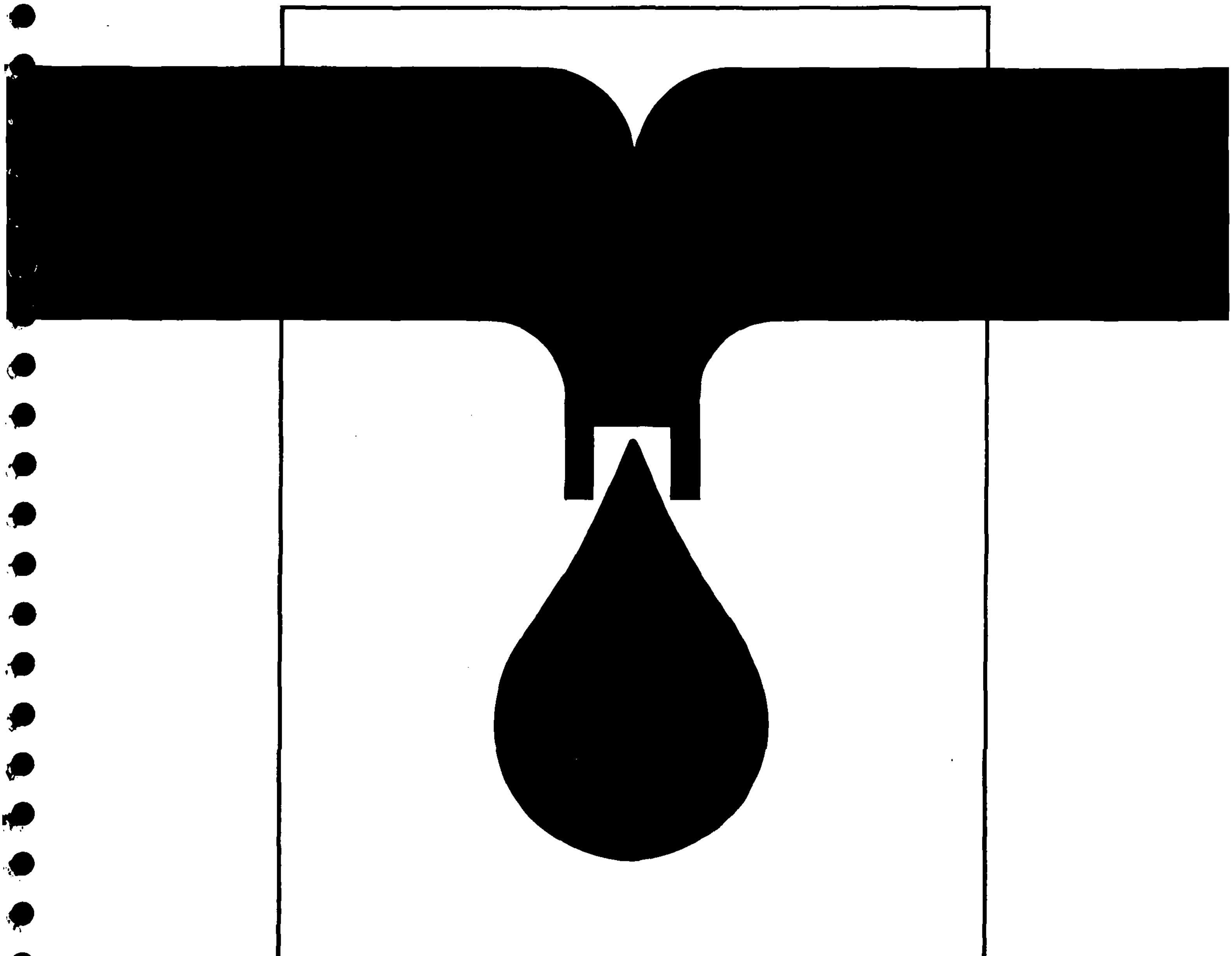
TRAINING MODULES FOR WATERWORKS PERSONNEL



Special Knowledge

2.6

Pipe laying procedures and testing of water mains

Foreword

Even the greatest optimists are no longer sure that the goals of the UN "International Drinking Water Supply and Sanitation Decade", set in 1977 in Mar del Plata, can be achieved by 1990. High population growth in the Third World combined with stagnating financial and personnel resources have led to modifications to the strategies in cooperation with developing countries. A reorientation process has commenced which can be characterized by the following catchwords:

- use of appropriate, simple and – if possible – low-cost technologies,
- lowering of excessively high water-supply and disposal standards,
- priority to optimal operation and maintenance, rather than new investments,
- emphasis on institution-building and human resources development.

Our training modules are an effort to translate the last two strategies into practice. Experience has shown that a standardized training system for waterworks personnel in developing countries does not meet our partners' varying individual needs. But to prepare specific documents for each new project or compile them anew from existing materials on hand cannot be justified from the economic viewpoint. We have therefore opted for a flexible system of training modules which can be combined to suit the situation and needs of the target group in each case, and thus put existing personnel in a position to optimally maintain and operate the plant.

The modules will primarily be used as guidelines and basic training aids by GTZ staff and GTZ consultants in institution-building and operation and maintenance projects. In the medium term, however, they could be used by local instructors, trainers, plant managers and operating personnel in their daily work, as check lists and working instructions.

45 modules are presently available, each covering subject-specific knowledge and skills required in individual areas of waterworks operations, preventive maintenance and repair. Different combinations of modules will be required for classroom work, exercises, and practical application, to suit in each case the type of project, size of plant and the previous qualifications and practical experience of potential users.

Practical day-to-day use will of course generate hints on how to supplement or modify the texts. In other words: this edition is by no means a finalized version. We hope to receive your critical comments on the modules so that they can be optimized over the course of time.

Our grateful thanks are due to

Prof. Dr.-Ing. H. P. Haug
and
Ing.-Grad. H. Hack

for their committed coordination work and also to the following co-authors for preparing the modules:

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It is my sincere wish that these training modules will be put to successful use and will thus support world-wide efforts in improving water supply and raising living standards.

Dr. Ing. Klaus Erbel
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Eschborn, May 1987

Title: Pipe laying procedures and testing of water mains

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1 Design

1.1 Drawings and plans

Just as in other technical fields, drawings play an important part in the design and construction of pipe systems. Their main functions are to pass on data to other specialists, to provide information for all interested parties and to establish for future reference a record of the exact location of the water mains and fittings laid. The drawings should also be revised accordingly for any amendments, extensions etc. of the pipe systems. To make the drawings easier to read, a system of symbols and notations is used (cf. fig. 1). These stand for certain technical expressions and standard pipe components.

The table below gives some of the most commonly-used symbols. Figures 2 and 3 show sections of plans on which the routes of water mains are marked.

Fig. 1 The main symbols

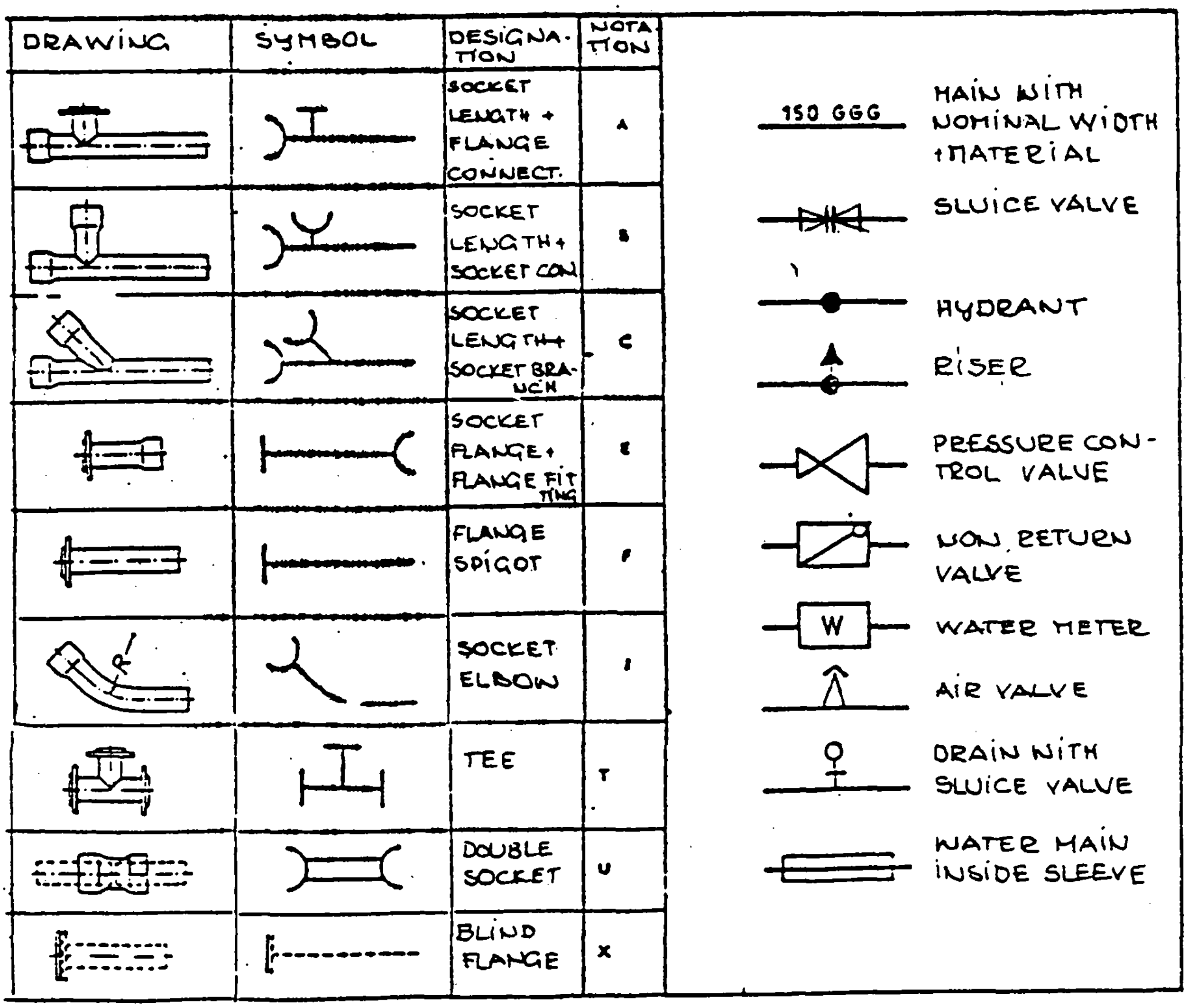
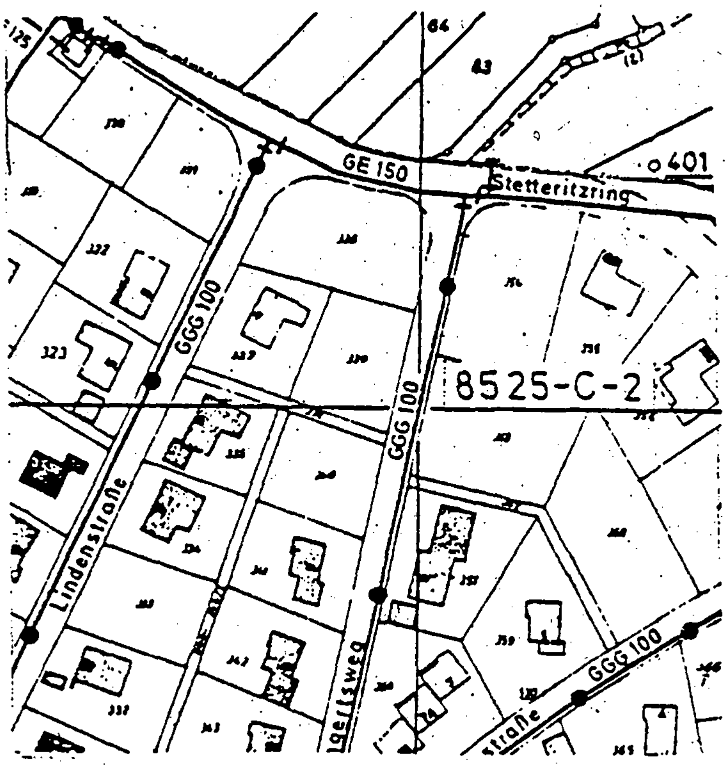


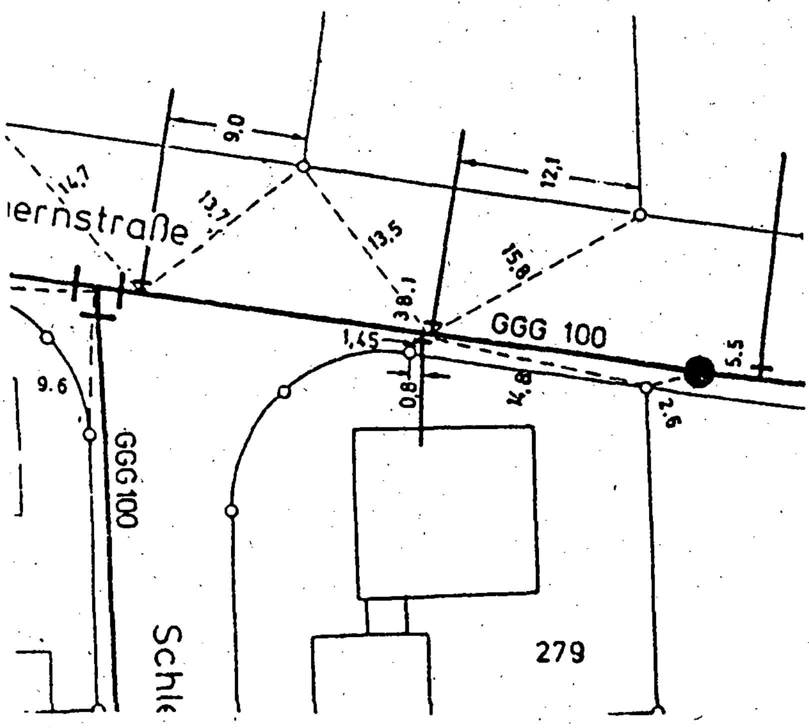
Fig. 2: Part of a lay-out plan, scale 1 : 2000.



The plan shows:

The route taken by the mains;
Material and nominal internal diameter;
Locations of stop valves and hydrants;
Boundaries of plots, cadastral numbers, roads.

Fig. 3: Part of a location plan, scale 1 : 500



The location plan gives additional information on the locations of communication pipes and distances from fixed surveying points.

1.2 Routing of water mains

1.2.1 General points

At an early stage in the design of a pipe network system, the best route for the mains to take has to be determined after taking into consideration both the technical and economic aspects. It seldom happens that the shortest possible path between two points is also simultaneously the optimum route. The factors determining this optimum route are not always the same, but vary according to whether long-distance transmission pipelines or water mains - service mains and communication pipes - are to be routed.

1.2.2 Long-distance transmission pipelines

Long-distance transmission pipelines are always routed outside built-up areas.

Mains of this category must be laid at an adequate distance away from surfaced roads, to allow for any subsequent road widening.
On steep gradient, the pipeline should be laid on a suitable line along the slope to ensure against damages due to landslide.

Wet or marshy ground should be avoided because of the risk of subsequent subsidence and of corrosion.

These mains should be laid with rising and falling gradients. The gradients of the pipeline should not be less than 4^{0}/oo. If pipelines are laid completely flat, air bubbles can form, leading to greater energy and pressure losses.

So that maintenance and repair work can be carried out, long-distance transmission pipelines must be accessible to motor vehicles.

These pipes should be laid in trenches to protect them from all external influences and frost. The thickness of the earth cover depends on climate.

1.2.3 Trunk and service mains

These are laid inside built-up areas, preferably underneath road reserves. Any other existing or planned facilities - e.g. electricity cables, gas mains - must be taken into account. The water mains should be laid if possible in undisturbed ground.

Ring mains with as few dead ends as possible are preferrable.

The depth below ground level depends on climate and on the anticipated volume of traffic.

A minimum gradient of 4 $^{o}/oo$ is important here too. Air is released from the high points via communication pipes.

Trunk and service mains are best laid at mid-distance between the centre of the road and the boundaries of building plots when it is not possible to lay them in the road reserve.

Communication pipes should follow the shortest possible route from service main to water meter and should be equipped in such a way that a reserve flow from the draw-off points back to the service main is restricted.

1.3 Calculation of pipe diameters

1.3.1 General points

The choice of diameter depends on the volume of water to be transported, the economic rate of flow and the required minimum pressure.

1.3.2 Volume of water

The volume of water to be transported is calculated by considering the size of the area to be supplied, the population density and the specific water consumption per inhabitant per day. The decisive factor is the maximum hourly consumption. The needs of large-scale consumers such as hospitals, schools or industry and also requirements for fire-fighting purposes must be given separate consideration.

The specific water consumption of a population varies widely. The average consumption in Germany, for instance, is approx. 140 l per person per day; for rural areas in Africa the existential minimum requirement is assumed to be 40 l/person per day.

1.3.3 Supply pressure

The supply pressure in the service mains should be between 2 and 6 bars, representing a head of 20 to 60 m.

1.3.4 Economic rate of flow

The economic rate of flow is used to calculate the optimum relationship between construction, investment and operating - mainly energy - costs. Both construction and operating costs are largely determined by the diameter of the pipes.

The relationships are as follows:

Large pipe diameter - higher construction costs - low pressure losses in the mains - lower energy consumption.

The economically optimum rate of flow is given when:

The annual sum of the costs of energy, capital servicing and maintenance gives the lowest figure.

Economic flow rates must be calculated individually because of local and seasonal fluctuations in construction and energy costs.

General rule:

Trunk, secondary and service mains	1.00 m/sec
Long-distance transmission pipelines	1.40 m/sec

2 Pipes

2.1 Pipe materials

2.1.1 General points

Pipes are an indispensable means of transporting water. The laying, operation and servicing of a pipe network is more labour-intensive and requires more material than any other element of a water-supply system.

To ensure the smooth functioning of a pipe network, particular care must be taken to choose the right type of pipe, made of the most suitable material, for the application. It is true to say that as a general rule there is <u>no ideal type of pipe which is equally suitable for all applications in a water-supply system</u>.

The choice of material should always be made according to the specific conditions existing on site.

Basic information on pipe materials is given in Module 2.1.

The most common types of pipe, pipe joints, fittings and materials are listed below, with an indication of their advantages/disadvantages and recommended applications.

2.1.2 Cast-iron pipes and joints

Cast-iron pipes are chiefly produced today from ductile cast iron in lengths between 5.00 and 6.00 m.

<u>Nominal internal diameters and pressure stages</u>

Cast-iron pipes are produced in diameters of up to 1000 mm and can withstand very high pressure stages.

<u>Material properties, protection</u>

Good bursting strength, elasticity.
The pipes are available provided with a cement mortar lining and an external coating of zinc and pitch.

Joints and fittings

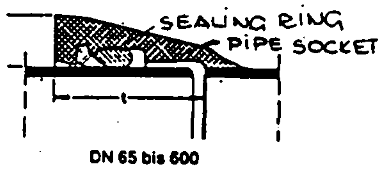


Fig. 4

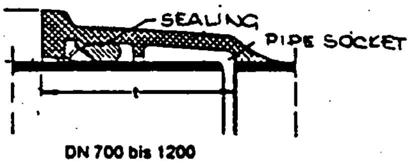


Fig. 5

Fig. 6

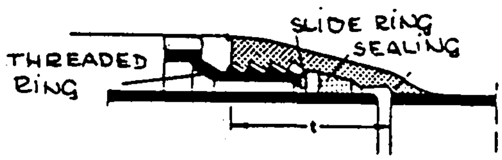


Fig. 7

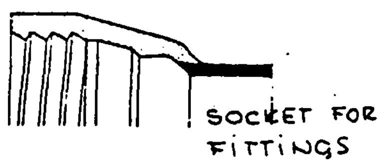


Fig. 8

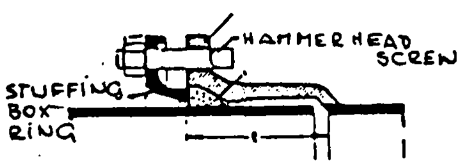


Fig. 9

Tyton joint (figs. 4, 5 and 6)

The Tyton sealing ring consists of a hard-rubber and a soft-rubber section. Tyton joints are simple in design and reliable in use. The joint can be bent through an angle of 3 to 6^0.

Tyton joints are also used for pipes with larger diameters. For smaller pipe diameters up to DN 400, Tyton rings with vulcanized-in stainless-steel claws, which can transmit longitudinal force, are also available.

Screwed socket joint (figs. 7 and 8)

The inside of the socket and outside of the ring have a cast thread. The joint is sealed through a compression of the rubber seal by tightening the ring. Bending of the joint up to 3^0 is possible. Used up to DN 400. Does not transmit longitudinal force.

Stuffing-box joint (fig. 9)

The stuffing-box joint consists of a profiled rubber ring compressed by means of a hammerhead screw and a stuffing-box ring. Used mainly for larger diameters from DN 500 and for pipes without an earth cover. Bending up to 3^0 possible. Does not transmit longitudinal force.

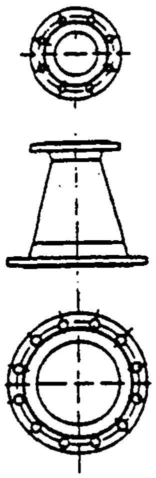


Fig. 10

Flange (fig. 10) and threaded joints

Both types of joint are rigid, withstand tensile stress and where pipes are laid underground are used only in combination with valves or instruments or in communication pipes.

The seal lies between the flanges and is compressed by tightening the screws.

Number and position of the drilled holes in the flange are standardized.

Recommended applications:

Pipes made from ductile cast iron are generally provided with Tyton joints. These pipes are easy to lay and reliable in use. Their use is widespread; special care must be taken only in the case of aggressive (untreated) water or aggressive soil, where measures must be taken to prevent corrosion.

2.1.3 Steel pipes and joints

Steel pipes are not used to any great extent in water-supply systems and are therefore given only brief mention here.

Advantages

High elasticity, few joints necessary, good bursting strength.

Disadvantages

Liable to corrode if not properly insulated; subsequent repairs to insulation difficult to carry out.
Welding of joints must be performed by competent, experienced workers.

2.1.4 Asbestos cement pipes and joints

Asbestos cement pipes are made of a mixture of asbestos fibres, cement and water and produced in lengths between 4.00 and 5.00 m. They are less resistant to shock and impact and have a lower flexural strength than steel or cast-iron pipes. Pipes made of asbestos cement are non-corroding and non-conductive. They are most economically used at pressures up to PN 10 and in diameters um to DN 600.

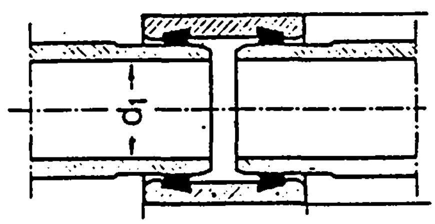


Fig. 11

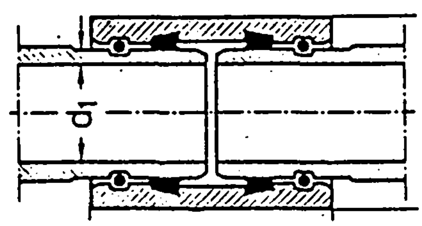


Fig. 12

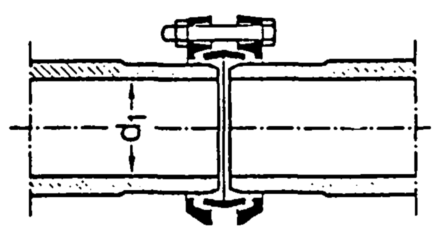


Fig. 13

Reka coupling (figs. 11 and 12)

Reka couplings are similar to double sockets. The calibrated spigot ends are inserted into the coupling from both sides. The spacer ring keeps the spigot ends apart. The seal is effected by sealing rings inserted on each side. Bending of the joint up to 6^0 is possible.
Reka couplings which can transmit longitudinal force are additionally secured by wire ropes (fig. 12).

Gibault coupling (fig. 13)

The Gibault coupling is made of steel with a profiled rubber sealing ring. Its advantage over the Reka coupling is that it can admit a wider range of tolerances.

2.1.5 Plastics pipes and joints

Plastics pipes used in water-supply systems are made mainly of rigid PVC (polyvinyl chloride) or PE (polyethylene). Both materials are non-corroding and non-conductive.

A disadvantage is their low resistance to material stresses under extreme temperature conditions, to impact and light. Pipes made from PVC are not suitable for above-ground applications (UV radiation causes embrittlement). In stony ground, plastics pipes should be well bedded in sand or suitable local material.
The use of PVC pipes is economical up to DN 300.

Pipes made from either rigid or flexible PE are used mainly for communication pipes.

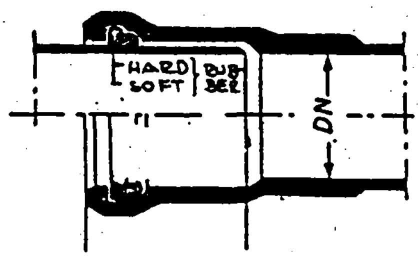


Fig. 14

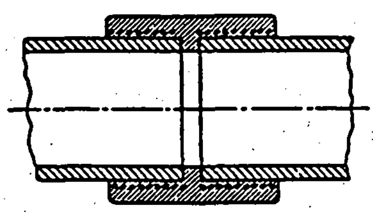


Fig. 15

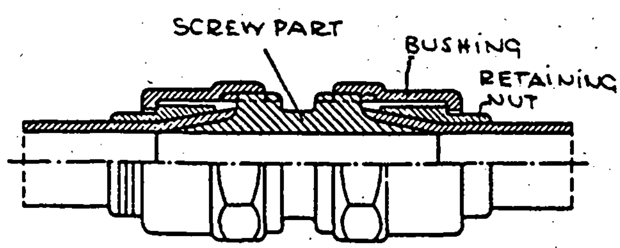


Fig. 16

The most commonly-used joint for PVC pipes is the socket with rubber sealing rings (fig. 14), similar to the Tyton joint described above.

PVC pipes can also be jointed with permanently adhesive sockets (fig. 15).

PE pipes are supplied in lengths; smaller-diameter pipes in rolls.
PE pipes are jointed separably using compression or socket-and-spigot joints or permanently by welding. (Fig. 16: compression joint).

2.1.6 Fittings

In pipe systems, it is often necessary to change direction, lay branches, install valves or instruments, increase or reduce diameter, etc. There are special fittings available for all these purposes; they are given the same protection against corrosion as the pipes and provided with the appropriate connecting elements. Pipes made of different materials are connected together by means of transition fittings.

2.2 Valves, instruments

2.2.1 Stop valves

The task of stop valves is to allow or prevent, either completely or only partially, the passage of water through the main. The design of such valves varies quite widely (see Module 2.3g for details).

Stop valves in water mains are used chiefly

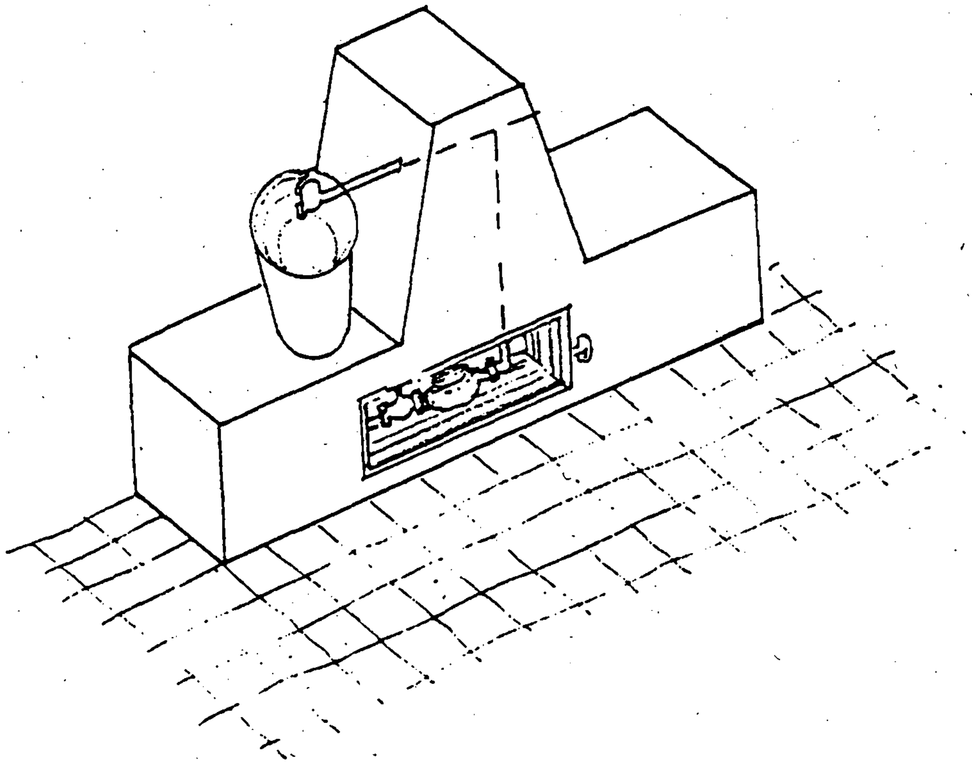
- to isolate certain sections of the main to allow repairs to be carried out or new branches to be connected,
- to regulate the flow of water,
- to permit the water to flow in one required direction only.

2.2.2 Public taps

In rural areas of developing countries, water is often distributed to consumers via publicly accessible taps (fig. 17). These taps should meet the following requirements:

- Hygienic conditions must be maintained: drainage facilities for leakages or overflow water must be provided at the distribution point.
- The structure should be solidly built of concrete or stone.
- A sensible, practical design is important.
- The water meter should be inaccessible to unauthorized persons.
- Taps should be self-closing.

Fig. 17: Public tap



2.2.3 Hydrants

Hydrants are used for a temporary supply of water and for special purposes such as fire-fighting. Hydrants are also installed at the high and low points of water mains for drainage, flushing or the release of air.

2.2.4 Air supply/relief valves

The function of these valves in pipe systems is to

- let air in during the drainage process,
- release air during filling,
- allow air which has collected in the pipe during operation to escape.

Air valves are installed at high points and at sharp vertical bends.

In service mains, underground hydrants are used for the same purpose. Another possible method of releasing the air from the mains is to locate communication pipes at the high points.

Long-distance transmission and feeder mains are provided *with automatic air valves. In underground pipes means that* manholes have to be provided.

2.2.5 Drains and wash-outs

As already pointed out under 1.2, water mains should always be laid at a slope, to prevent air bubbles forming and so prevent the consequent risk of breakdowns. The low points in the pipe system which result are then provided with drain outlets.

The following points should be noted:

- drain outlets are installed at the lowest points of the pipe network;
- they are closed by means of a sluice valve;
- there should be a free flow zone between the drain outlet and the recipient ditch, stream or canal;
- no contaminants must be allowed to enter the water main through the drain outlet.

Drain outlets are often combined with wash-outs.

2.2.6 Transfer points

If local service mains are supplied from a transmission or feeder main, the point of transfer will usually be provided with the following:

- water meter
- non-return valve
- stop valve
- pressure-control valve

3 Excavation work and pipe-laying

3.1 Digging and backfilling of trenches

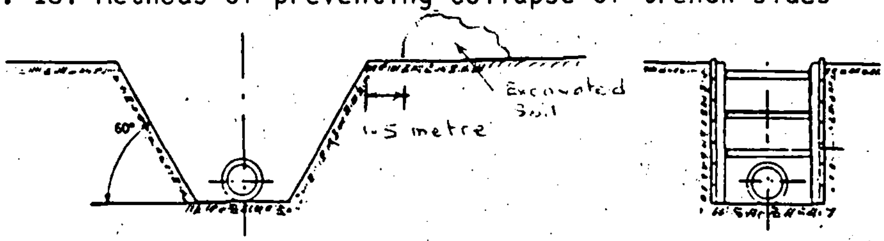
Before excavation of the pipe trench is begun, the axis of the pipe and its gradient must be transferred from the plan to the actual site. The pipe axis is marked from bend to bend and the correct gradient established to sight distance with the aid of sight rails.

Any already existing underground services such as drains, electricity mains, telephone cables etc. must be taken into account.

Depending on the stability of the ground, measures may have to be taken to prevent the sides of the trenches from collapsing inwards.

If there is enough space, the sides of the trench should be sloped, to an extent depending on the stability of the ground, or if space is limited they may be shored up using sheeting (cf. fig. 18). Materials, including excavated soil should be kept at least 1,5 metre from the edge of the trench.

Fig. 18: Methods of preventing collapse of trench sides



A minimum of 0.35 m working space is required on either side of the pipe.

3.2 Preparation of trench floor

In neutral, light soil (sand, gravel), the undisturbed ground should form the floor of the trench. In heavy soils (clay, rock), a bed of sand or suitable local material approx. 20 cm thick should be prepared for the pipe; the pipe should also be bedded in sand or suitable local material on all sides.

Where the ground is not firm enough, the floor of the pipe trench should be stabilized with a layer of crushed rock or coarse gravel.

Revised:

The stabilizing layer and trench floor should then be compacted and covered with fine sand or suitable local material before the pipe is bedded.

The floor of the trench should slope evenly; the pipe must be in full contact with the ground at all points.

To ensure that the trench floor is even, appropriate checks should be carried out using sight rails.

The trench should be backfilled and compacted in layers of approx. 30 to 50 cm thick.

The material used in the proximity of the pipe should be stone-free and care must be taken not to damage the insulating layer.

3.3 Laying of pipes

When laying pipes, the following rules must be observed:

- Pipes should be transported with care and sudden impacts avoided. Sharp-edged lifting and transporting aids such as chains or cables, should not be used.

- Pipes made from PVC must not be exposed to sunlight for any length of time.

- Before they are laid, the pipes should be inspected for faults; any imperfections in the protective coating should be repaired and extensively damaged pipes either rejected or shortened to their re-usable length.

- Pipe joints should be cleaned with particular care.

- The manufacturer's instructions must be followed throughout the pipe-laying process; this is especially imprtant if joints are to be bent at an angle from the pipe axis.

- There should always be a pipe brush inside the pipe; this is pulled through when a new length is fitted on.

During work breaks, all openings must be closed using plugs, covers, blank flanges etc.

Pipes must be protected against upthrust and against compressive stress by means of earth bridges.

4 Calculation of thrust blocks

4.1 General points

The forces occurring inside the pipe are sufficient to pull the joints apart at elbows, branches and pipe ends, if these cannot transmit longitudinal force. To prevent this from happening, such points are strengthened by thrust blocks, which are generally made of concrete. Calculation of the thrust blocks is based on the maximum pressure which can occur; usually during the test pressure of a pipe. It must be noted that the area of pressure taken for calculations is that of the outside diameter of a pipe (socket).

4.2 Calculation of shearing force

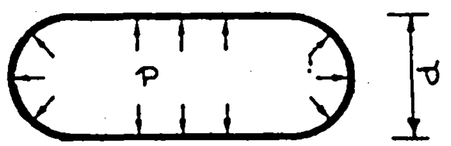
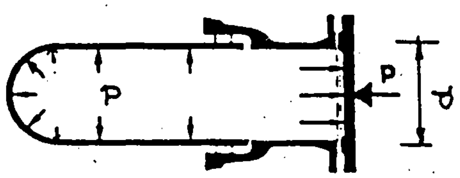


Fig. 19



The shearing force is calculated by the formula

$$P = \frac{p \times d^2 \times 3.14}{4} = \quad (N)$$

where

P = shearing force in N (newtons)

p = maximum possible pressure in N/mm² (10 bars = $1 \frac{N}{mm^2}$)

d = outside diameter (cf. figs. 19 and 20)

Table 1 below gives the shearing forces calculated for the most commonly-used pipe diameters at a pressure of 15 bars (usual test pressure).

Table 1 Shearing force F 15 for a test pressure of 15 bars

DN	80	100	125	150	200	250	300	400
P15 (N)	11300	16400	24400	34000	58100	88400	125200	216800

4.3 Thrust blocks for pipe ends

The greater part of the shearing forces occurring in the pipe is transferred via a concrete foundation to the earth wall. In order not to exceed the permissible soil pressure, the area of pressure of the concrete abutment must be adequately dimensioned.

The surface area of the thrust block is calculated with the aid of the formula

$$A = \frac{P}{\sigma} \ (\mathrm{mm}^2)$$

where

A = area of the thrust clock in mm^2

P = shearing force in N

σ = permissible soil pressure in $\mathrm{N/mm}^2$

Table 2 Permissible soil pressure for different types of subsoil

		bars	$\mathrm{N/mm}^2$
Pasty ground	=	0.4	0.04
Soft ground	=	1.0	0.1
Semi-hard ground	=	2.0	0.2
Hard ground	=	4.0	0.4
Stratified rock	=	15.0	1.5
Solid rock	=	30.0	3.0

4.4 Thrust blocks for pipe bends

The shearing force which has to be absorbed by the thrust block wherever the pipe changes direction (i.e. at bends) is the resultant of two forces effective along the length of the pipe (cf. fig. 21).

The resultant is calculated with the aid of the formula

$$P_R = 2 \times P \times \sin \frac{\alpha}{2} \ (N)$$

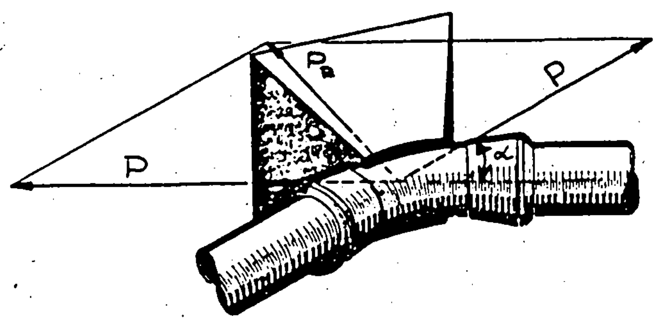
where

P_R = resultant shearing force in N

P = shearing force (N)

α = angular deviation

Fig. 21: Parallelogram of forces



The following values of $2 \times \sin \frac{\alpha}{2}$ result for the most common angular deviations (bends):

11°	22°	30°	45°	60°	90°
0.2	0.4	0.5	0.8	1.0	1.4

Table 3: Dimensioning of thrust block, calculated for a test pressure of 15 bars and soil pressure of 0.1 N/mm²

	cm^2 cm · cm	$\alpha = 11^\circ$	$\alpha = 22^\circ$	$\alpha = 30^\circ$	$\alpha = 45^\circ$	$\alpha = 90^\circ$	$\alpha = 60^\circ$ PIPE END + BRANCHES
80	F BxH	500*) 20x25	500*) 20x25	600 23x26	850 29x30	1600 42x38	1150 34x33
100	F BxH	500*) 20x25	650 23x27	850 27x31	1250 35x36	2300 51x45	1650 41x40
125	F BxH	500*) 18x28	950 28x34	1250 34x37	1850 43x44	3450 62x55	2450 50x49
150	F BxH	650 21x31	1300 33x40	1750 40x44	2600 50x52	4800 73x65	3400 59x57
200	F BxH	1100 27x39	2250 43x52	3000 52x58	4450 66x67	8150 96x85	5800 78x75
250	F BxH	1600 34x48	3400 53x64	4550 64x71	6750 81x83	12 400 118x105	8850 96x92
300	F BxH	2300 40x58	4800 63x76	6450 76x85	9600 97x99	17 600 141x125	12 500 114x110
400	F BxH	4000 52x76	8350 83x100	11 150 100x112	16 600 127x130	30 450 185x165	21 650 150x145

Absorption of shearing forces through ground friction

If it is not possible to transfer the shearing forces to the undisturbed ground of a trench side, recourse must be had to the force of resistance resulting from the ground friction.

This is calculated with the aid of the formula: $G \frac{P}{\mu}$

where

G = weight of the concrete body in N
P = shearing force - resultant
μ = frictional coefficient of average ground

Examples and recommended methods of construction are given in Module 3.6.

5 Pressure test

The separate components of a water main must be connected in such a way that no unwanted shifts of position can occur and the completed pipeline is watertight. Any changes of position after the pipes have been laid can seriously disrupt the system and usually lead to bursts. Leaks - which most often occur at joints - tend to gradually enlarge the weak spot and eventually cause considerable damage. Such effects can be avoided if the strength and water-tightness of all mains are tested after laying.

Before pressure is exerted, it is important to ascertain whether the main is adequately supported. In particular, thrust blocks must have been provided at bends and pipe ends and the mains must be loaded with earth bridges.

The correct procedure is to fill the pipe with clean water slowly enough to allow all the air inside it to escape. Trapped cushions of air cause percussions and thus may result in considerable damage.

The selected test pressure should be realistically, but not unnecessarily high. For long-distance transmission mains the test pressure should be 5 bars above operating pressure, but not less than 10 bars.

In service mains, the test pressure should be 1.5 times the nominal pressure.

Since temperature may affect the results of the test, a time should be chosen when temperatures can be expected to remain fairly constant. The temperature at the beginning and at the end of the test should be roughly the same.

The duration of the test depends on the diameter and on the length of the pipe section to be tested.

The following rough guide is given for water mains which are longer than 50 m:

up to DN 400	6 hours
between DN 400 and DN 500	12 hours
more than DN 700	24 hours

The test is considered to be passed if the pressure does not noticeably drop throughout its duration.

6 Flushing and sterilization

All water-supply systems must be cleaned, flushed and sterilized before going into operation.

In flushing, a volume of water several times the capacity of the pipe is forced through it at high speed, so that any contaminants, such as grit, stones etc. are carried away.

After flushing, the pipes are disinfected with chlorine. The chlorine concentration in the water should be between 5 and 10 g/m^3. The pipe must always be completely full. The disinfectant solution is left in the pipe for several hours and then rinsed out. When rinsing out, care should be taken to avoid polluting the environment; the concentration of chlorine in the water should not then be greater than 0.5 g/m^3.

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TRAINING MODULES FOR WATERWORKS PERSONNEL

List of training modules:

Basic Knowledge

0.1 Basic and applied arithmetic
0.2 Basic concepts of physics
0.3 Basic concepts of water chemistry
0.4 Basic principles of water transport
1.1 The function and technical composition of a watersupply system
1.2 Organisation and administration of waterworks

Special Knowledge

2.1 Engineering, building and auxiliary materials
2.2 Hygienic standards of drinking water
2.3 a Maintenance and repair of diesel engines and petrol engines
2.3 b Maintenance and repair of electric motors
2.3 c Maintenance and repair of simple driven systems
2.3 d Design, functioning, operation, maintenance and repair of power transmission mechanisms
2.3 e Maintenance and repair of pumps
2.3 f Maintenance and repair of blowers and compressors
2.3 g Design, functioning, operation, maintenance and repair of pipe fittings
2.3 h Design, functioning, operation, maintenance and repair of hoisting gear
2.3 i Maintenance and repair of electrical motor controls and protective equipment
2.4 Process control and instrumentation
2.5 Principal components of water-treatment systems (definition and description)
2.6 Pipe laying procedures and testing of water mains
2.7 General operation of water main systems
2.8 Construction of water supply units
2.9 Maintenance of water supply units Principles and general procedures
2.10 Industrial safety and accident prevention
2.11 Simple surveying and technical drawing

Special Skills

3.1 Basic skills in workshop technology
3.2 Performance of simple water analysis
3.3 a Design and working principles of diesel engines and petrol engines
3.3 b Design and working principles of electric motors
3.3 c –
3.3 d Design and working principle of power transmission mechanisms
3.3 e Installation, operation, maintenance and repair of pumps
3.3 f Handling, maintenance and repair of blowers and compressors
3.3 g Handling, maintenance and repair of pipe fittings
3.3 h Handling, maintenance and repair of hoisting gear
3.3 i Servicing and maintaining electrical equipment
3.4 Servicing and maintaining process controls and instrumentation
3.5 Water-treatment systems: construction and operation of principal components: Part I - Part II
3.6 Pipe-laying procedures and testing of water mains
3.7 Inspection, maintenance and repair of water mains
3.8 a Construction in concrete and masonry
3.8 b Installation of appurtenances
3.9 Maintenance of water supply units Inspection and action guide
3.10 –
3.11 Simple surveying and drawing work

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