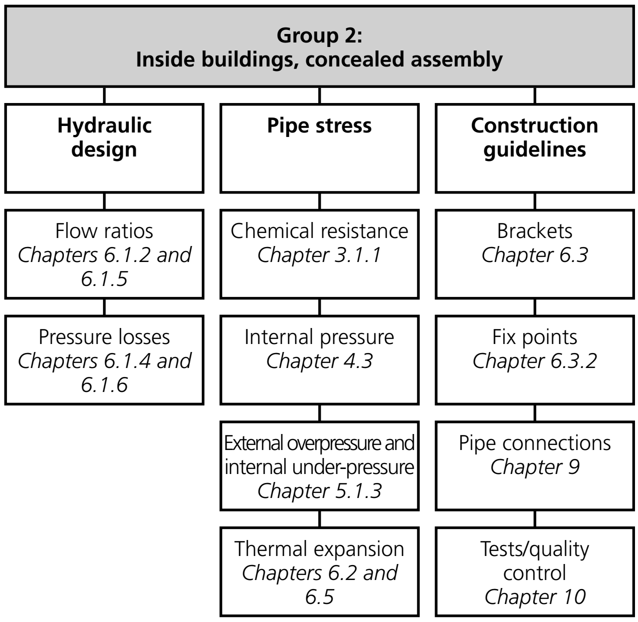
Fundamentally it will always be possible to lay an underground polypropylene network. Longitudinal expansion does not necessarily have to be taken into account because problems resulting from longitudinal expansion generally do not arise. For hot water systems the material strength decreases in the course of time and the load of soil and traffic become more evident for the life cycle of the system. Buried systems' accessibility for maintenance is limited. Planning aids and influential factors for these pipe systems can be seen in illustration 5.5.

Standards



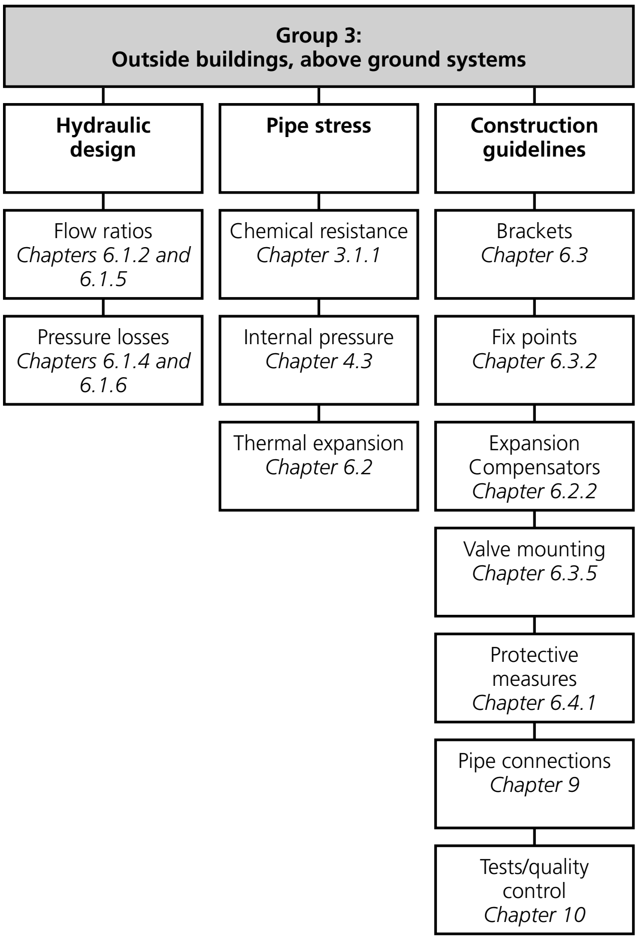
Pipe systems are usually installed so that the pipelines can elongate under the effects of heat. The latitude of movement can be provided by the installations own compensation elements (e.g. expansion bends and compensators) and by properly positioned sliding and guiding brackets. Special consideration needs to be given to ensure adherence to the acceptable support distances and the limiting of flexural loads in pipe bends and branches.

Illustration 5.2 Inside buildings, mounted assembly



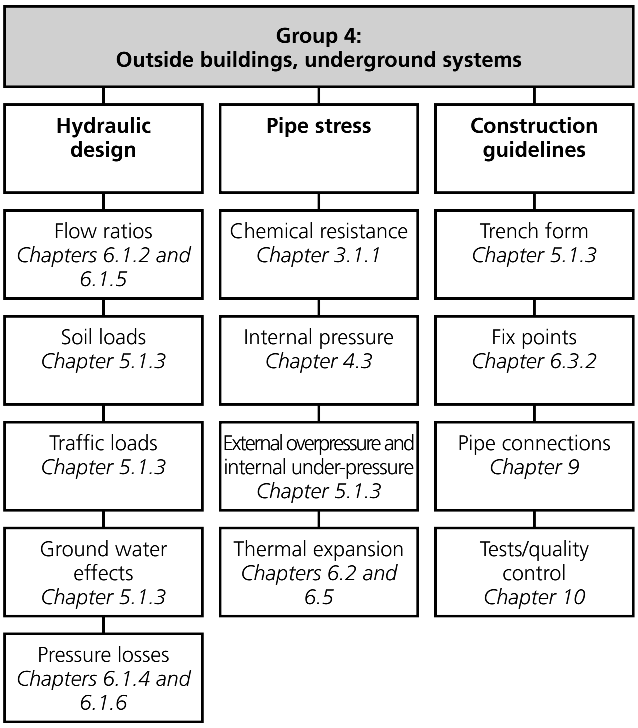
Pipe systems can also be installed so that an encasement in concrete walls, decks, foundations, etc. is possible after completion of the installation. The concrete surrounding the pipe impedes length changes resulting from temperature fluctuations (e.g. due to the temperature of the flow medium or the effects of external temperature). Since no friction-type connection exists between the plastic pipe and the concrete, measures must be taken to protect individual pipe elements.

Illustration 5.3 Inside buildings, concealed assembly



Pipe systems can also be installed without special thermal linear compensation. Pipe systems in which linear movement is impeded must pay special attention to the tensile and compressive stresses that occur, as well as to forces at fixed points. Exposed plastic pipes that are rigidly or firmly clamped (e.g. on a pipe bridge) can be exposed to large temperature variations. For this reason, calculations can be used in individual cases to test the expected stresses in order to determine if linear compensation can be excluded.

Illustration 5.4 Outside buildings, above ground systems



Buried pipe systems are subject to other load characteristics than above ground pipe systems. In designing pipelines, emphasis is placed on determining the largest possible load capacity of the pipe under the effects of external forces and the testing of stability.

Illustration 5.5 Outside buildings, underground systems

Standards

5.1.2 Influence of operating conditions
The influence of pressure and temperature fluctuations depends on the individual system. Since the possibility of thermal linear compensation is not always available, this limitation must be taken into account when calculating load effects. Stress due to internal pressure, bending, external loads, etc. can collectively occur and make it necessary for the individual pipe system to be sized in a system-dependent manner.

5.1.3 Structural analysis
Depending on the nature of the load, various tests can be run on buried pipe systems. In one design, it is the stress and deformation calculation that is important. In another, it is a stability test. The principles underlying the calculations for buried plastic pipe installations are provided in ATVA 127. If you require additional assistance contact the Wefatherm Export Sales Office.

The stress and deformation calculation
Soil loads and traffic loads give rise to pipe cross-section tensile and compressive stresses. The extent of the stress is influenced by the elasticity of the pipe. In general, increasing the elasticity of the pipe will reduce tension. The testing for stress is therefore to be conducted while considering all inner and outer influential factors (e.g. soil stress, traffic load, water, ground water, chemical resistance and internal over- or under-pressure). The manner of embedding in the ground is particularly responsible for degrees of pipe deformation. The higher the compression ratio of the surrounding ground, the smaller the deformation. The requirement of locating the pipe zone in compactable soil is derived from this observation. The acceptable vertical deformation of a PP pipe is currently 6% and is based on the average pipe diameter. Stress and deformation calculations are always performed in parallel.

Stability test
In a PP pipe susceptible to deformation, exceeding a critical load will cause the pipe cross section to buckle. This occurs as a result of increased external (external overpressure due to the effects of groundwater, depth of the covering soil, etc.) or internal (under-pressure) stresses. The stability test is used to document the safety clearance between the critical and actually occurring load. Details and instructions for the calculation and the installation of the pipe systems are provided in the following chapter.

5.2 Maintenance

Legionella contamination can have severe and even deadly consequences. Reducing the risk of contamination for the installation, owners care obligation is based on risk analysis and a maintenance plan.

Risk analyses
Collective drinking water installations in mentioned buildings are submitted to a risk analyses and maintenance plan:
- Medical care facilities
- Rehabilitation and recover centres
- Care and shelter centres
- Hotels
- Swimming pools and wellness centres
- Buildings which have a lodging function and/or shower facilities

Maintenance plan
The maintenance plan describes, as most important part, how risks for periodic management actions are limited and how the water quality is monitored. Also is written down how to act when requirements are not met.
Taking samples and analysing water samples is first done for the risk analysis and then every half year. Also the number of samples, related to the number of tap points, is specified.

Management measures
Management measures are:
- Flushing of less operated tap points
- Measuring temperatures
- Check non-return valves
- Taking water samples
- Flushing boilers and storage tanks

Follow the applicable laws, standards, guidelines, regulations and instructions for environmental protection, professional associations and the local utility companies.

5.3 Pipe selection

5.3.1 Pipe wall configurations
Wefatherm pipes are available in three different wall configurations.

Standard pipe
This is the traditional mono layer pipe as described in the standards ISO 15874 and DIN8077/8078. The international product certification applies on this pipe wall type.
- PP-R available in SDR 6 - 7,4 - 11
- PP-RCT available in SDR 7,4 - 11
- Thermal expansion factor 0,150 mm/m.K

Properties:
- Marking = green colour for hot and cold water
  purple colour for reused water
- Mono layer = PP-R/PP-RCT

The international product certification applies on this pipe wall type.

DVGW product

Illustration 5.6

Fiber pipe
This is a three-layer pipe of which the middle layer is enforced with glass fiber. The production of these pipes is externally monitored by the South German Plastics Centre (SKZ), Wurzburg.
- PP-R available in SDR 7,4
- PP-RCT available in SDR 11 - 7,4
- Thermal expansion factor 0,035 mm/m.K
- Less bracketing
- Higher thermal stability

Properties:
- Marking = 4 red stripes
- External layer = PP-R/PP-RCT
- Middle layer = glass fibre compound
- Inner layer = PP-R/PP-RCT

GEPRÜFT SKZ ÜBERWACHT

Illustration 5.7

Stabi pipe
This is a traditional mono layer pipe with an additional encapsulated perforated aluminium layer. The function of the perforated aluminium layer is to limit the thermal expansion of the pipe. It is no oxygen barrier. The fully encapsulated aluminium layer is additional to the traditional standard pipe. Before welding the additional aluminium layer needs to be removed. For above ground outdoor application we provide the stabi UV pipe with outer layer of UV resistant black PE.
- PP-R available in SDR 7,4
- Thermal expansion factor 0,030 mm/m.K
- Less bracketing
- Suitable for hot water lines and mains
- Black UV resistant pipe for outdoor application

Properties:
- Marking = many shallow dimples
- External layer = encapsulated aluminium
- Standard pipe = PP-R

Illustration 5.8

Standards

5.3.2 Pipe wall selection

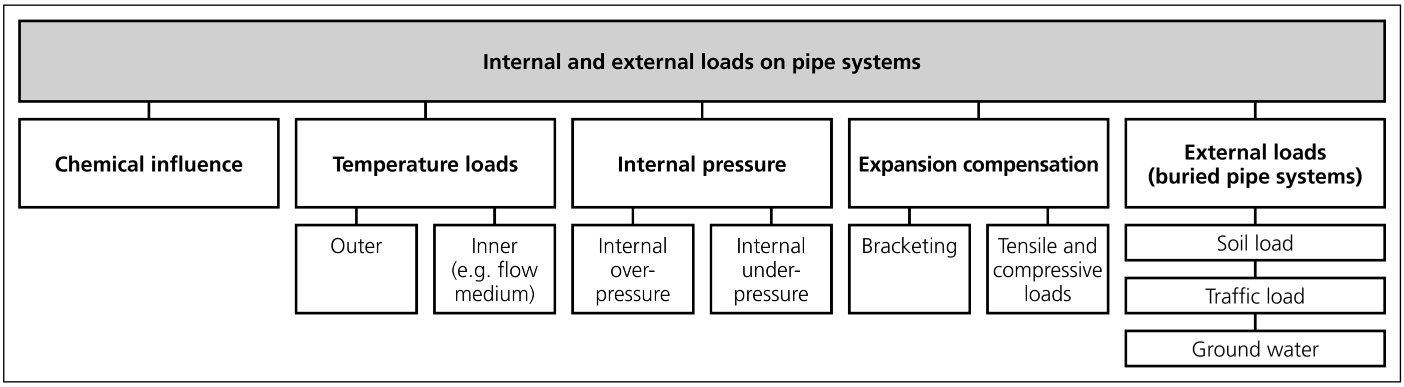


Illustration 5.9

Chemical influence
The first step in material selection for plastic pipe systems is to check the plastics material resistance against the chemical influence of the medium flowing through the pipe. The chemical resistance of polypropylene against a number of fluids is given in chapter 3.

In general, drinking water for human consumption can be conveyed without restriction by a polypropylene pipe system. The potentially dissolved amount of chlorine is of such a low value that it has no chemical influence on the polypropylene material at consumption temperature (max. 25°C).

> ! In hot tap water systems the potentially dissolved amount of chlorine can be increased due to secondary (preventive and corrective) disinfection water treatment. Especially in recirculating hot water systems with water temperatures above 70°C limitations have to be respected. See limitation mixed copper/PP-R hot water recirculation systems and manufacturers position on Legionella prevention & control and Wefaterm PP-R pipe systems.

The pipe wall selection is based on the required wall thickness (indicated by the SDR value), preferred expansion behaviour of the pipe system and the jointing technique. The required SDR value is determined by the temperature load and internal pressure.

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Temperature load and internal overpressure
An overload of pressure in a pipe system due to internal overpressure results, especially in association with additional heat effects, in a continuous expansion of the pipe until it breaks. The danger of an expansion arises as a result of too small wall thicknesses, in which an indiscriminate wall thickness increase is not justifiable. In the presence of heat expansion, a wall thickness enlargement also increases the reactive forces on the pipe fixed points. The engineer must ensure that the wall thickness is designed to meet the requirements while the pipe remains elastic in response to any length changes that might arise. A sudden change in structural operating conditions due to internal pressure leads to pressure surges. The distinctive elasticity of the plastic pipe has the advantage that the extreme values of pressure waves are significantly lower than in steel pipes. Despite this fact, pipe systems operated by pumps or containing rapidly closing shut-off valves must be tested for any foreseeable effects of pressure surges.

For hot and cold water installations the German DVGW work sheet W 534 prescribes a nominal pressure of 10 bar for hot and cold water systems.

Standard ISO 15874 defines 4 operating classes:

Class	Temperature maximum in °C	Application
1	60	hot water supply
2	70	hot water supply
3	70	low temperature heating
4	80	high temperature heating

Table 5.1

Standard DIN 8077 calculations for PP-R and PP-RCT materials, at several temperatures, safety (design) factors and SDR values, these tables are given in appendix B. The steps in the pipe selection process are described in following example.

Example for the selection of pipe

Basic parameters: Cold water
Maximum Operating Pressure 10 bar
Medium temperature 20-25°C

Selection process steps
Step 1: Select medium temperature => 20°C
Step 2: Select required design life cycle => 50 years
Step 3: Read Maximum Operating Pressures => MOP 15,4 bar > OP 10 bar
Step 4: Read SDR value => SDR 11

Temperature °C	Operating years	Maximum Operating Pressure SDR 11	SDR 7,4	SDR 6	SDR 5
10	1	21,1	33,4	42,1	53,0
	5	19,8	31,5	39,7	49,9
	10	19,3	30,7	38,6	48,7
	25	18,7	29,7	37,4	47,0
	50	18,2	28,9	36,4	45,9
	100	17,8	28,2	35,5	44,7
20	1	18,0	28,5	35,9	45,2
	5	16,9	26,8	33,7	42,5
	10	16,4	26,1	32,8	41,4
	25	15,9	25,2	31,7	39,9
	50	15,4	24,5	30,9	38,9
	100	15,0	23,9	30,2	37,8
30	1	15,3	24,2	30,5	38,5
	5	14,3	22,7	28,6	36,0
	10	13,9	22,1	27,8	35,0
	25	13,4	21,3	26,8	33,8
	50	13,0	20,7	26,1	32,9
	100	12,7	20,1	25,4	31,9

Table 5.2 Maximum Operating Pressure (MOP) for PP-R for water safety factor (SF) = 1,25 DIN 8077

Basic parameters: Hot water
Maximum Operating Pressure 10 bar
Medium temperature 70°C

Selection process steps
Step 1: Select medium temperature => 70°C
Step 2: Select required design life cycle => 50 years
Step 3: Read Maximum Operating Pressures => MOP 12,9 bar > OP 10 bar
Step 4: Read SDR value=> SDR 7,4

Temperature °C	Operating years	Maximum Operating Pressure SDR 11	SDR 7,4
50	1	12,6	20,1
	5	12,2	19,3
	10	12,0	19,0
	25	11,7	18,6
	50	11,5	18,3
	100	11,3	18,0
60	1	10,7	17,0
	5	10,3	16,3
	10	10,1	16,0
	25	9,9	15,7
	50	9,7	15,4
70	1	9,0	14,3
	5	8,6	13,7
	10	8,5	13,5
	25	8,3	13,1
	50	8,1	12,9
80	1	7,5	11,9
	5	7,2	11,4
	10	7,0	11,2
	25	6,9	10,9

Table 5.3

Standards

5.3.3 Pipe diameter selection
In order to select the pipe diameters correctly, the following must be determined:
- Number and size of the removal points connected
- Peak flow at each removal point
- Flow speeds
- Pressure losses

A considerable amount of data is necessary in order to calculate the correct diameters for a pipe network. The following data is required:
- Geodetic height difference
- Minimum supply overpressure and/or pressure on the output side of a pressure reducing or pressure increasing device
- Pressure losses at items of equipment such as water gauges, filters, water treatment units etc.
- Minimum flow pressures of the removal point fittings employed
- Pipe friction pressure gradient of the pipe material employed
- Coefficients of resistance of the fittings and connection units employed

Planning aid
You can find the tables providing the relevant information (pipe friction resistances, loss coefficients for fittings and connection units etc.) in appendix B.

The use of modern software systems make the repeating calculations efficient. Different software systems are available. Ensure that the underlying calculations are based on the national requirements.

If you require assistance for the design and calculation of water supply systems contact the Wefatherm Export Sales Office.