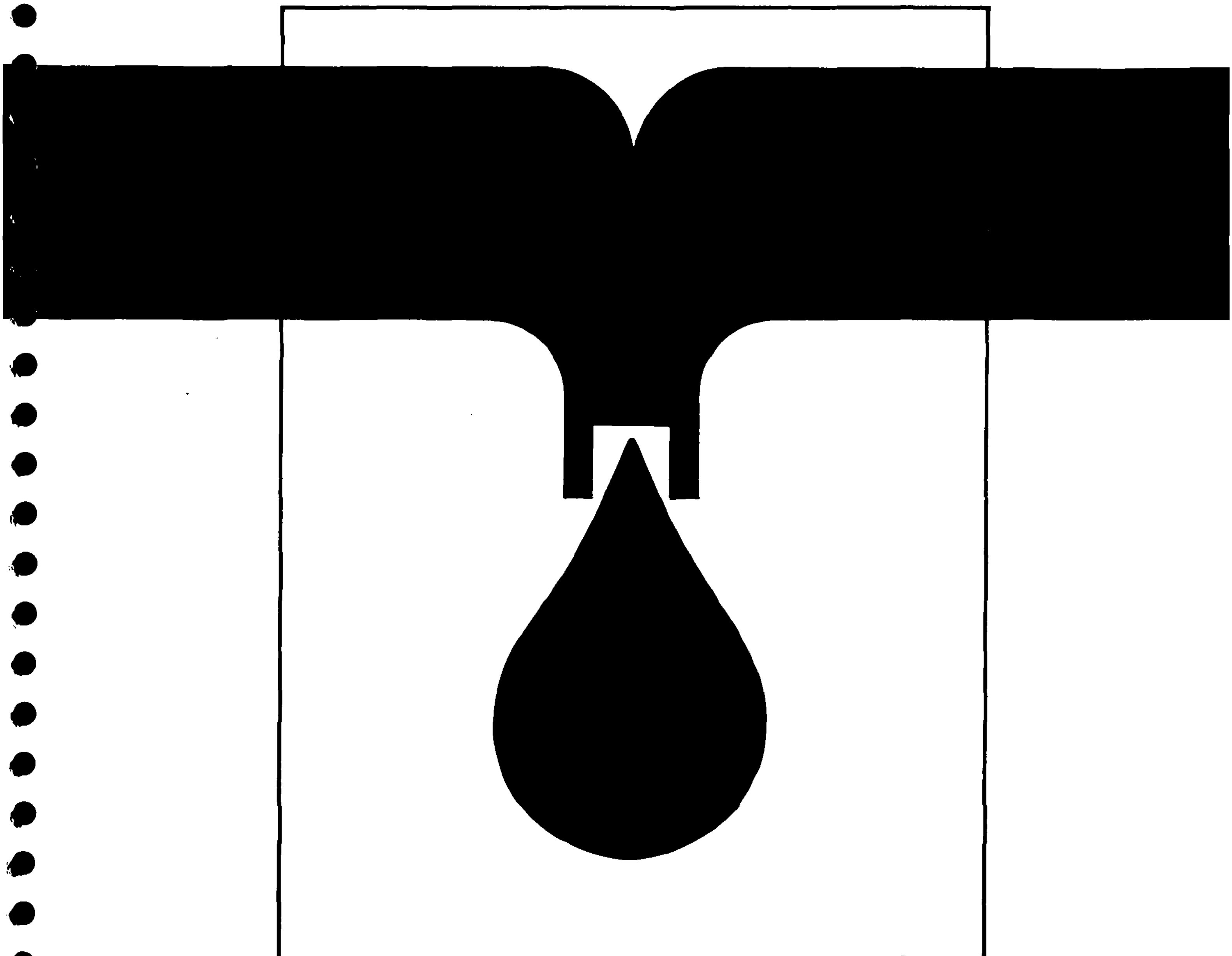
TRAINING MODULES FOR WATERWORKS PERSONNEL



Special Skills

3.6

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:

Dipl.-Ing. Beyene Wolde Gabriel
Ing.-Grad. K. H. Engel
Ing.-Grad. H. Hack
Ing.-Grad. H. Hauser
Dipl.-Ing. H. R. Jolowicz
K. Ph. Müller-Oswald
Ing.-Grad. B. Rollmann
Dipl.-Ing. K. Schnabel
Dr. W. Schneider

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
Head of Division
Hydraulic Engineering,
Water Resources Development

Eschborn, May 1987

Title: Pipe-laying procedures an testing of water mains

Table of contens: Page

1. Simple surveying and setting-out work

1.1 Setting out of straight lines and angles

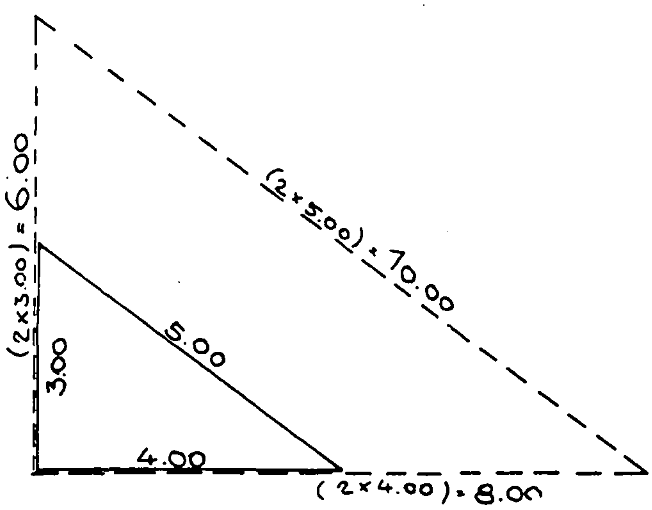
1.1.1 Setting out of a straight line

Ranging rods are planted vertically at the beginning and end of the required straight line, and other range poles lined in at intermediate points between them by sighting from one end. The observer should stand roughly 2 to 3 metres behind the first range pole to achieve a better sight.

For precise setting-out work a theodolite or level with horizontal circle is used. The telescope is set up vertically above one extremity of the line and the required straight line set out by adjusting a given horizontal angle and sighting along the bases of the ranging rods.

1.1.2 Setting out of a right angle

A right angle can be plotted by setting out the sides of a triangle in the ratio 3:4:5.



In practice, this involves measuring out the lengths of the two adjacent sides (in the example 3.00 and 4.00 m). and moving the positions of these sides about until the lenght of the hypotenuse is exactly 5.00 m. The triangle can be made larger or smaller by multiplying or dividing the lengths of the sides by the same figure, i.e. the ratio remains the same.

In the example shown by dotted lines, the lengths of the sides of the triangle have been multiplied by 2:
(3.00 m x 2 = 6.00 m, 4.00 m x 2 = 8.00 m, 5.00 m x 2 = 10.00 m)

1.1.3 On-site determination of the angle of a bend

Where the location route of a pipe changes direction, the angle of the bend can be determined on site, using special tables.

For this purpose, the alignment of the approaching pipe axis is continued beyond the bend and the alignment of the diverging pipe axis sighted in. Then, from the point of divergence, an arc with a radius of 10.00 m is marked out, to cut both the fixed and the diverging pipe axis, and the two points of intersection are joined by a straight line. The length of this line is used to find the angle of the bend from table 1.

In the example shown in fig. 2, the length of the connecting line is 6.01 m and the angle of the bend 35°.

Fig. 3 shows an instance where an elbow giving an angle of 30° is installed and the remainder of the required angle achieved by bending two socket joints through 2 1/2° each.

s m	γ°	s m	γ°	s m	γ°	s m	γ°
0,000	0	4,330	25	8,450	50	12,189	75
0,175	1	4,500	26	8,610	51	12,310	76
0,350	2	4,670	27	8,770	52	12,450	77
0,550	3	4,840	28	8,925	53	12,585	78
0,700	4	5,010	29	9,080	54	12,720	79
0,875	5	5,175	30	9,240	55	12,860	80
1,045	6	5,345	31	9,390	56	12,990	81
1,220	7	5,515	32	9,545	57	13,120	82
1,395	8	5,680	33	9,700	58	13,250	83
1,570	9	5,850	34	9,850	59	13,380	84
1,745	10	6,010	35	10,000	60	13,510	85
1,920	11	6,180	36	10,150	61	13,640	86
2,090	12	6,350	37	10,300	62	13,770	87
2,265	13	6,510	38	10,450	63	13,890	88
2,440	14	6,680	39	10,600	64	14,020	89
2,610	15	6,840	40	10,750	65	14,140	90
2,785	16	7,000	41	10,890	66		
2,955	17	7,170	42	11,040	67		
3,130	18	7,530	43	11,180	68		
3,300	19	7,490	44	11,330	69		
3,475	20	7,650	45	11,470	70		
3,645	21	7,810	46	11,610	71		
3,815	22	7,980	47	11,760	72		
3,990	23	8,135	48	11,900	73		
4 50	24	8,295	49	12,040	74		

Table 1 - On-site determination of the angle of a bend

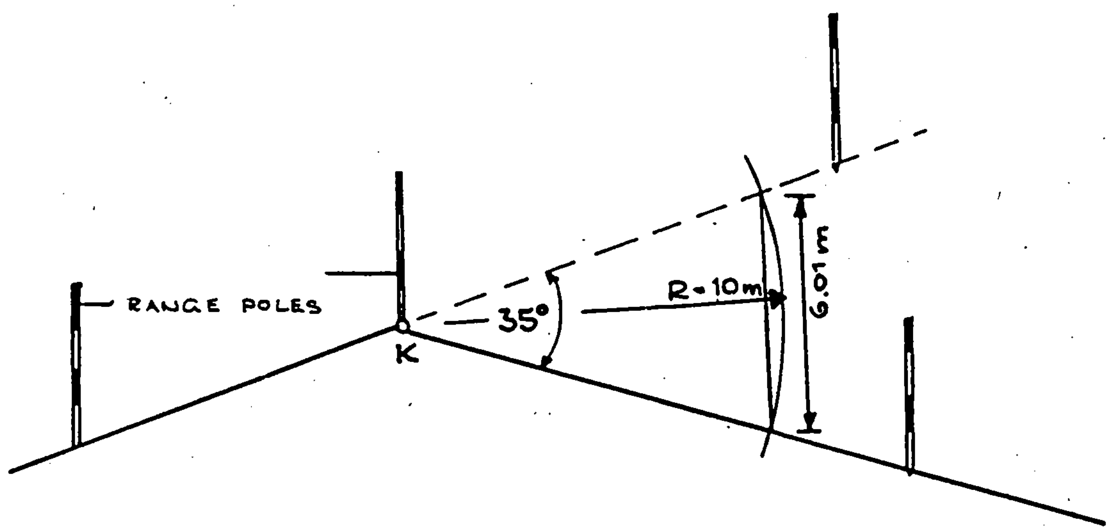


Fig. 2 Measuring the angle of a bend Range poles

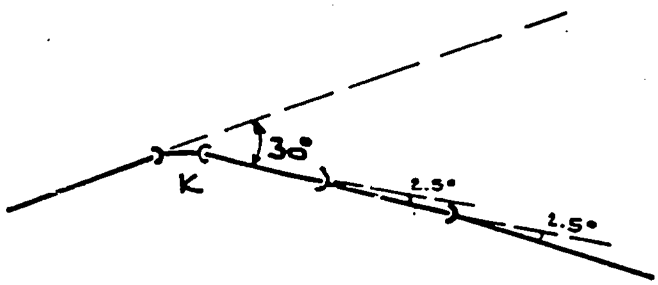
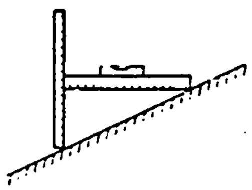


Fig. 3 Constructing a pipe bend

1.2 Levelling

1.2.1 Stepping down

This is the simplest method of levelling and it is necessary on steep slopes. An offset staff or levelling rod is adjusted with the aid of a spirit level so that it is exactly horizontal, and the perpendicular distance from the ground measured along a plumb line.



1.2.2 Spirit levelling

This is the most commonly used method of leveling. The technique is used to ascertain the varying levels of the ground along a pipe route, longitudinal and cross sections, depths of foundations, elevations of buildings, etc.

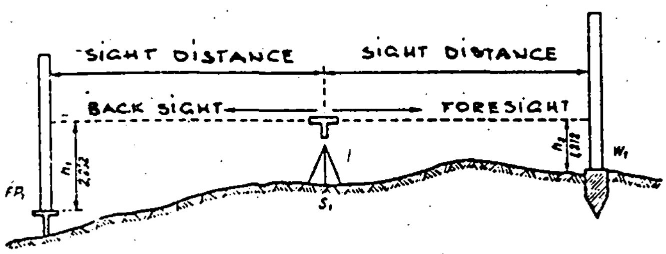


Fig. 4 Spirit levelling

Basic principles of the technique

The line of sight of the levelling instrument (telescope) is adjusted with the aid of a spirit level until it is exactly horizontal, and the height h_1 between the line of sight and the upper edge of a known fixed point is read off the levelling staff. The height of the collimation line ZH is then

$ZH = FP_1/m.s.l + h_1 = 100.000 + 2.252 = 102.252$ (back sight)

After this, the levelling staff is set up on the point W_1, the level of which is sought, and the height h_2 between the horizontal line of sight and the point of elevation is read off the levelling staff.
The level of W_1 is then given by

$W_1 = ZH - h_1 = 102.252 - 1.212 = 101.040$ (foresight)

1.3 Use of sight rails

Sight rails are needed to prepare a trench floor with the required fall of gradient.

Sight rails are set up at all changes of gradient and at bends. If the bends lie out of sight of each other, intermediate sight rails are set up.

At least 2 fixed sight rails and 1 boning rod (traveller) are needed.

The upper edge of the two fixed sight rails is related to the planned level of the trench floor at each position. The difference in level between the top edge of the sight rail and the planned bottom of the trench is the same for each fixed sight rail. This is selected (as a round number) in such a way that the top edge of the sight rail is roughly at eye level. The height of the boning rod corresponds to the difference in level between the fixed sight rails and the trench floor at each position.

The sighting procedure is begun by setting up the boning rod at an arbitrary position in the trench between the two sight rails. The trench is at the correct level if, when sighting along the trench, the upper edges of the sight rails and of the boning rod are seen to be in alignment.

<u>Example</u>

Position 1:	planned trench floor level	124.35 m above m.s.l.
	level of ground	125.80 m above m.s.l.
Position 2:	planned trench floor level	124.85 m above m.s.l.
	level of ground	126.10 m above m.s.l.

Calculation of length of boning rod:

= mean ground level + eye level - mean trench floor level
= 125.85 + 1.50 m - 124.60 m = 2.75 m, rounded off <u>2.50 m</u>

Height of sight rail at position 1:
124.35 m + 2.50 m = 126.85 m above m.s.l.
Height of sight rail at position 2:
124.85 m + 2.50 m = 127.35 m above m.s.l.

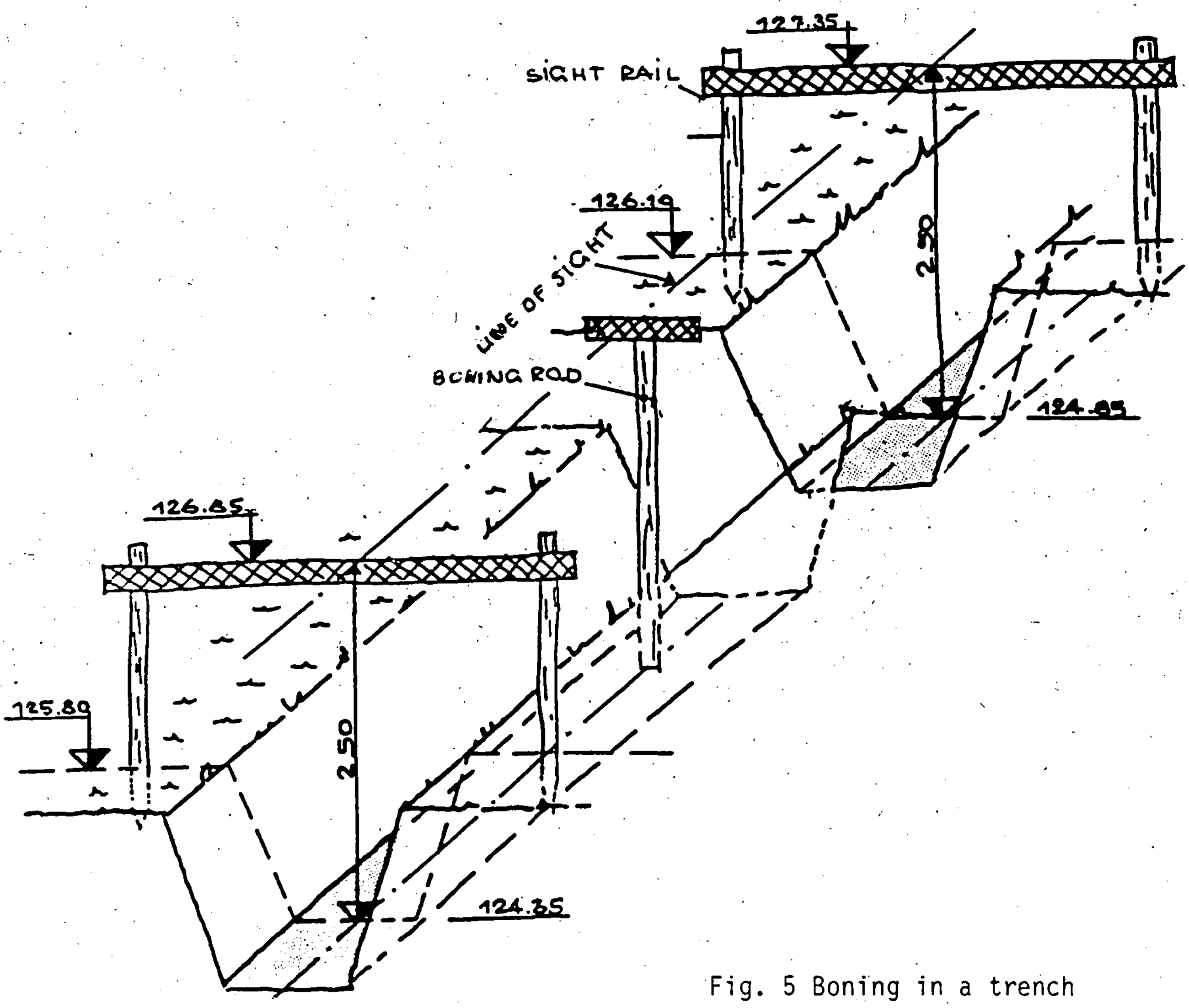


Fig. 5 Boning in a trench

2. Transport and storage of pipes

Pipes for water supply systems are normally transported by lorry and unloaded either directly where they are to be used, along the route of the pipeline, or first stored for an intermediate period. Smaller pipes can be unloaded by hand; larger pipes need a crane or excavator. If no machines are available, a temporary structure must be erected - e.g. a ramp constructed out of planks or square-sawn timbers.

When unloading, transporting or storing pipes, attention must be paid to the following points:

To prevent any damage to the external insulating layer, no sharp-edged devices or tools may be used when unloading the pipes.

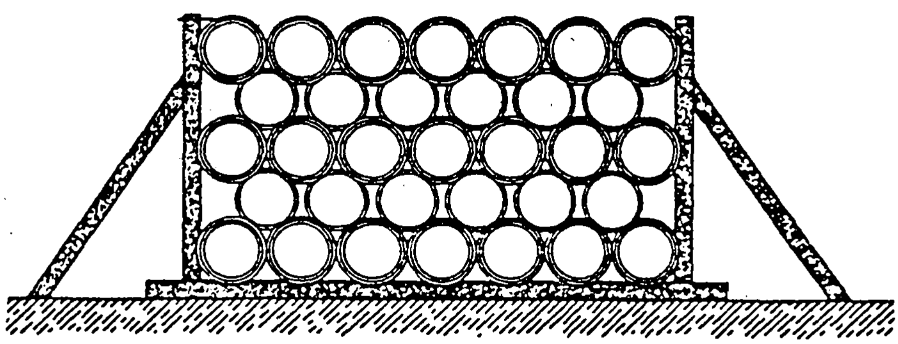
All pipe lengths must be stored in such a way that their internal surfaces cannot be contaminated by earth, dirt, mud or dirty water.

When storing the pipes, care must be taken to secure them against rolling, slipping or vibration.

Seals, rubber rings and plastics pipes must be covered to prevent direct exposure to sunlight.

If pipes are stacked, a level, adequately strong (depending on the height of the pile) supporting surface should first be made out of planks or square-sawn timbers.

When stacking large-diameter pipes, it is advisable to provide intermediate stages made of square timbers and to secure each layer separately with wedges. The supporting timbers should be approx. 1 m away from the end of the pipes. The storage area should be chosen in such a way that the pipes do not come into contact with muddy ground.



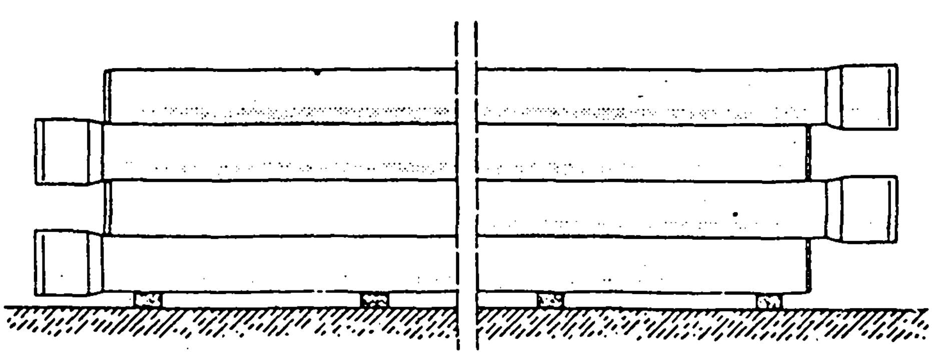


Fig. 6 Stacked pipe lengths

3 Preparation of the trench floor and backfilling of the trench

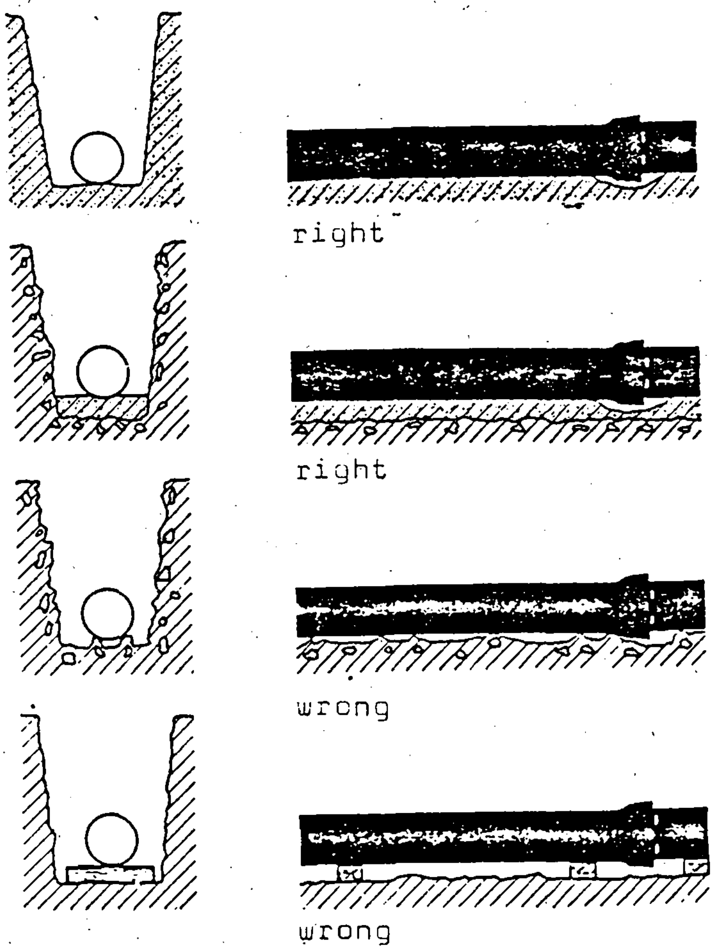


Fig. 7 Preparation of trench floor

Fig. 7 Laying of pipes

The reliable functioning and efficiency of pipe systems depend very largely on the correct, competently performed laying of the pipes. Pipes must be laid so that they slope steadily, with rising and falling gradients. Socket holes must be provided for the joints. Point and linear loads must not occur. Trench floors not providing adequate support must be stabilizied with broken stone, coarse gravel or layers of lean-mixed concrete. These stabilizing layers should be covered with fine sand or suitable local material to prevent damage to the insulating layer on the pipe.

When the pipes have been laid thrust blocks must be constructed to support bends, branches and fittings at pipe ends. Before the pressure test, the pipes must be weighted with earth bridges to prevent changes of position and, if there is ground water in the trench, to counter upthrust.

Following the pressure test, the socket holes and trenches should be carefully filled in with earth or other suitable filling material. Care must be taken to use only stone-free material, especially when covering plastics or asbestos cement pipes. Aggressive peat or heavy clay soils should not be used.

Trenches under roads or other areas used by traffic should be back-filled and compacted in layers.

4 Tools, accessories and other equipment used in pipe laying

4.1 Tools for cutting and re-working pipes

In addition to standard small tools such as hammers, spanners, pliers, emery paper and wire brushes, use is made in pipe laying of other, special tools and accessories, which are specifically adapted to the material and the internal diameter of the pipes. Some of these tools and appliances are described below.

Metal bow saws with inserted saw blade can be used for all types of material and smaller diameters.

Fig. 8 Metal bow saw

Plastics pipe cutters are suitable for cutting polyethylene pipes up to DN 2"

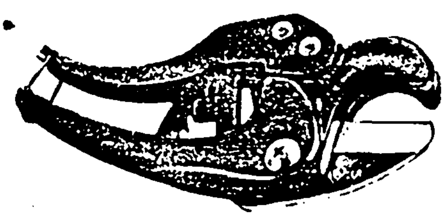


Fig. 9 Plastics pipe cutter

Handsaws can be used to cut PVC pipes up to DN 200.

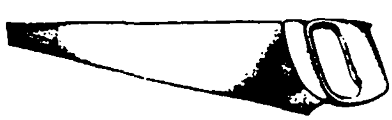


Fig. 10 Handsaw

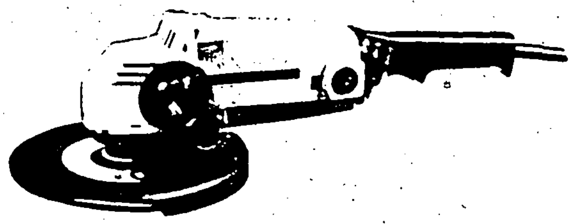


Fig. 11 Electric angular-type disc grinder

Electric angular-type disc grinder

This appliance is suitable for all materials and diameters. It should be noted, however, that cutting asbestos cement pipes with this tool produces a fine dust which is detrimental to health; appropriate precautions should therefore be taken. To prevent accidents, under wet conditions a cutting grinder driven pneumatically or by a petrol engine should be used.

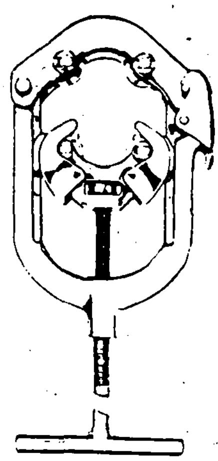


Fig. 12 Four-wheel pipe cutter

Four-wheel pipe cutters are available in various sizes and are especially suitable for steel or cast iron up to DN 250. The cutting wheels are exchangeable and should be matched to the pipe material.

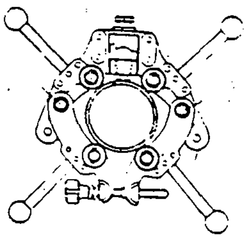
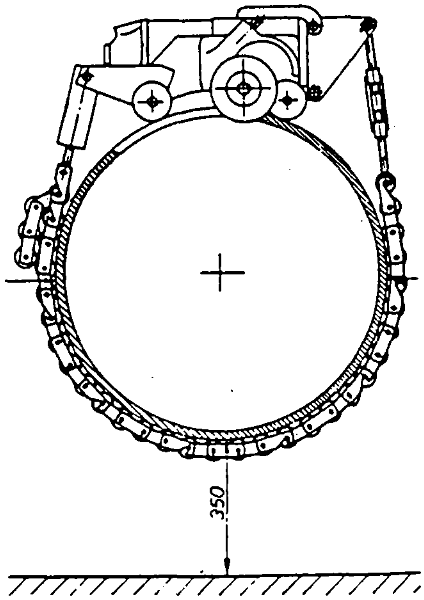


Fig. 13 Pipe cutter

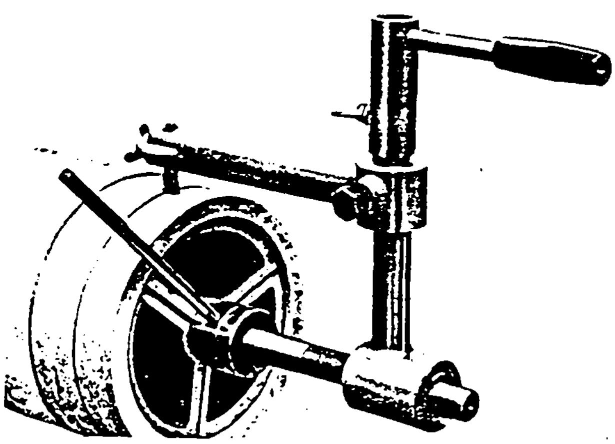
The pipe cutter is suitable for all pipe materials and for diameters up to 400 mm. The device is simple to use, not dependent on any energy supply and can be used where space is limited. The tool is adjusted to different pipe diameter by means of guide attachments. The cutters are ground on both sides and can be re-ground several times.



Motor-driven pipe saws are used for large-diameter pipes. The pipe saw is fixed to the pipe with an adjustable, spring-mounted stirrup chain and guide rollers. When power feed is switched on, the saw automatically travels round the pipe. Saws provided with pneumatic motors can also be used under water.

Fig. 14 Pipe saw

After cutting, the cut pipe ends must be prepared for jointing. The cut ends of steel, cast-iron and plastics pipes are skimmed and chamfered using a file suited to the material. The cut ends of asbestos cement pipes must be re-worked to recover the bore for jointing.



The turning device for recovering the bore of asbetos cement pipes is fixed in the pipe with the aid of a clamping attachment adjusted to the pipe's internal diameter. The turning tool can generally be set to a cutting depth of at most 1.5 mm. If necessary, the pipe must be turned several times until the required external diameter is achieved.

Fig. 15 Turning device

4.2 Special devices and tools for jointing socket pressure pipes and fittings.

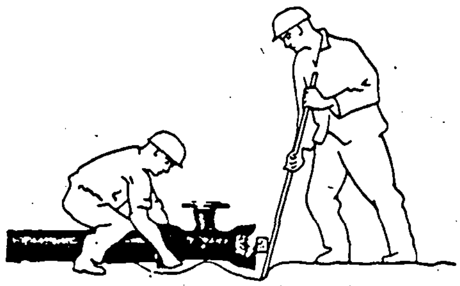


Fig. 16. Fitting with a lever

When fitting pipes using a lever, the spigot end is pushed into the socket of the pipe length in front of it. A thick piece of square-cut wood should be placed between the socket and the lever.
-Suitable up to DN 150-

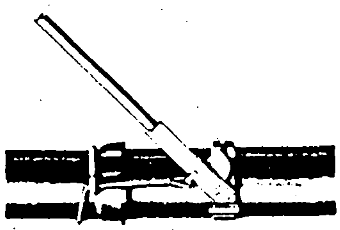


Fig. 17 Fitting device

When a fitting device is used, a clamping ring is placed over the spigot end of the pipe and a cable with bracket fixed to the socket. Then the fork is placed over the clamp pin, the cables connected up and the spigot end pushed in.
-Suitable up to DN 400-

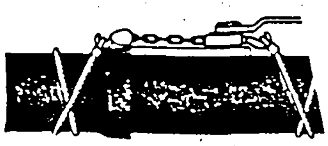


Fig. 18 Windlass

A hoist or windlass is used for larger-diameter pipes. One end of the windlass is attached to a cable fastened to the spigot and the other to a cable attached to the socket, and the pipe lengths are pushed in together.

5 Pipe jointing

5.1 General points

The most common types of joints in pipe laying are socket and flange joints, with rubber seals. Depending on the pressure stage, type of pipe material and pipe diameter, screwed or adhesive joints and compression screwed joints are also used. Some of the methods commonly used to joint pipes are described below. When carrying out the work, the insructions and recommendations of the manufacturer should always be followed.

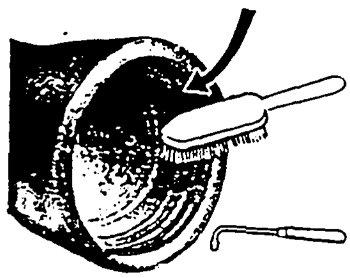


Fig. 19 Cleaning the socket

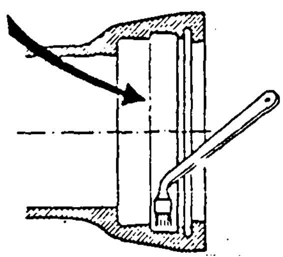


Fig. 20 Application of lubricant

5.2 Tyton socket

The inside of the socket must be thoroughly cleanded, paying particular attention to removing any remains of paint or dirt from the retaining groove and the seat of the seal. The spigot end should be well cleaned up to the mark showing the depth of insertion in the socket.
The sealing surface inside the socket is coated with the lubricant provided by the pipe manufacturer.
The sealing ring is cleaned and held in such a way that it takes on the form of a heart. The sealing ring is placed in the socket so that the outer hard-rubber rim engages in the retaining groove inside the socket. Then the complete ring is pressed smoothly into place round the socket. The inner hard-rubber rim of the ring must

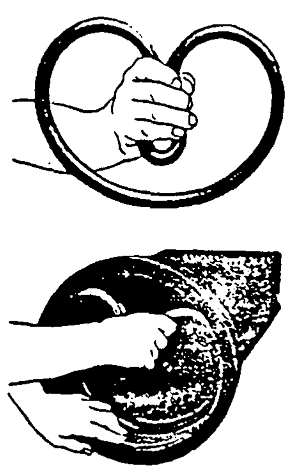


Fig. 21 and 22 Insertion of the sealing ring

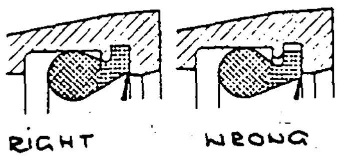


Fig. 23 Correct seating of the sealing ring

not project over the spigot. A thin layer of lubricant is applied to the sealing ring. The spigot is coated with lubricant, especially at the bevelled edge, and then pushed up to the mark into the socket. After the joint is completed, the seat of the sealing ring should be inspected round the complete circumference of the pipe, using a feeler.

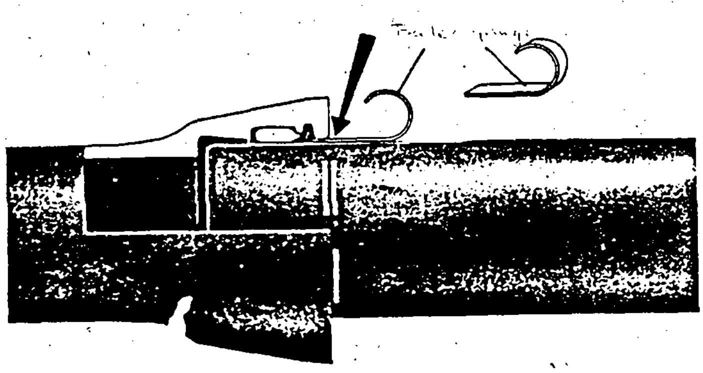


Fig. 24 Examination of seat of sealing ring

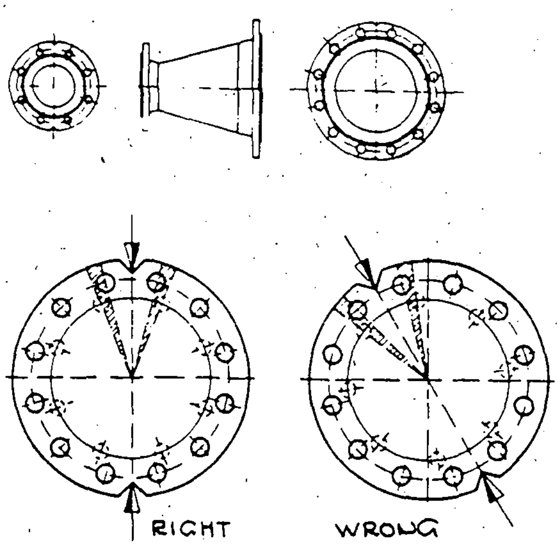


Fig. 25 Flange joints

5.3 Flange joint

A flange joint consists of two flanges, a sealing ring and a number of hexagon-head screws. The position of the screw holes, whatever the material, is such that they are arranged symmetrically to the two main axes, without being in these axes, and that their overall number is divisible by 4 in all pipe diameters.

Flanges having the same nominal diameter and the same nominal pressure can be joined regardless of their design and the material of which they are made. Corrosion-proof screws should be used as far as possible; otherwise a protective bandage should be wrapped round the flanges.

Before screwing them together, the sealing strips of the flanges should be thoroughly cleaned.

The screws should be thightened in crosswise order, i.e. each screw followed by its opposite, so that compression is as even possible; finally all screws are fully tightened.

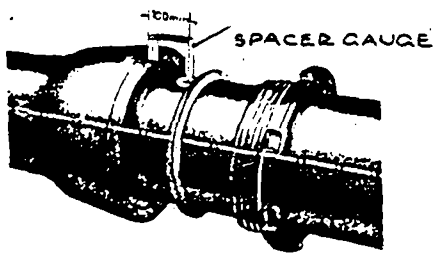


Fig. 26 Screwed socket joint

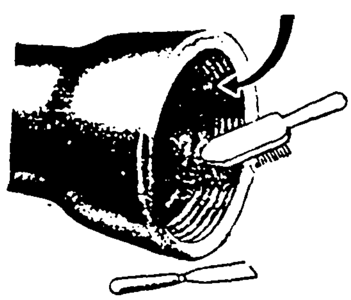


Fig. 27 Cleaning of threaded socket

5.4 Screwed socket joint

The screwed socket joint consists of a socket, a rubber sealing ring and a threaded ring. The inside of the socket and the outside of the ring have a cast thread. Screwing in the ring compresses the rubber ring and seals the joint.

Procedure:

The sealing and threaded surfaces should be cleaned particularly thoroughly. The depth of insertion in the socket is marked on the spigot end. The threaded ring, slide ring and sealing ring are pushed in that order down the spigot, beyond the mark.

The spigot is thoroughly coated with the lubricant supplied by the manufacturer, then placed

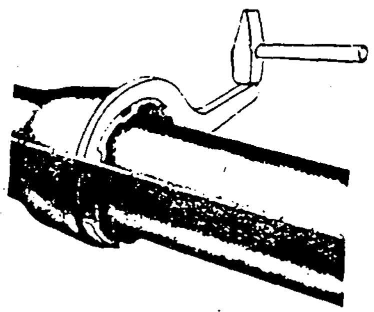


Fig. 28. Tightening of a screwed socket joint

in the socket and the insertion depth checked. The sealing ring is pressed into its seat and the slide ring pushed up. The threaded ring is screwed in and tightened with a hammer or ram.

5.5 Jointing of plastics pipes

5.5 Socket-and-spigot joints

Plastics pipes laid underground usually have socket-and-spigot joints sealed with rubber rings. The procedure is similar to that described under 5.2 for Tyton sockets.

5.5.2 Adhesive sockets

The proceudre with adhesive sockets is as follows:

The spigot is pushed into the socket and the depth of insertion marked. Care should be taken to push the spigot right up to the end of the socket. The surfaces which are to be stuck together must be dry, free of dirt and treated with a special cleaner recommended or supplied by the pipe manufacturer. Where pipes are highly discoloured, these surfaces should be roughened with emery paper before jointing.

Jointing by this method should not be carried out at temperatures below 5°C. The adhesive is applied with a brush to the inside of the socket and to the spigot, and the spigot inserted without delay into the socket, up to the mark.

No correction can be made after insertion. Any excess adhesive must be removed immediately.

5.5.3 Welded and screwed joints

One of the methods of jointing which produces a permanent joint is welding. Two types of welded joints are described below:

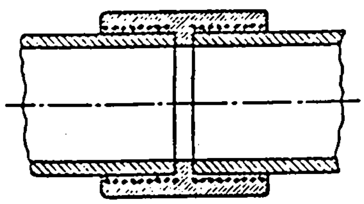


Fig. 29 Welded joint

One type of welded joint used for polyethylene pipes is the electrically welded socket. Here, heating wires with contact sockets are let into the end surfaces of the sockets. The coil is heated up by an automatic device via these contacts. The heat reaching the material produces a tight joint between spigot and socket.

The second commonly used method is butt welding. In this, the pipes are heated by a heating element to approx. 200°C; the heating element is removed and the pipe ends joined under pressure of 1 to 2 bars. The disadvantage of this method is the welding bead which it produces in the interior of the pipe.

Screwed joints are separable joints which are mainly used for small-diameter polyethylene pipes.

5.6 Jointing of asbestos cement pipes

Various different types of joints are offered by the manufacturs of asbestos cement pipes. One commonly used type is the "Gibault" coupling. This is a stuffing-box joint; it is sealed through the compression of rubber "O" rings by screws which are tightened between an intermediate sleeve ring and two outer loose flanges. "Gibault" couplings can be bent at an angle, accommodate relatively large tolerances of external diameter and can be re-sealed.

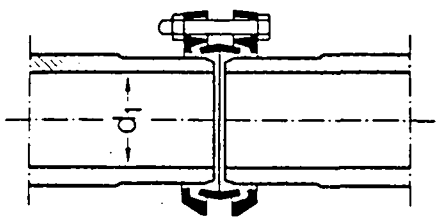


Fig. 30 "Gibault" coupling

6. Concrete thrust blocks for pressure pipes

6.1 General points

Numerous forces act on pipes and their joints.

Pipes are under stress from tne internal pressure - i.e. test or operating pressure. In the operation of a pipe system, sudden increases of pressure may occur, - e.g. pressure surges ("water hammer") caused by closing a stop valve too quickly. Negative pressure may occur when a pipe is being drained.

Where pipes are laid underground, other external forces also act on them; e.g. during back-filling of the trench and compacting of the material, followed by the pressure of the earth covering and possibly by traffic movements, etc.

In the case of pipes with joints which transmit longitudinal force - i.e. welded and flange joints - the shear forces are transmitted to the entire pipe run. Pipes with joints which do not transmit longitudinal force - i.e. Tyton, screwed and socket-and-spigot joints - either cannot transmit forces acting along the longitudinal axis, or only to a very limited extent.

In this case, unbraced bends, tees and fittings at pipe ends are forced away by the internal pressure in the pipes.

The forces resulting from the internal pressure in the pipe must be resisted by thrust blocks or anchorage.

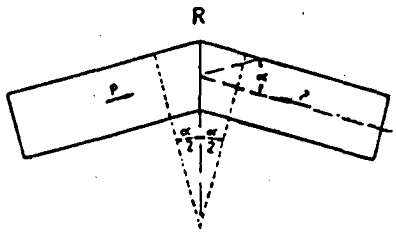
Generally speaking, the forces should be transmitted to the side of the trench; if this is not possible, the concrete thrust blocks must be dimensioned in such a way that the shear stress is absorbed through the friction between concrete and earth alone.

6.2 Calculation of the resultant shear stress at elbows

The resultant shear stress R is calculated by the formula:

$$R = 2P \times \sin \frac{\alpha}{2} \qquad P = p \frac{\pi \times d^2}{4}$$

where



P = shear stress parallel to pipe axis (N)

R = resultant shear stress (N)

d = outer diameter of pipe

p = test pressure

Table 2 below gives the resultant shear stresses R for the usual test pressures from 15 to 21 bars, also for the usual angles and diameters up to DN 500.

Table 2 Resultant shear stresses R in KN
1 KN (kilonewton) = 0.1 t

	Dia. 100 Test press. 15	21	Dia. 150 Test press. 15	21	Dia. 250 Test press. 15	21	Dia. 300 Test press. 15	21	Dia 400 Test press. 15	21	Dia 500 Test press. 15	21
11°	3.2	4.5	6.7	9.3	17.3	24.3	24.5	34.5	42.5	60.0	67.0	94.0
22°	6.4	9.0	13.3	18.6	34.5	48.5	49.0	68.0	85.0	119.0	130.0	182.0
30°	8.5	11.9	17.6	24.7	46.0	64.0	65.0	91.0	112.0	157.0	173.0	242.0
45°	12.6	17.6	26.0	36.5	68.0	95.0	96.0	134.0	166.0	232.0	255.0	357.0

6.3 Concrete thrust blocks for horizontal elbows

The calculations below are based on the following assumed data:

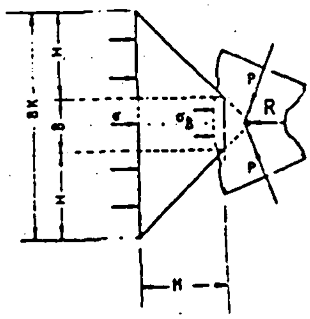
the side of the trench is to be used to absorb the shear stress and the thrust block is to be concreted against the trench side;

the distribution angle of the shear stress is 90°;

the permissible stress applied to the trench side is σ_B = 10 N/cm² (σ for sand or clay soils);

the permissible compressive stress on the concrete, σ_b = 200 N/cm²

Theoretical shape of the concrete thrust block:



B = width of contact of thrust block and elbow,

$$= \frac{R}{0.707d \times \sigma_b}$$

H = tickness of concrete thrust block calculated using the formula:

$$\frac{N}{\sigma_B} = (2\ H + B)\ (2\ H + 0.707d)$$

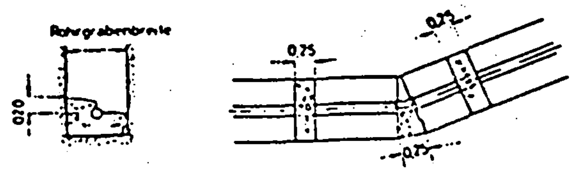
Examples:

The following examples of thrust blocks in varying sizes are shown for the resultant shear stresses "R" given in table 2:

Example I

DN 80 - 150

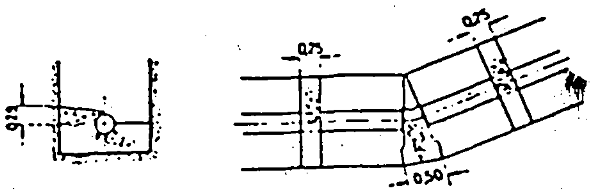
R = 10 KN (1 t)



Example II

DN 100 - 250

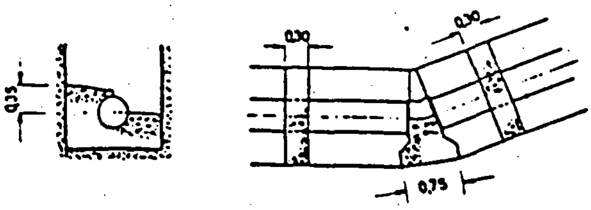
R = 10 KN - 20 KN



Example III

DN 150 - 400

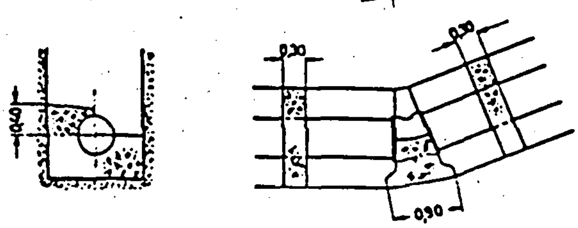
R = 36 KN - 52 KN



Example IV

DN 200 - 400

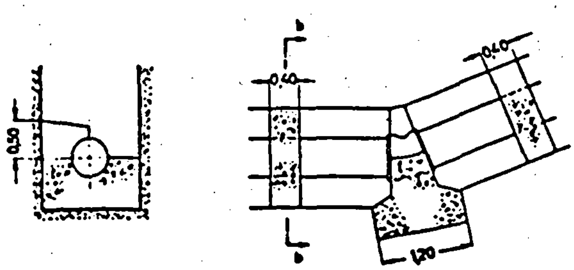
R = 52 KN - 72 KN



Example V

DN 250 - 500

R = 72 KN - 120 KN

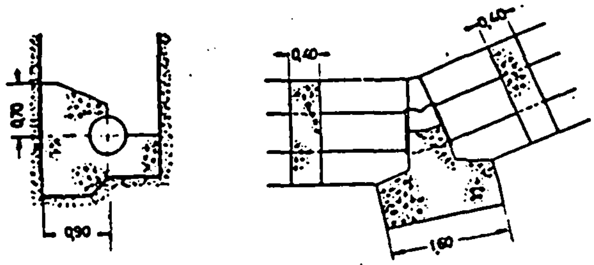


Revised:

Example VI

DN 300 - 500

R = 120 KN



It is not permissible to fill any gap that might result between trench side and concrete with trench-filling material after construction of the thrust block. The thrust block must be firmly connected to the undisturbed ground. Depending on the type of fitting, adequate space should be allowed for re-packing or re-tightening the joint.

6.4 Concrete supports for vertical elbows

6.4.1 Resultant force directed towards the air

In the case of vertical elbows, the shear stress must be absorbed by the weight of concrete. The figures given in the table below and the following examples are given for dry pipe trenches. If the support is in water, the resulting upthrust must be taken into account.

Table 3 Concrete thrust blocks in m³ for test pressures between 15 and 21 bars

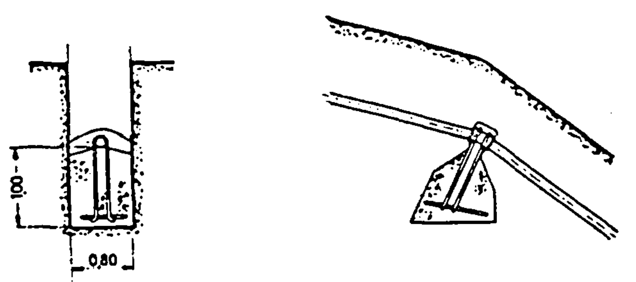
la	Di 100		Dia. 150		Dia. 250		Dia. 300		Dia. 400		Dia. 500	
	15	21	15	21	15	21	15	21	15	21	15	21
11°	0.15	0.20	0.30	0.42	0.79	1.10	1.12	1.51	1.93	2.75	3.04	4.25
22°	0.29	0.41	0.60	0.85	1.57	2.20	2.22	3.11	3.85	5.38	5.91	8.28
30°	0.39	0.54	0.80	1.12	2.08	2.91	2.95	4.12	5.10	7.14	7.85	10.99
45°	0.57	0.80	1.19	1.66	3.08	4.31	4.35	6.10	7.54	10.56	11.60	16.24

Examples:

Example I

up to DN 150

up to 0.65 m³ of concrete

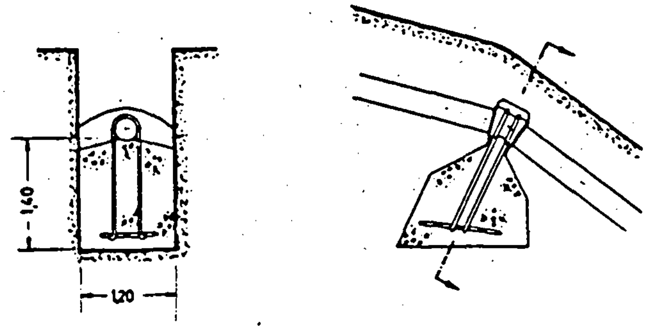


Example II

DN 150 - 300

0.65 to 1.30 m³

of concrete

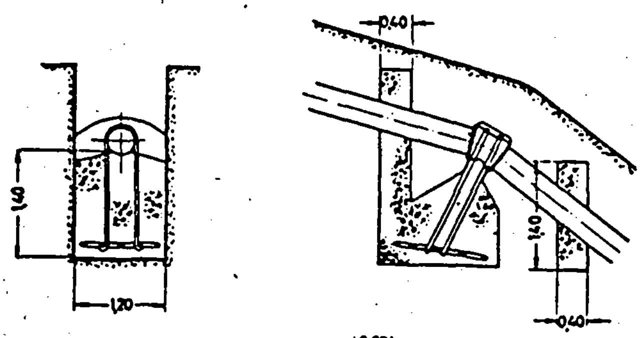


Example III

DN 150 - 400

1.30 to 2.60 m³

of concrete

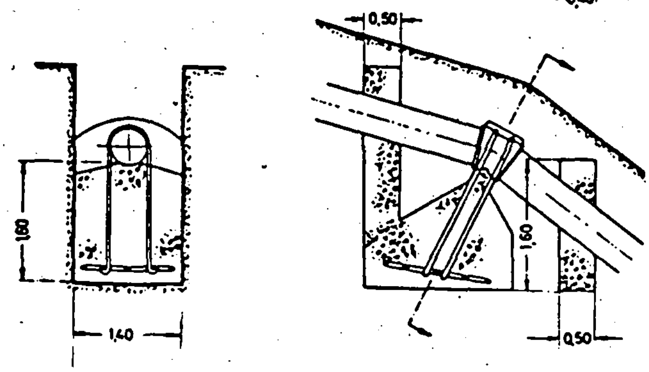


Example IV

DN 200 - 500

2.60 to 5.20 m³

of concrete



6.4.2 Resultant force directed towards the ground

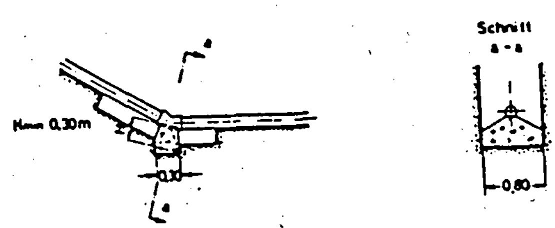
The shear stress directed towards the grond is absorbed by the undisturbed trench floor. The amount of the resultant shear stress can be found in Table 2.

Examples

Example I

DN 80 - 150

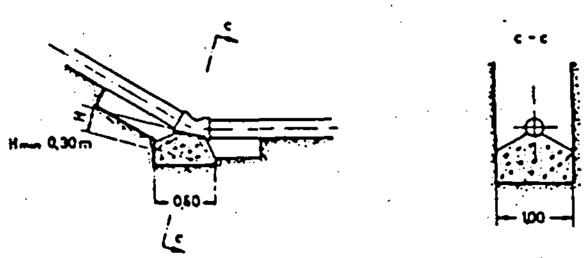
R = up to 30 KN (t)



Example II

DN 150 - 250

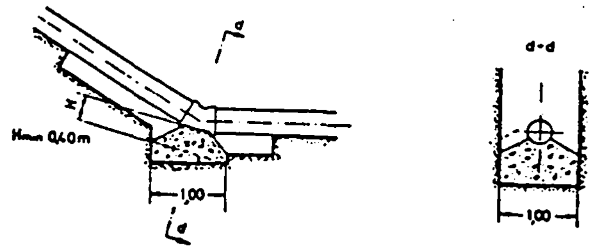
R = 30 - 90 KN



Example III

DN 200 - 300

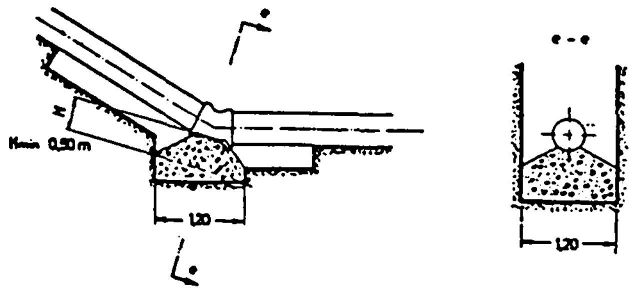
R = 90 - 120 KN



Example IV

DN 250 - 400

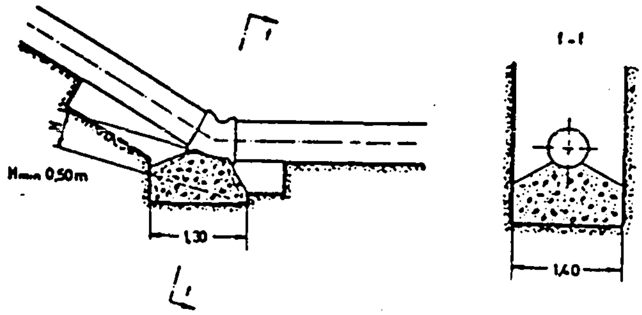
R = 120 - 160 KN



Example V

DN 300 - 500

R = 160 - 220 KN

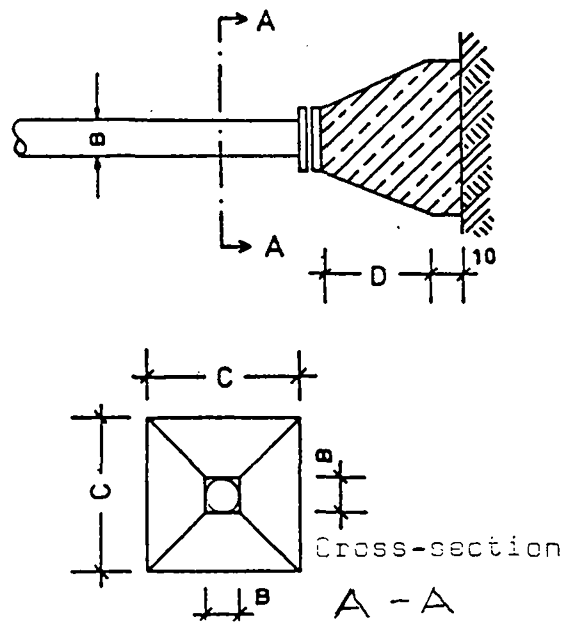


6.5 Concrete supports for pipe ends

Table 4 Dimensions of thrust block at 15 bars test pressure

DN	B x B	C x C	D min
100	10 x 10	40 x 40	10
150	15 x 15	60 x 60	15
200	20 x 20	70 x 70	25
250	25 x 25	90 x 90	32
300	30 x 30	110 x 110	40
400	40 x 40	140 x 140	50
500	50 x 50	170 x 170	60

(figures in cm)



7 Pressure testing

A pressure test is a test carried out over a certain limited period of time with a test pressure 1.5 times the nominal pressure of the pipe.

Longer pipes are divided into lengths of approx. 500 m for testing.

Testing procedure:

Before being filled with water, the pipe length must be adequately supported and anchored not only at the ends of the test run, but also at all elbows and tees.

Pressure tests should not be carried out against closed valves. The pipe should be closed off with the aid of blank flanges or plugs.

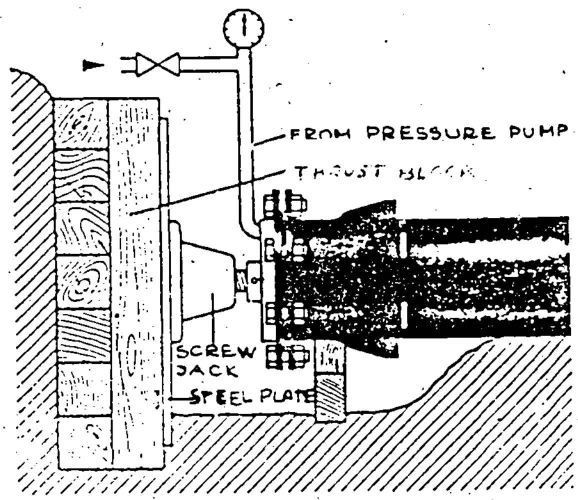


Fig. 31 End construction for pressure test

The supports an anchors must be dimensioned so as to resist the relevant test pressure. Attention should be paid to the permissible earth pressure (see heading 6 for examples). If the pipe is laid in a trench, the pipe bridges should be adequately stressed and the joints kept free. The water used for the pressure test should be as clean as possible. The pipe should be filled slowly enough to allow all the air to escape.

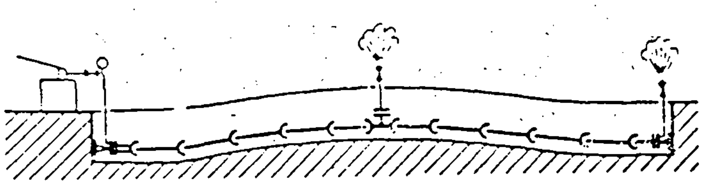


Fig. 32 Air release from pipe run

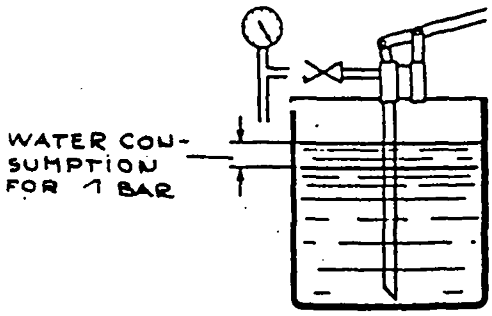


Fig. 33 Pressure pump tank

The amounts of water required to produce the pressure are read off at the pressure pump tank.

For the test, calibrated pressure gauges should be installed, wherever possible at the lowest point of the pipe run. An autographic recorder plus an additional monitoring manometer are recommended.

The duration of the test depends on the diameter and importance of the main. It should last long enough to allow all defects to be discovered.

In the case of cast-iron and steel pipes without cement mortar lining, also PVC pipes, the test pressure must remain constant, at temperatures as even as possible, for a period of several hours.

In the case of asbestos cement or cement-mortar lined pipes, the inner walls of the pipe absorb water.

Standard figures for the water absorption of asbestos cement pipes in l/m^2 of internal surface at a pressure of 10 bars:

During the

1st half hour	2nd half hour	3rd half hour	4th half hour
0.03	0.02	0.015	0.0125

As a safety measure, no work may be carried out on the mains during the pressure test. If there is leakage during the test period, the pipe must be drained slowly and, after the defective section has been located and the fault remedied, re-filled and tested again.

Flushing and disinfection

Before new pipes are taken into service, these must be thoroughly cleaned, flushed and disinfected.

Suggestions on methods to follow here are given in Module 3.7

8 Laying of communication pipes to private or public draw-off points

8.1 General requirements

Communication pipes are the connecting link between the water mains and the individual draw-off points; they must be laid with the same care as the mains themselves.

When possible, communication pipes, should be run in a straight line uphill to the draw-off points and should be covered with earth as a precaution against frost or other damage.

If the mains run empty, due to lack of water or repair work, there is a risk of contaminated water being sucked back into the drinking water supply system from the draw-off point (fig. 34).

To avoid the risk of contaminating of entire main, with the health risk this involves, non-return valves preventing back siphonage and air relief valves must be installed in the communication pipe (fig. 35).

The non-return vales should be installed before the first draw-off point, most conveniently following the water meter.

The air valve should be located at the high point of the mains system after the back-shiphonage preventing device.

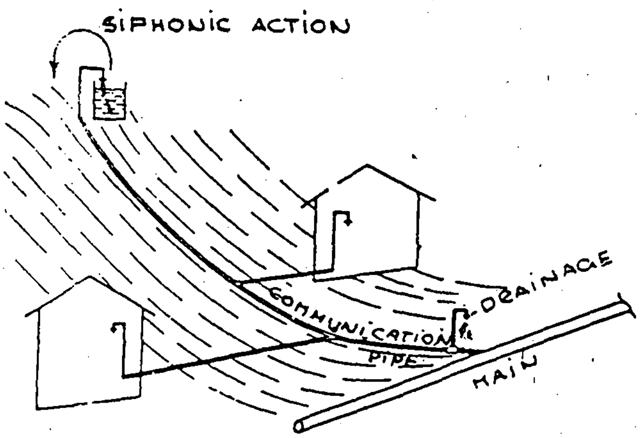


Fig. 34

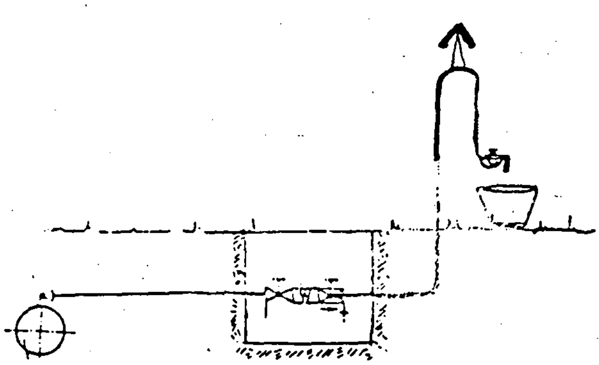


Fig. 35

Water meters are installed to measure the quantity of water consumed by individual consumers and to calculate the appropriate charges. They also discourage unnecessary wastage of water through dripping or running taps.

Where water is supplied without a meter, spring-loaded, self-closing valves should be installed.

8.2 Connection of communication pipes to the main

Communication pipes are generally connected to the main by means of tapping clamps or tapping bridges. Due to their narrow bracket, tapping clamps are only suitbale for cast-iron pipes. In the case of plastics or asbestos cement pipes, tapping bridges should be used, since the pressure on the pipe will then be less due to the greater width of the bridge.

Water mains may be tapped either under pressure or without pressure. When a main is tapped under negative pressure, a stop valve is necessary in addition to the tapping clamp. The following examples have been chosen for description from the many varieties of tapping devices and valves on the market.

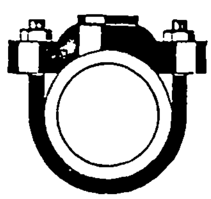


Fig. 36 Tapping clamp for cast-iron and steel pipes

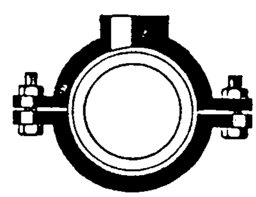


Fig. 37 Tapping bridge for PVC and asbestos cement pipes

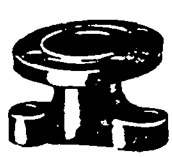


Fig. 38 Tapping clamp with flange

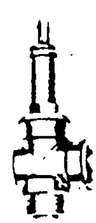


Fig. 39 Valve

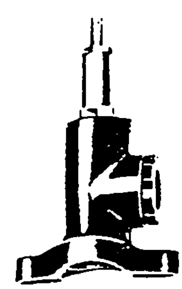


Fig. 40 Valve tapping clamp

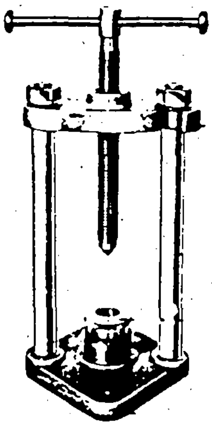


Fig. 41 Screw-on column-type tapping device

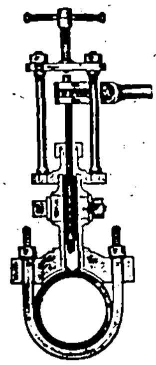


Fig. 42 Tapping operation

8.2.1 Description of the tapping procedure

The tapping device is srewed onto the pipe clamp or bridge by means of a nipple and a drill, chosen to correspond to the material of the pipe and the required drilling diameter. By turning the spindle, a hole is cut through the side of the pipe. After the hole has been drilled, the device is removed and the communication pipe connected up by means of the tapping clamp. If the clamp has a flange instead of a thread, a tapping device with flange instead of thread is also used.

If the pipe is to be tapped under pressure, a valve as shown in fig. 39 or a valve tapping clamp as in fig. 40 is installed in addition to the tapping clamp. The procedure is then as follows:

The top section of the valve is removed and the tapping device screwed on.

An auxiliary valve with flushing outlet is connected at the side.

Tapping is carried out and the drill withdrawn to its starting position.

The flushing outlet on the auxiliary valve is opened and the borings of (flushed out) during the drilling process.

The shutoff piston of the flushing pipe is screwed into the prepared valve seating and packed.

The tapping device is removed and the top section replaced.

The shutoff piston is withdrawn.

The tapping valve is closed and the auxiliary valve with flushing outlet removed.

Communication pipes and water meters

Polyethylene pipes have proved particularly suitable as communication pipes. These are supplied in rolls of up to 100 m, depending on diameter.

The brass screwed pipe joint shown below has proved reliable and easy to install.

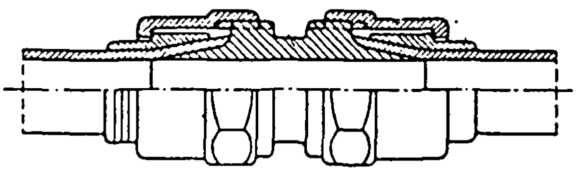


Fig. 43 Brass screwed joint for polyethylene pipes

Installation directions:

1. Cut off the polyethylene pipe at right angles,
2. Push the coupling nut and clamping sleeve over the pipe,
3. Tap the supporting sleeve right in,
4. Push the pipe up to the limit into the fitting,
5. Tighten the coupling nut with a pipe wrench.

Installation of water meters

Water meters must be protected from frost or other damage. They should be installed in such a way that they can be easily read and exchanged without an unreasonable amount of work.

Fig. 44. shows a typical meter installation, with intake valve, water meter and non-return valve. Exchanging the meter is facilitated by insertion of an approx. 2 cm long screwed fitting. Where pipes pass through walls, they should be wrapped in felt tape or provided with protective outer tubing.

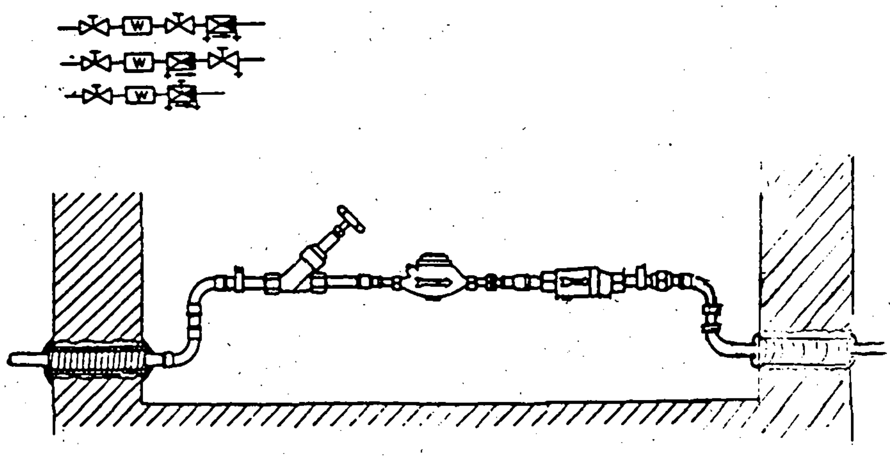


Fig. 44 Typical water meter installation

8.3 Public taps

Fig. 45 shows a public tap, which can be installed in either a concrete or stone masonary structure.

A recess is shown in the lower part of the structure; this should be left free for the installation of the valves and the water meter. The recess should be closed off and provided with a steel door and padlock.

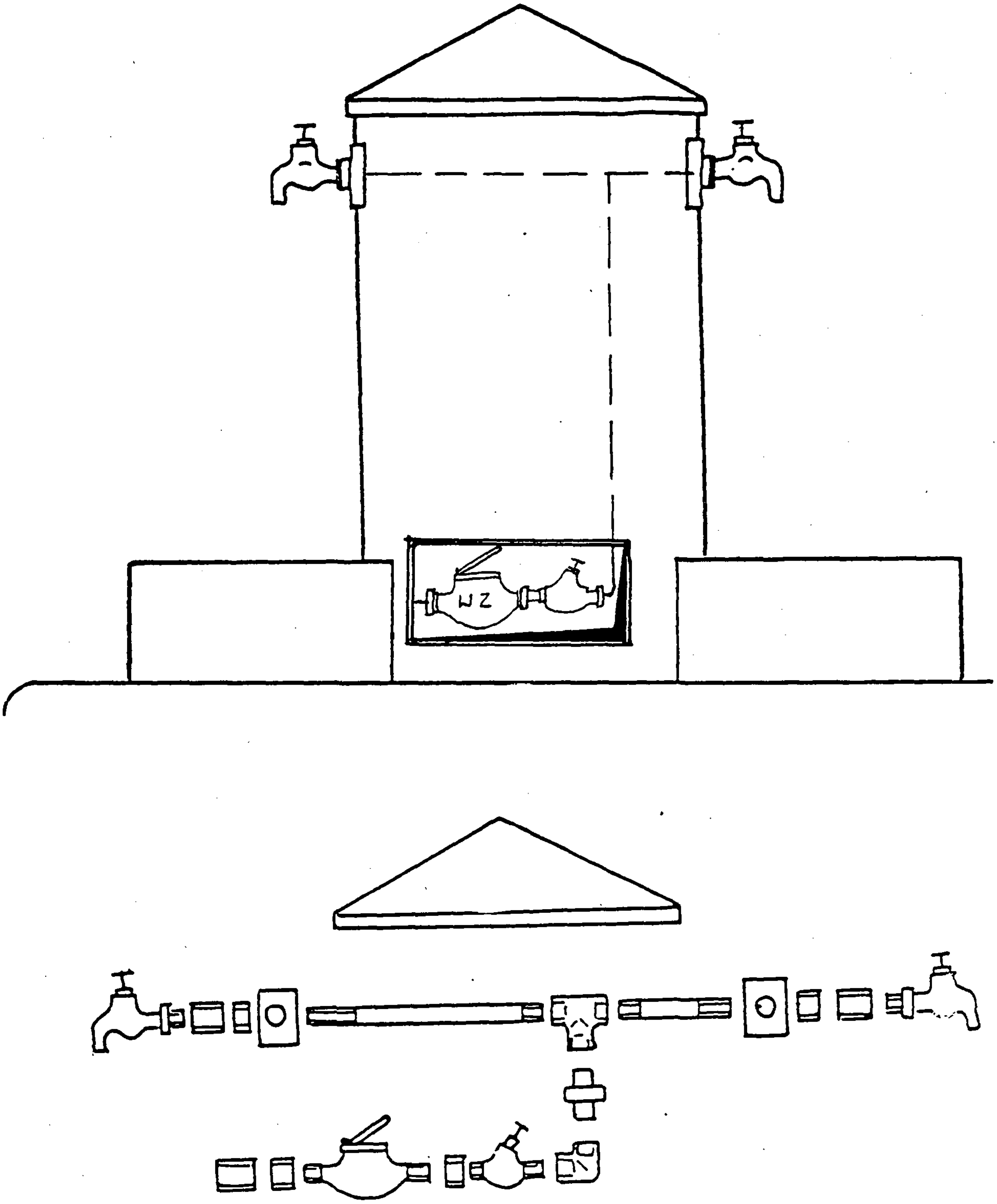


Fig. 45 Public tap

Table 1. On site determination of the angle of a bend

Fig. 2 Measuring the angle of a bend

Range poles

Fig. 3 Constructing a pipe bend

Fig. 4 Spirit levelling

Sight distance Sigth distance

Back sight Foresight

Fig. 5 Boning in a trench

Sight rail Bonding rod Line of sight

Fig. 6 Stacked pipe lengths

Fig. 7 Preparation of trench floor

rigth wrong right wrong

Fig. 8 Metal bow saw

Fig. 9 Plastics pipe cutter

Fig. 10 Handsaw

Fig. 11 Electric angular-type disc grinder

Fig. 12 Four-wheel pipe cutter

Fig. 13 Pipe cutter

Fig. 14 Pipe saw

Fig. 15 Turning device

Fig. 16 Fitting with a lever

Fig. 17 Fitting device

Fig. 18 Windlass

Fig. 19 Cleaning the socket

Fig. 20 Application of lubricant

Figs.21 and 22 Insertion of the sealing ring

Fig. 23 Correct seating of the sealing ring right wrong

Fig. 24 Examination of seat of sealing ring

Fig. 25 Flange joints right wrong

Fig. 26 Screwed socket joint Spacer gauge

Fig. 27 Cleaning of threaded socket

Fig. 28 Tightening of a screwed socket joint

Fig. 29 Welded joint

Fig. 30 "Gibault" coupling

Table 2 Resultant shear stresses R in KN

Table 3 Concrete thrust blocks in m³ for test pressure between 15 and 21 bars

Table 4 Dimensions of thrust block at 15 bars test pressure

Fig. 31 End construction for pressure test

From pressure pump

Thrust block

Steel plate

Screw jack

Fig. 32 Air release from pipe run

Fig. 33 Pressure pump tank

Water consumption for 1 bar

Fig 34

Siphonic action

Communication pipe

Drainage

Main

Fig. 35

Fig. 36 Tapping clamp for cast-iron and steel pipes

Fig. 37 Tapping bridge for PVC and asbestos cement pipes

Fig. 38 Tapping clamp with flange

Fig. 39 Valve

Fig. 40 Valve tapping clamp

Fig. 41 Screw-on column-type tapping device

Fig. 42 Tapping operation

Fig. 43 Brass screwed joint for polyethylene pipes

Fig. 44 Typical water meter installation

Fig. 45 Public tap

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
Dag-Hammarskjöld-Weg 1 + 2 · D 6236 Eschborn 1 · Telefon (0 61 96) 79-0 · Telex 4 07 501-0 gtz d

The government-owned GTZ operates in the field of Technical Cooperation. Some 4,500 German experts are working together with partners from some 100 countries in Africa, Asia and Latin America in projects covering practically every sector of agriculture, forestry, economic development, social services and institutional and physical infrastructure. – The GTZ is commissioned to do this work by the Government of the Federal Republic of Germany and by other national and international organizations.

GTZ activities encompass:

- appraisal, technical planning, control and supervision of technical cooperation projects commissioned by the Government of the Federal Republic of Germany or by other authorities
- advisory services to other agencies implementing development projects
- the recruitment, selection, briefing and assignment of expert personnel and assuring their welfare and technical backstopping during their period of assignment
- provision of materials and equipment for projects, planning work, selection, purchasing and shipment to the developing countries
- management of all financial obligations to the partnercountry.

The series **"Sonderpublikationen der GTZ"** includes more than 190 publications. A list detailing the subjects covered can be obtained from the GTZ-Unit 02: Press and Public Relations, or from the TZ-Verlagsgesellschaft mbH, Postfach 36, D 6101 Roßdorf 1, Federal Republic of Germany.

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
- **2.3a** Maintenance and repair of diesel engines and petrol engines
- **2.3b** Maintenance and repair of electric motors
- **2.3c** Maintenance and repair of simple driven systems
- **2.3d** Design, functioning, operation, maintenance and repair of power transmission mechanisms
- **2.3e** Maintenance and repair of pumps
- **2.3f** Maintenance and repair of blowers and compressors
- **2.3g** Design, functioning, operation, maintenance and repair of pipe fittings
- **2.3h** Design, functioning, operation, maintenance and repair of hoisting gear
- **2.3i** 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
- **3.3a** Design and working principles of diesel engines and petrol engines
- **3.3b** Design and working principles of electric motors
- **3.3c** –
- **3.3d** Design and working principle of power transmission mechanisms
- **3.3e** Installation, operation, maintenance and repair of pumps
- **3.3f** Handling, maintenance and repair of blowers and compressors
- **3.3g** Handling, maintenance and repair of pipe fittings
- **3.3h** Handling, maintenance and repair of hoisting gear
- **3.3i** 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
- **3.8a** Construction in concrete and masonry
- **3.8b** Installation of appurtenances
- **3.9** Maintenance of water supply units Inspection and action guide
- **3.10** –
- **3.11** Simple surveying and drawing work

gtz

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH

P. O. Box 5180
Dag-Hammarskjöld-Weg 1+ 2
D 6236 Eschborn/Ts. 1
Telephone (0 6196) 79-0
Telex 407 501-0 gtz d
Fax No. (0 6196) 79-1115