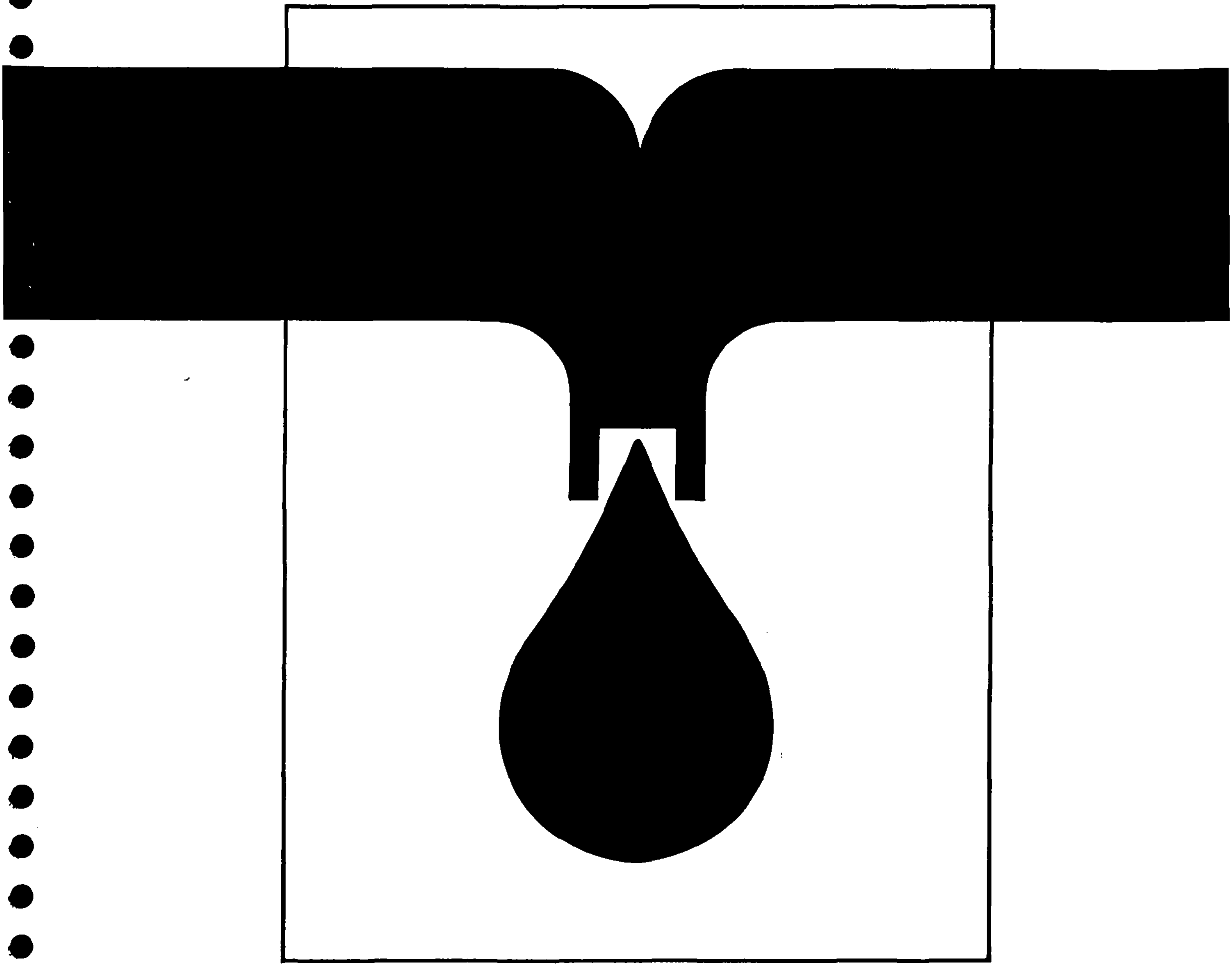
TRAINING MODULES
FOR
WATERWORKS PERSONNEL



Special Knowledge
2.11
Simple surveying and technical drawing

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
Head of Division
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Eschborn, May 1987

Title: Simple surveying and technical drawing

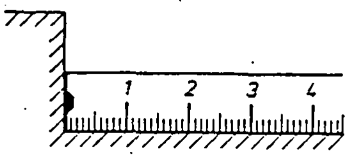
Table of contents:

1 Appliances and instruments

1.1 Instruments used to measure length

In simple measurements of length, a metrestick, measuring rod, linen tape measure or rolled steel band is used. Greater precision is obtained with the use of invar tapes, optical distance measurement or electro-optical distance measurement.

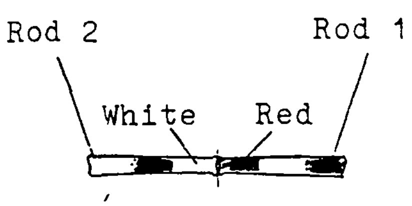
Metresticks



Positioning of the metrestick

Metresticks are folding rules, usually made of wood. They have a length of one or two metres and are graduated along their complete length in centimetres and millimetres. Since the graduation begins at the metal-clasped ends of the rule, the end can be placed flush against the staff, peg etc. where measuring begins. If the distance to be measured is longer than two metres, care must be taken to measure in a straight line.

Measuring rods (staffs)



Two rods placed end-to-end

These are made of well-seasoned, knot-free pine or fir and are supplied in pairs. Each rod is 5 m long and is graduated only in decimetres. Centimetres or millimetres have to be measured off with a metrestick. Whole metres are painted alternately red and white (or black and white).

Fluctuations to temperature have very little effect on the accuracy of measuring rods. On the other hand, they are susceptible to damp (the wood swells), and should therefore always be kept in a dry place.

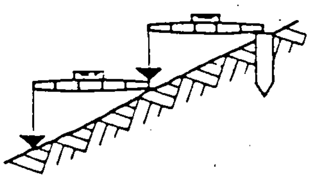
Use of rods to measure length

Measuring is always carried out with two rods. One of these begins with a metre length marked in red, the other with a metre length marked in white. For convenience, the measuring process should always be started with the same rod, e.g. the "red" rod.

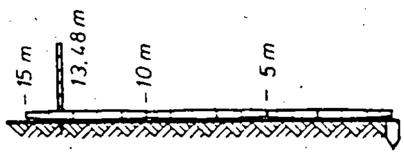
Care must be taken always to measure the horizontal distance between two points and to avoid any lateral divergence from the line of measurement.

On horizontal, level sites the rods are simply placed end-to-end on the ground. At the starting point of the measurement, the end of the rod must be placed precisely against the middle of the peg (nail) or the middle of the range pole.

When measuring distances along sloping ground, the "stepping-down" method is generally used. In this, the measuring rods are adjusted to the horizontal one after the other with the aid of a spirit level and the ends of two rods positioned exactly one above the other using a plumb line.



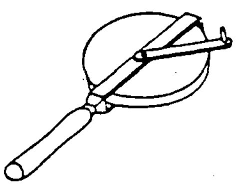
Measuring a distance by stepping down



Horizontal measurement using rods (staffs)

Measuring tapes

Measuring tapes or bands are made of steel or plastics in various lengths (20, 30, 50 and 100 m). When not in use, the tape is kept rolled up in a frame or case. Coated steel bands with a length of 20 metres are

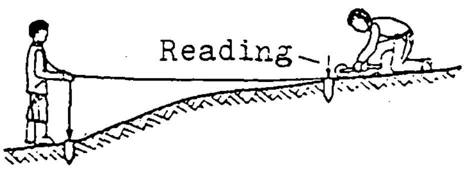


Measuring tape

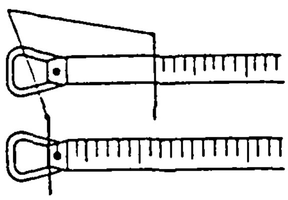
the most widely used. The tape is graduated in centimetres, the first decimetre additionally in millimetres. These tapes are calibrated at a temperature of +20°C and a tensile stress of 50 N. Frequent cleaning is important; steel bands must be carefully dried and lightly oiled to prevent rusting.

Measurement using tapes

Measuring tapes are most widely used to measure distances on level ground which are not longer than the tape itself. On sloping ground, the unrolled tape must be held in such a way that both ends are at the same level (i.e. the distance measured is horizontal). A certain sag of the tape is unavoidable and is already taken into account in its calibration. The tape should therefore be held neither too loosely nor too taughtly (standard tension approx. 50 N). The end of the tape must be plumbed above the measuring point. This is in principle the same method as stepping down a slope with a measuring rod, but the rod gives more accurate results.



Measuring with a tape up a slope



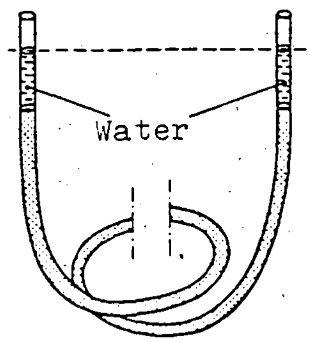
Position of zero line

1.2 Instruments used to measure levels

In the measurement of levels ("levelling"), the vertical distance in level between two points is measured. Depending on the required degree of accuracy and the distance between the two points, various different appliances are used.

Hose level

This consists of a hose, 15 to 25 m long, with a water gauge (glass tube) inserted into each end. The hose is filled

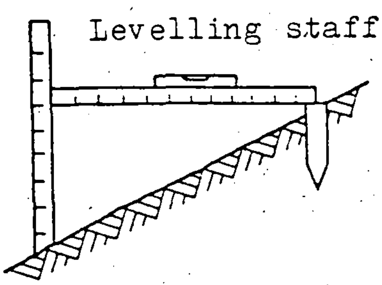


Hose level

with water and moved about so that air can escape. The glass tubes are then sealed temporarily with corks, so that no water is lost during transport. In communicating vessels, liquids stand at the same vertical height. In application of this principle, the surface of the water in one of the glass tubes is placed against a point with a known level, and the corresponding level of the other water surface marked on the structure or sight rail.

Levelling staff

A levelling staff is used to measure the vertical difference in level and the horizontal distance between two points, which should not be too far away from each other. A dressed board with a length of several metres can be used as levelling staff, but better is a purpose-made, graduated rod.

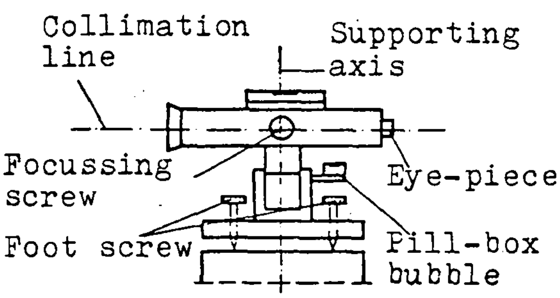


Levelling

The levelling staff is placed on a point and adjusted with the aid of a spirit level until it is horizontal. Using a vertical measuring rod (perhaps a metre-stick), the level at the underside of the levelling staff is ascertained, also the horizontal distance; the end of the levelling staff being plumbed.

Level

Levels are used to ascertain varying levels over greater distances. The instrument consists of a telescope which can be turned on a sub-structure (the "levelling head") round an axis which is vertical to the telescope (supporting



Level

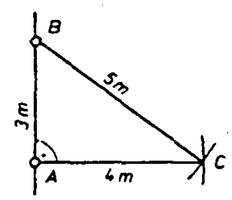
axis). With the aid of the pill-box bubble on the levelling head, the supporting axis is adjusted until it is approximately vertical. A bubble tube is used to adjust the telescope (line of collimation) until it is horizontal. The greater majority of levels used nowadays have a device which is responsible for automatic horizontal adjustment of the collimation line of the telescope. Such instruments (automatic or autoset levels) have no bubble tube.

1.3 Instruments used to measure angles

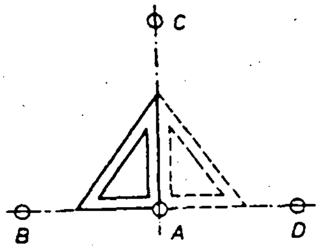
Setting out of right angles

A full circle is divided into 360° (degrees) or 400 gons. 90°, or 100 gons, make a right angle. Right angles are set out on a site with the aid of a cross staff or prism square. If neither of these is available, right angles can also be set out by an application of Pythagoras' theorem.

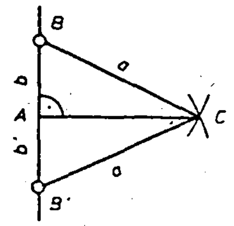
Application of geometrical principles



According to Pythagoras' therorem, any triangle of which the sides are in the ratio 3 : 4 : 5 must be right-angled. Assuming that a right angle is to be set out at point A, first of all point B is marked at a distance of 3 m from point A. Then two measuring rods are positioned in such a way at points A and B that a triangle with its sides in the ratio 3 : 4 : 5 is formed. If two measuring tapes are available, the same technique is used, but the distances increased proportionately.

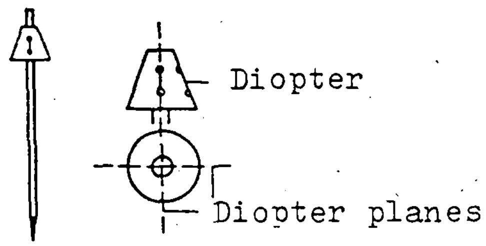


A site square is made by nailing boards together into a triangle with its sides in a 3 : 4 : 5 ratio. Site squares are used to set out and check the accuracy of right angles. A right angle can also be obtained with the aid of an isosceles triangle:



Two equal distances, b = b', are measured from point A. Point C is established by holding two measuring tapes of equal length (a = a) each with one end at points B and B' and moving them through an angle until they meet.

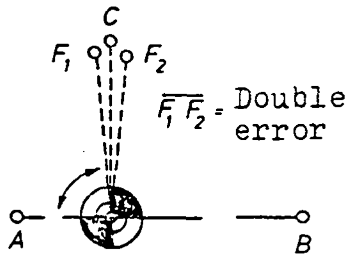
Cross staff



A cross staff consists of a truncated cone-shaped metal body screwed onto a metal staff approx. 1.40 m long. The staff is pointed at its other end, so that it can be pushed into the ground. The head of the cross-staff has sets of slits, i.e. two arranged vertically one above the other, in opposite faces (diopter slits). They are positioned in such a way that sight lines are formed which are perpendicular to each other.

When a right angle has to be set out, the cross staff is first set up at the appropriate point on the survey line and adjusted, with the aid of the pill-box bubble fastened to it, until it is vertical. Then the instrument is turned until a staff set up some distance away along the survey line can be seen through the splits. A staff is then lined in through the other slits at right angles to the first line.

The right angle set out in this way is checked by turning the cross staff through 90° and lining in a second staff.



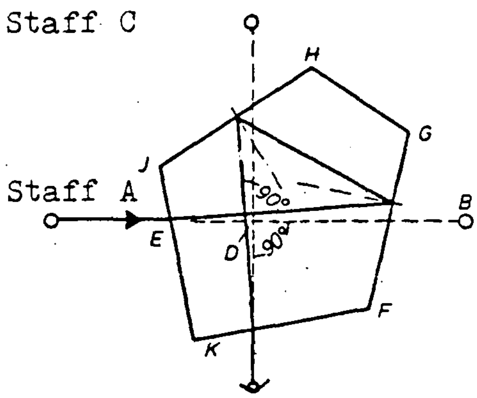
If there is an error, this second line will not coincide with the first. The angle of divergence between the two lines is equal to twice the error. The correct line giving the right angle lies in the exact middle between the two lines.

Setting-out points to the side of the survey line are determined with the aid of the cross staff at right angles to the line and marked.

Prism square

In this instrument, a ray of light is broken and reflected in glass prisms in such a way that the incident ray is at right angles to the emergent ray. The type of prism commonly used in setting-out work is the five-sided prism, or pentagon.

The prism is housed in an open metal casing. A shaft-type handle, to which a plumb line or plumb level can be fastened, is screwed to the underside of the casing. When a right angle is being set out, the instrument must be precisely vertical above the point on the survey line.



Passage of rays through five-sided prism

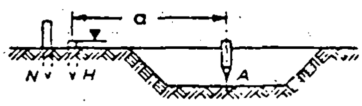
The light ray coming from staff A is refracted on its entry E into the prism, reflected by the metallized prism surface FG (angle of incidence = angle of reflection), reflected again by the prism surface HJ, which is also metallized, and refracted again at its emergence in K, so that after emergence the ray is at an angle of 90° to the direction of incidence. The eye sees staff A in the prism, above or below the prism staff C. If staffs A and C form a straight line, the angle between points A, D and C is a right angle.

Measurement of other angles

Other angles are measured with a magnetic compass, a prism drum ($\sphericalangle \alpha$ can be altered) or a level with horizontal circle. With the aid of a plumb bob, the level is set up exactly above the measuring point, and the measured angle read off the 360° scale on the horizontal circle. A vertical circle can also be provided for measurement of vertical angles.

2 Setting out of longitudinal sections (pegging out)

If work is being done on the axis, pegging must be carried out outside the area of work. A level peg H and number peg N are driven in at regular intervals, at the same distance a from and at right angles to the axis. Where the level of the ground at right angles to the axis fluctuates quite widely, and at bends, pegging is carried out on both sides of the axis.



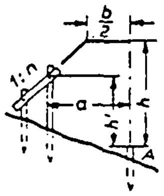
3 Setting out of cross sections

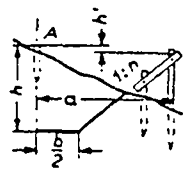
The toe of the slope and its angle are indicated with templates. Since, in cutting and filling work, the axis peg A is removed when work starts, its position then has to be established by the following method:

Embankment side and Cutting side

$$a = \frac{b}{2} + n\,(h - h');$$

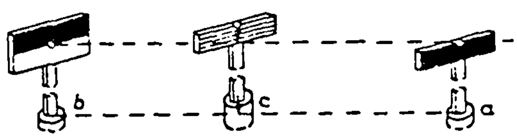
$$h' = h - \left(\frac{a}{n} - \frac{b}{2n}\right).$$





4 Boning

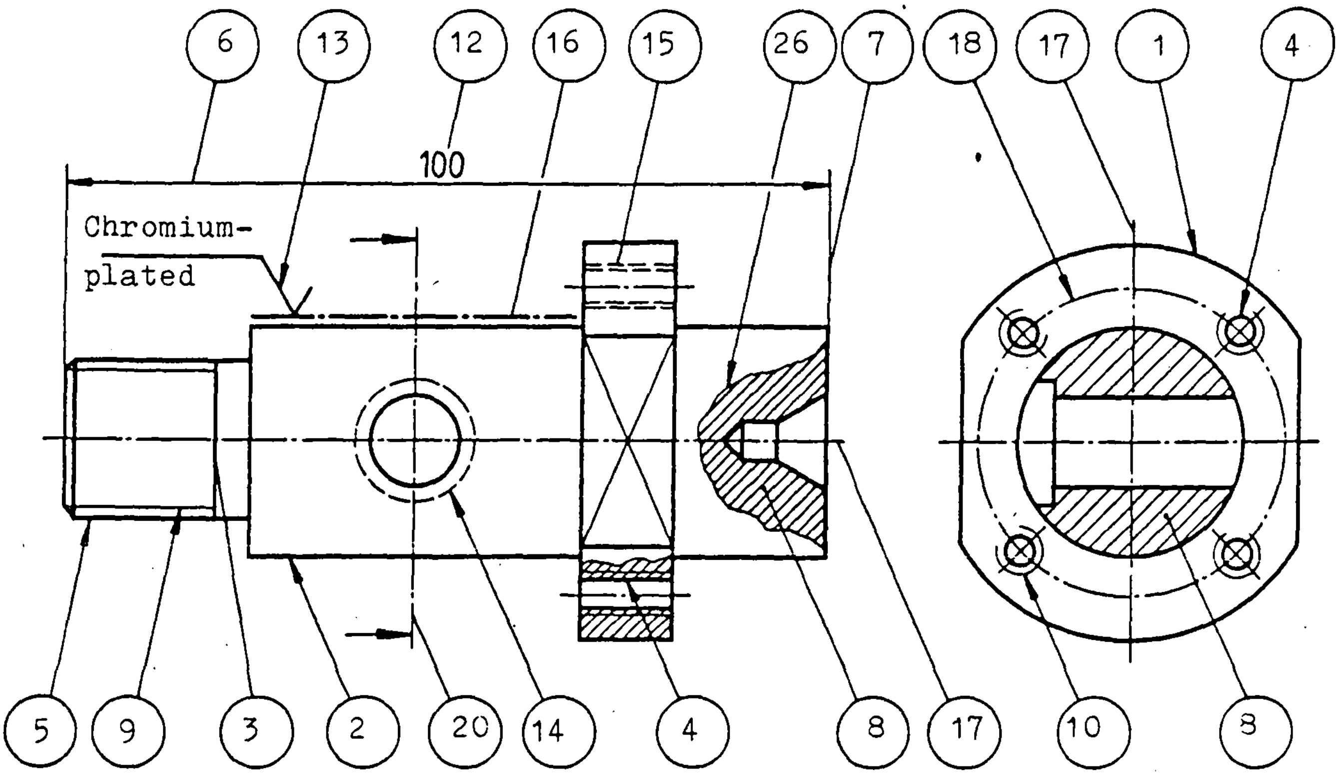
In boning, a slope is set out using boning rods (T-shaped staffs). A rod with a black cross board is set up at a known level at point a, and a boning rod with a black-and-white cross board at a known level at point b. The peg at point c is driven into the ground until the top edge of the (red) boning rod coincides with the centre line on the board at point b.



5 Representation of bodies

Types and widths of lines

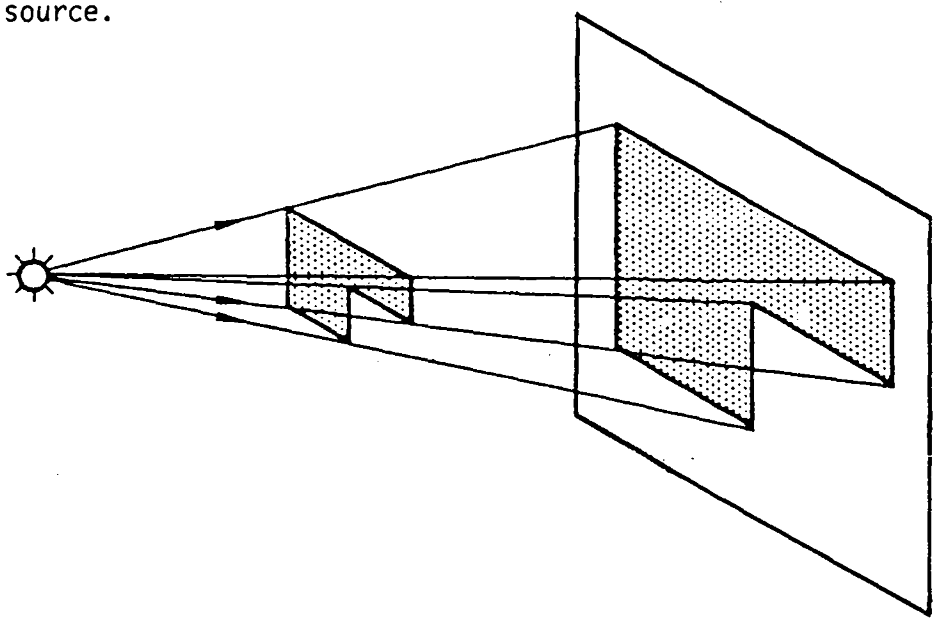
Type of line	Width	No.	Uses
Solid line	Broad (0.5)	1	Visible edges of bodies
		2	Contours of surfaces
		3	Ends of threads
		4	Minor diameter of internal threads
		5	Thread diameter of external threads
	Narrow (0.25)	6	Dimension lines
		7	Auxiliary dimension lines
		8	Shading of cut surfaces
		9	Minor diameter of bolt threads
		10	Major diameter of internal threads
		11	Reference lines
	Medium wide (0.35)	12	Dimensions; annotations
		13	Symbols for surface finishes, tolerances of shape and position
Broken line	Narrow (0.25)	14	Concealed (not visible) edges and contours
		15	Concealed threads
Dash and dot lines	Broad (0.5)	16	Surface finishes
	Narrow (0.25)	17	Centre lines
		18	Bolt circles
		19	Pitch circles of gear wheels
		20	Lines of sections
		21	Lines of sections
Dash and double dot lines	Narrow (0.25)	22	Contours of adjacent parts
		23	Positions of adjustable parts
		24	Indication of original shape
		25	Centre of gravity lines
Freehand lines with zigzag	Narrow (0.25)	26	Break lines
		27	Break lines (plotting machine drawings)



5.1 Stereoscopic representation of perspective

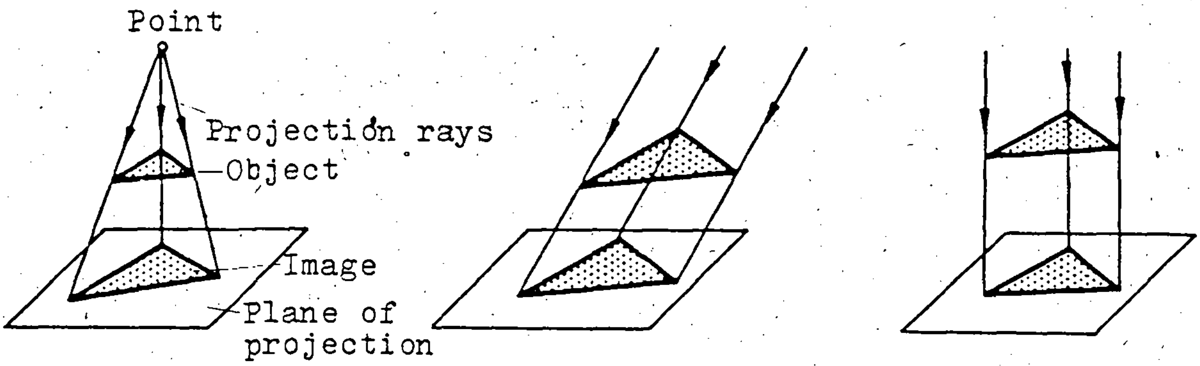
What is projection?

In projection, the object is represented on a plane surface (plane of projection) by means of projecting rays from a light source.



Types of projection

Central — Parallel (oblique, vertical)



Projecting rays go through a point; applications: photography, architecture, art

Projecting rays are parallel;

oblique — application: stereoscopic engineering drawings

vertical — application: technical drawings (DIN 6)

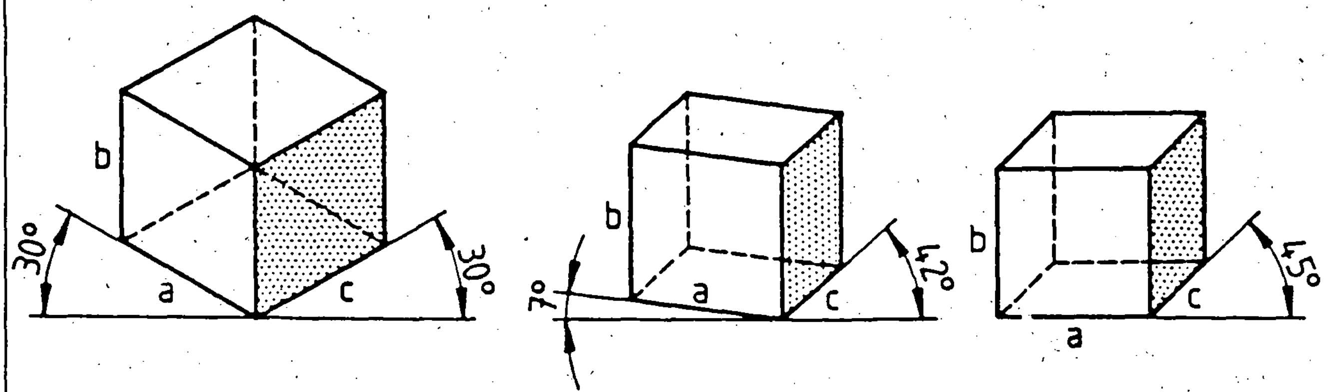
Isometric projection

(isometry = having the same measurement)

Dimetric projection

dimetry = having two measurements)

Other, non-standardized perspective



Ratio of sides $a:b:c = 1:1:1$

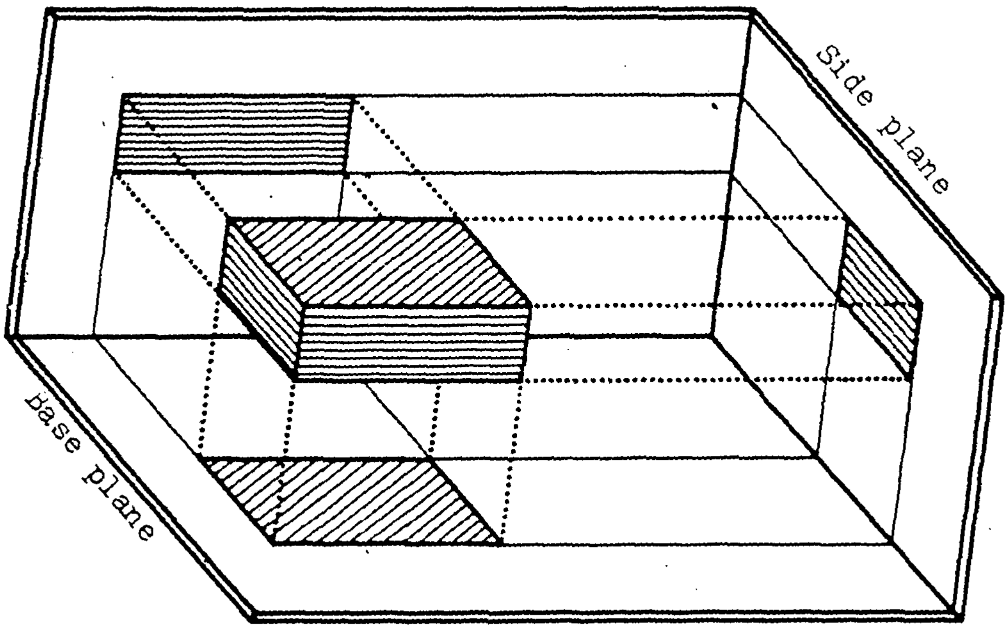
Ratio of sides $a:b:c = 1:1:\frac{1}{2}$

Ratio of sides $a:b:c = 1:1:\frac{1}{2}$

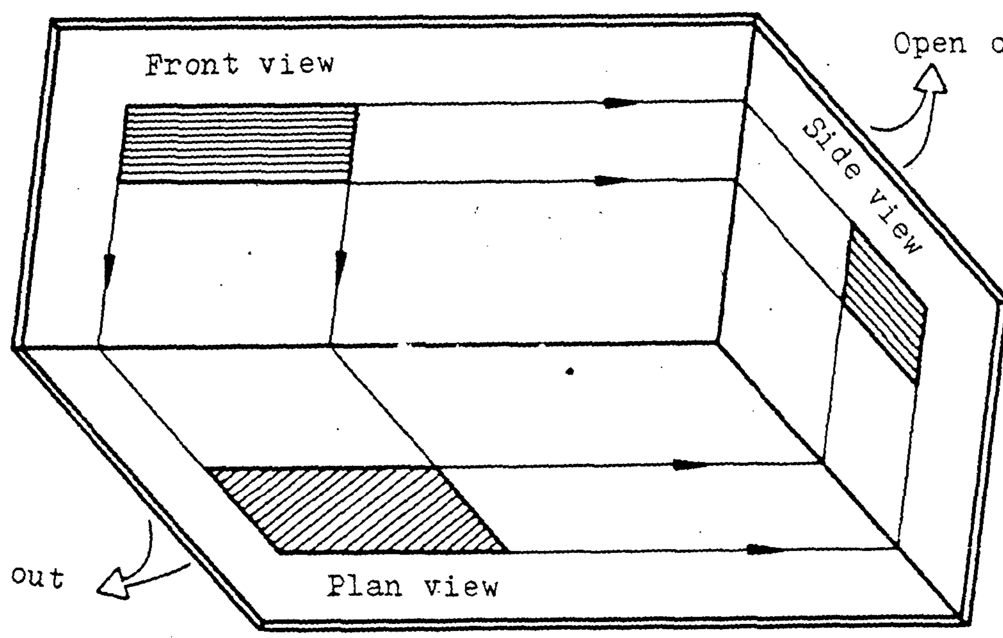
Revised:

Vertical parallel (orthographic) projection (ratio of sides not to scale).

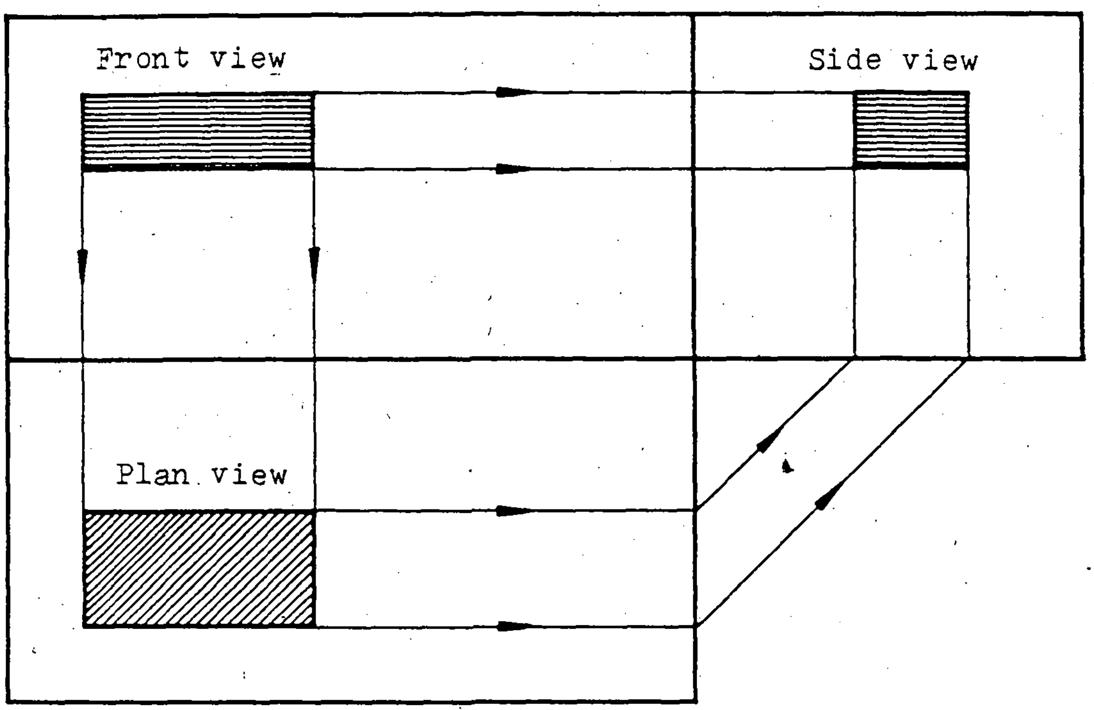
Body in a corner formed by three planes



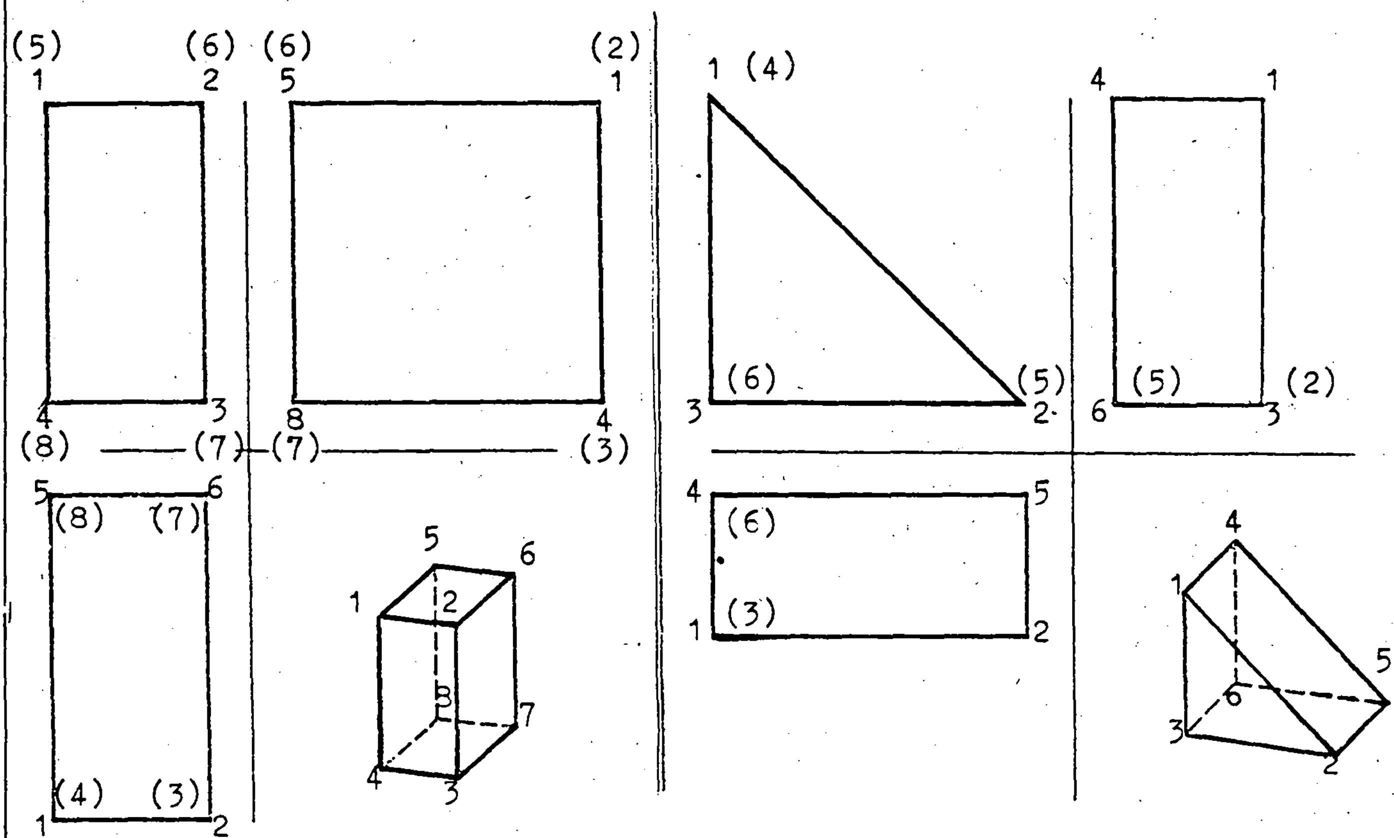
Representation on the three planes



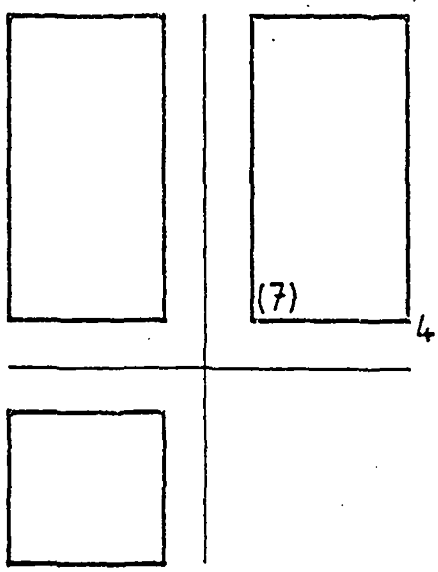
Representation on one plane

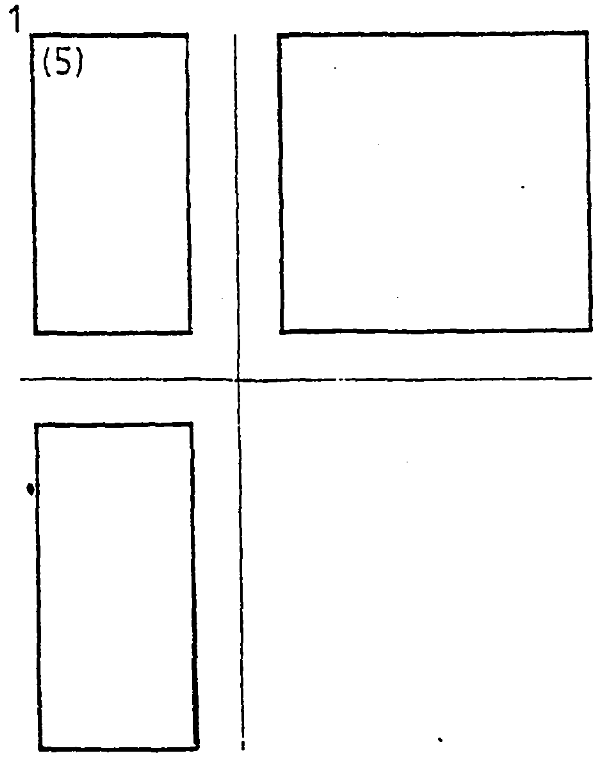


Correlation of the individual corner points concealed in the three views (corner points behind them are given in brackets).



Exercises:





5.2 Rules for the representation of cross-sections

Concept:

A cross-section is the plane figure produced by a cut through a solid body. The aim is to simplify representation and dimensioning of the drawn part and to facilitate comprehension.

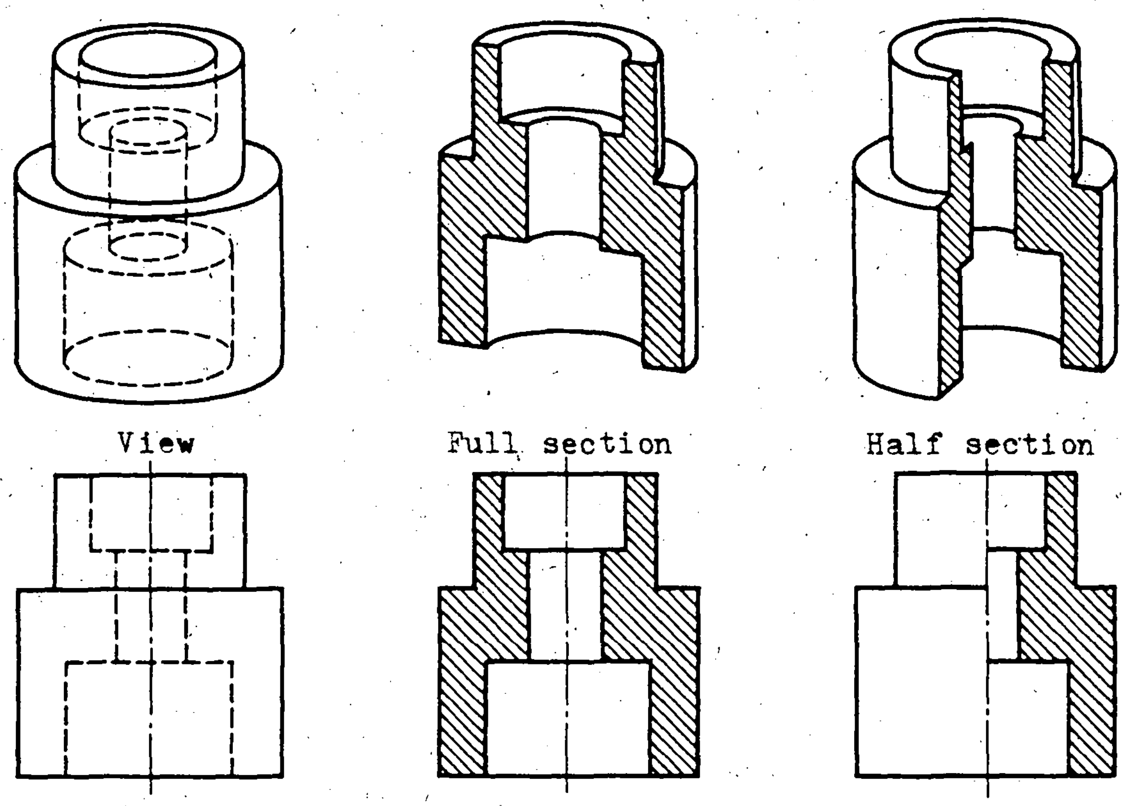
The imaginary cut is usually through the centre of the body.

When a cross-section is drawn, edges which were concealed before become visible. Concealed edges of the body are not represented.

Types of cross-section:

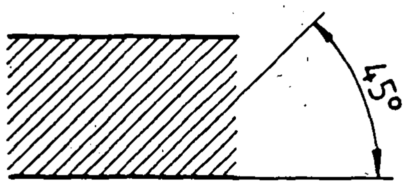
1. Full section
2. Half section
3. Part section

Representation:



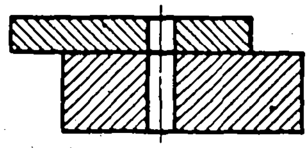
Rules:

1. Lines used for shading are narrow solid lines at an angle of 45°.

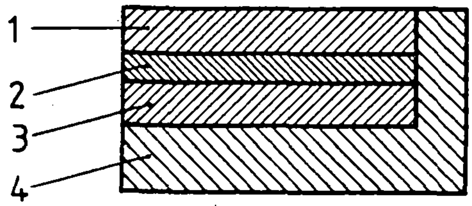


2. The distance between shading lines is constant and should be adapted to the area of the cut surface.

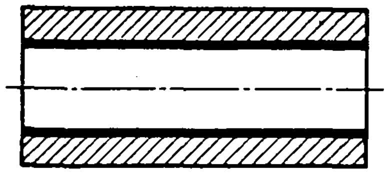
3. Cut surfaces belonging to the same part are shaded in the same direction.



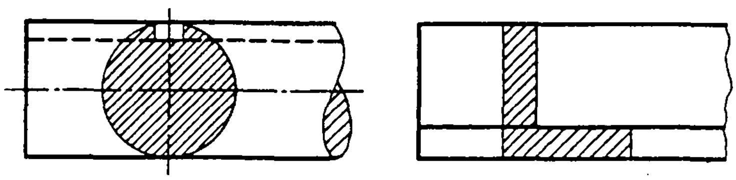
4. Different parts are shaded in opposite directions, or the distance between the shading lines is altered.



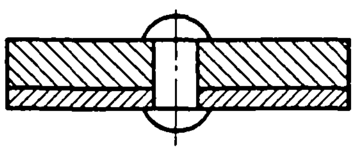
5. Very narrow cut surfaces may be blacked in.



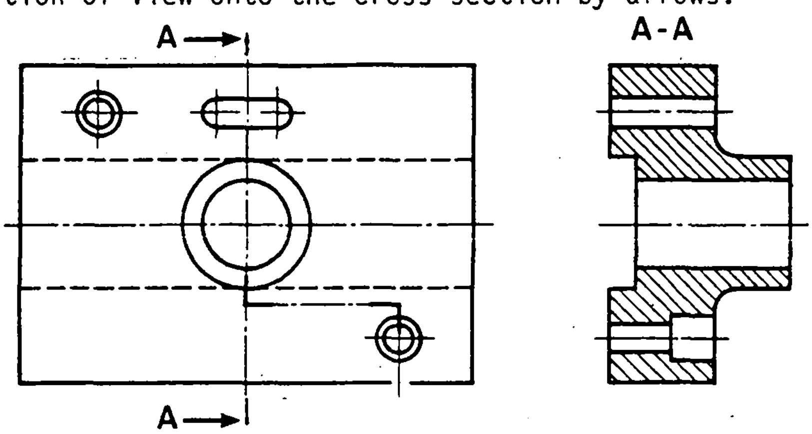
6. Cross-sections of shafts, profiles etc. can be drawn on the face view.



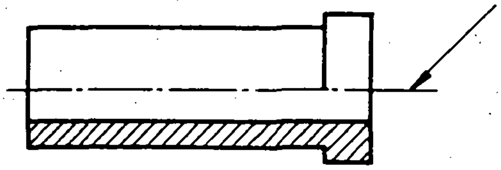
7. Shafts, screws, rivets etc. are not drawn in section.



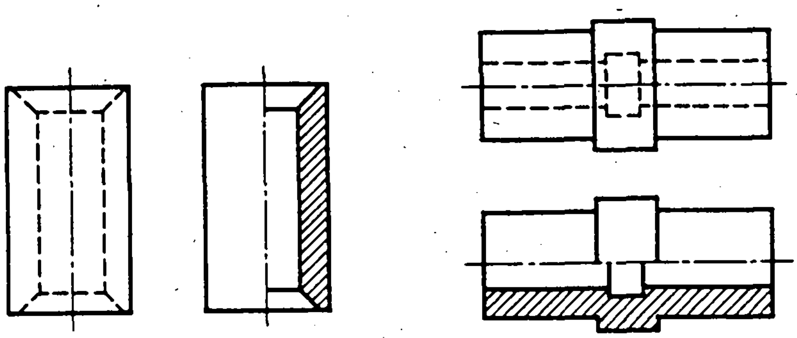
8. Some bodies may require several sections. The line of the section is indicated by a dash-and-dot line and letters, the direction of view onto the cross-section by arrows.



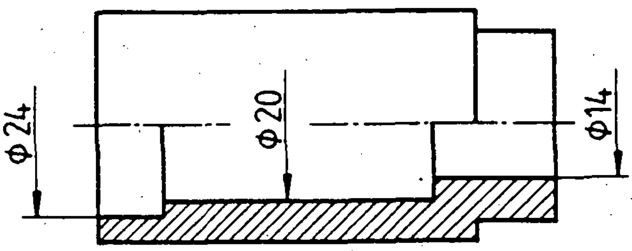
9. A section does not create additional edges.



10. Symmetrical hollow parts can be drawn in half section. If possible, the part shown in section should be to the right of or underneath the centre line.

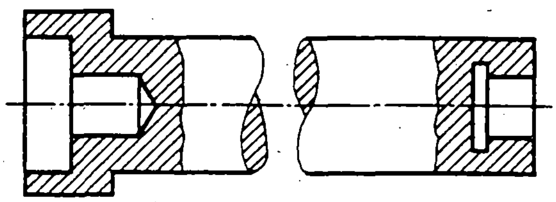


11. The diameters of the interior forms are given shortened dimension lines. The dimension line extends for a short distance beyond the centre line. The dimension line has only one arrow-head.



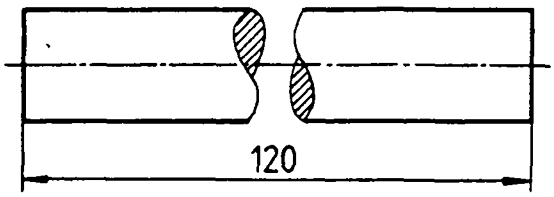
Part section

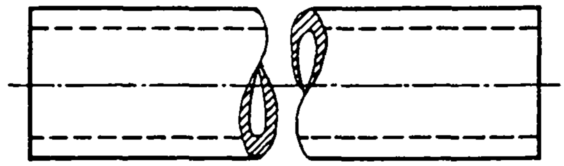
12. In the representation of solid bodies with circular cross-sections, only part of the body is shown as broken off. This allows the visible edges to be dimensioned.



Break lines

13. Objects can be drawn broken off. The break line of cylindrical bodies is shown by curved free-hand lines.



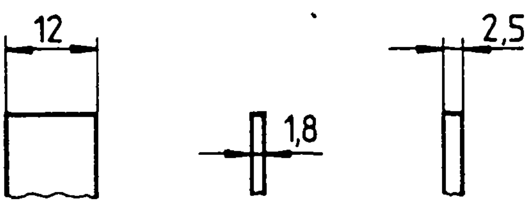


5.3 Rules for the dimensioning of drawings

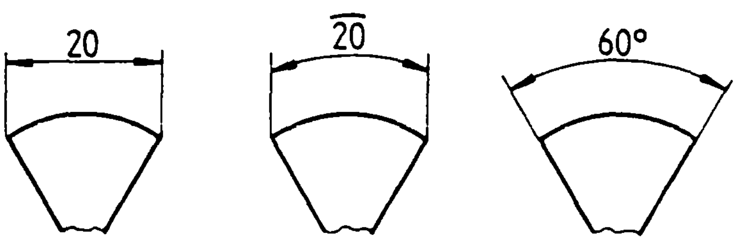
1. The dimensions in technical drawings give information on aspects of the manufacture of a part, its functioning and test results.

Dimension lines

2. Dimension lines are narrow solid lines.
3. The first dimension line must be at least 8 mm away from the edge of the body; following this, the distance between dimension lines is at least 5 mm.
4. The dimension figure is written above - or where space is limited, next to - the dimension line.

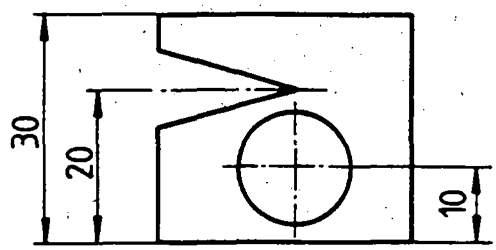


5. Edges of bodies and centre lines may not be used as dimension lines.
6. Equally, dimension lines must not be drawn as extensions of edges of bodies or centre lines.
7. The dimension lines indicating the length of an arc or the size of an angle are drawn as follows:



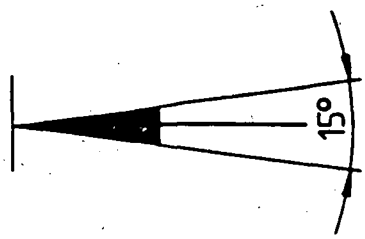
Auxiliary dimension lines

8. Auxiliary dimension lines are narrow solid lines.
9. Auxiliary dimension lines generally begin at the edge of the body and at right angles to it.
10. Auxiliary dimension lines extend for 1 to 2 mm beyond the dimension line.
11. Wherever possible, auxiliary dimension lines should not cross each other or any other line.
12. Centre lines may be used as auxiliary dimension lines. Outside the edges of the body, these are then continued as narrow solid lines.

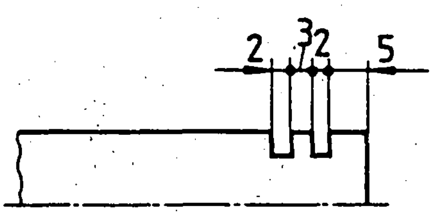


13. Auxiliary dimension lines must not be continued from one view through to another.

Dimension arrows



14. The length of the arrow is equal to roughly five times the width of the lines used for the edges of the body.
15. Where space is limited, the arrows are drawn on the outside, or points are used.

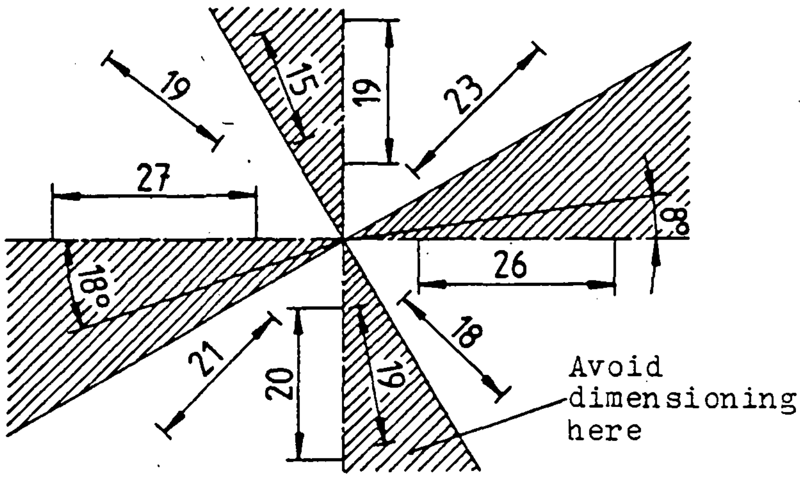


16. Dimension lines for radii or shortened diameter dimension lines have only one arrow-head.

Dimensions

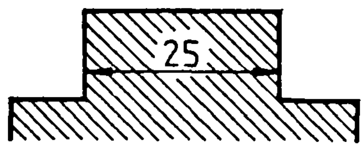
17. The units of the dimensions are not named. Any units which deviate from the others must be given.
18. The size of the lettering depends on that of the drawing; 3.5 mm is normal.

19. Dimensions should be legible from below or from the right.

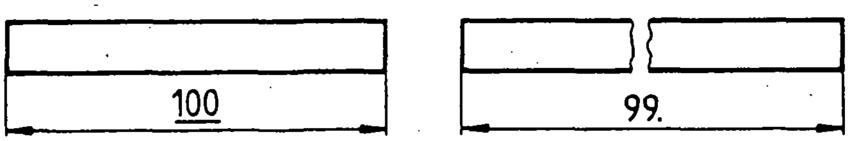


20. No other line should pass through a dimension figure or the space between its digits.

21. Where space is limited, centre lines, auxiliary dimension lines and shading must be interrupted to allow insertion of the dimensions.



22. Where a body is not drawn to scale, the dimensions are underlined. This does not apply if a part is drawn as interrupted.



23. Each dimension is entered only once.

24. To prevent confusion, numbers such as 6, 9, 66, 68, 89 and 99 are followed by a point.

Enlargements - reductions

Large or very small parts cannot always be drawn in their natural size without problems. In such cases the part is drawn larger or smaller.

In addition to the natural scale (1 : 1), DIN ISO 5455 specifies the following scales:

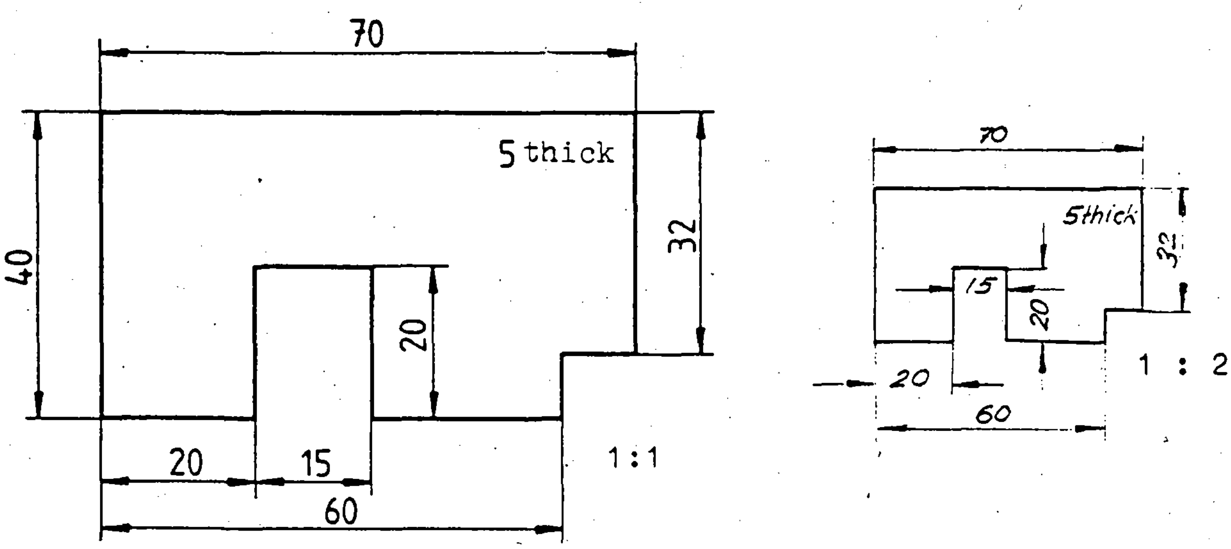
Enlargements:

2 : 1	5 : 1	10 : 1

Reductions:

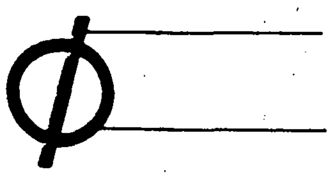
1 : 2	1 : 5	1 : 10
1 : 20	1 : 50	1 : 100
1 : 200	1 : 500	1 : 1000

When dimensioning the drawing, it is always the actual dimensions of the part which are entered. In the title of the drawing, the main scale is given in large lettering and the other scales in small lettering. Where the scale differs from the main scale, this is indicated next to the relevant part.



Diameter

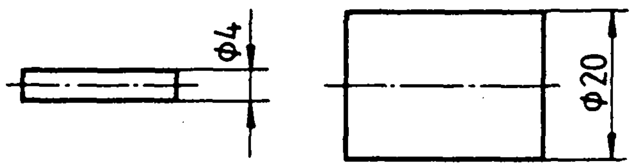
1. The height of the diameter sign is equal to that of the dimension figure.



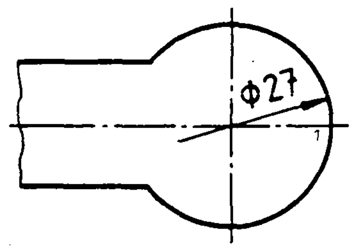
Line at an angle of 75° passes through the centre of the circle

Circle the same size as small letters

2. The diameter sign precedes the dimension.
3. If the circular figure is not visible, the diameter sign is used.

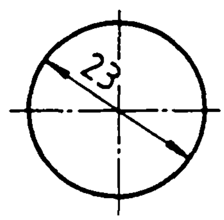


4. If the dimension line for a diameter has only one arrow-head, the diameter sign must be used.



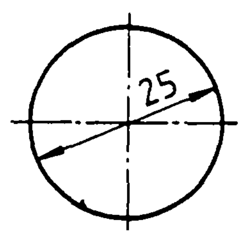
5. The dimension line must pass through the centre of the circle.

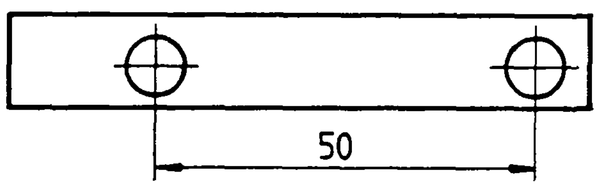
6. If the circular figure is clearly visible, the Ø can be dispensed with.



7. If the dimension line for a diameter has an arrow-head at both ends, the Ø is not necessary.

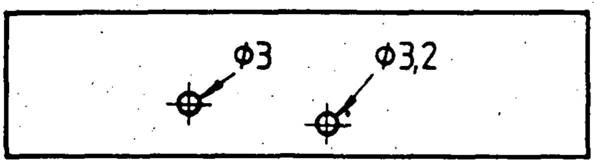
8. In the case of drill-holes, the distance between the centres of the bores is dimensioned.





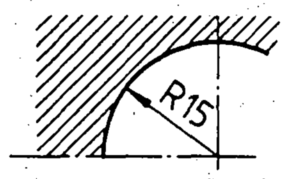
9. The centre lines of bores form a cross and project approx. 2 mm over the edge of the circle.

10. Where drill-holes are very small, a reference line is used.

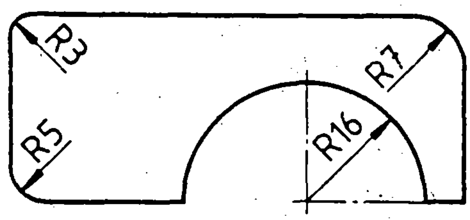


Radii

1. The dimension is always preceded by the letter R.

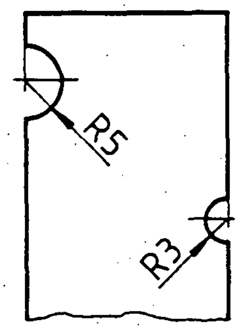


2. The dimension line of a radius has only <u>one</u> arrow-head and begins at the centre of the circle.



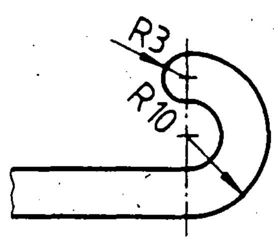
3. As a general rule, the arrow should point from the <u>inside</u> of the circle.

4. If space is limited, the arrow may point from the <u>outside</u>.

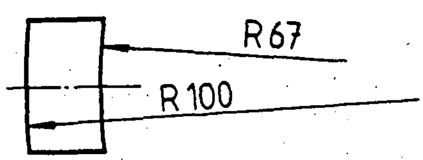


5. The centre is only marked when this is <u>necessary</u> (e.g. for manufacturing, operational or testing reasons).

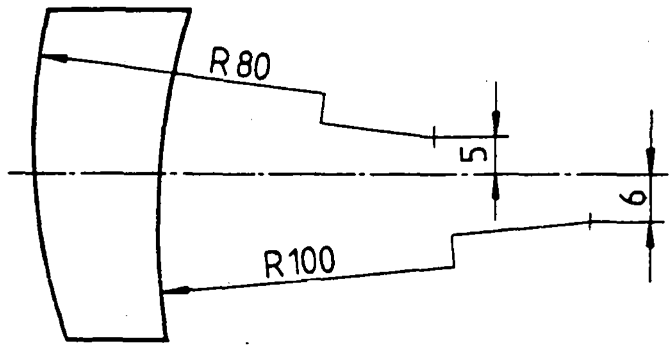
6. The centre is marked by the intersection of the centre lines.



7. Where a radius is very large, the dimension line can be shortened.



8. If, in the case of large radii, the centre has to be established, the dimension line is drawn bent at right angles and shortened. The dimension line with the arrow-head must point to the geometric centre.

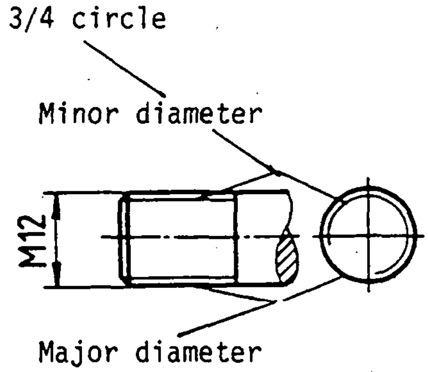


5.4 Rules for the representation and dimensioning of threads

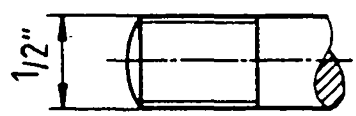
External (male) threads DIN 27

1. The major diameter (external) is shown by a broad solid line and the minor diameter by a narrow solid line.

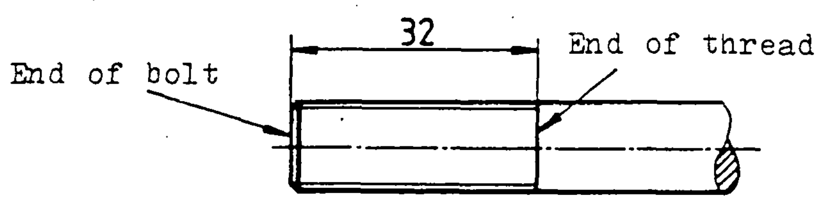
Metric thread



Whitworth thread



2. The end of thread is shown by a broad solid line. The end of the bolt belongs to the length of the thread.



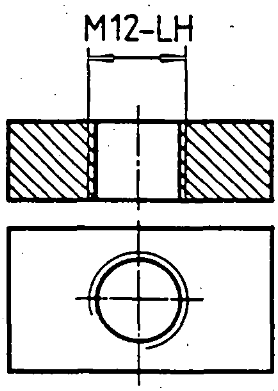
3. The major diameter is dimensioned and given the appropriate designation according to DIN 202, e.g.:

M 12	Metric thread, Ø in mm
M 20 x 1.5	Metric fine thread, Ø in mm
1/2"	Whitworth thread, Ø in inches
W 84 x 1/6"	Whitworth fine thread, Ø in mm, pitch in inches

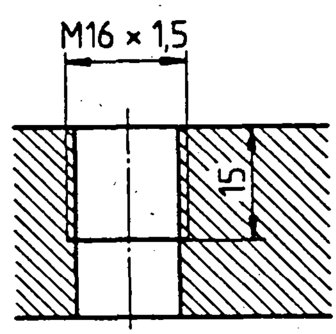
Internal (female) threads

4. The minor diameter is shown by a broad solid line and the major diameter by a narrow solid line.

The shading is continued up to the broad solid line.

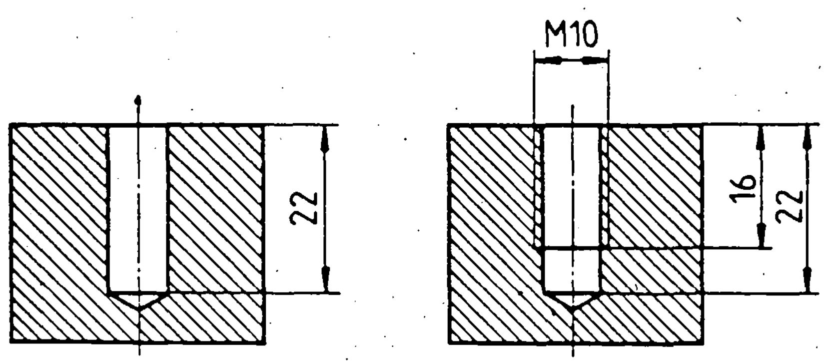


Left-handed thread (-LH)



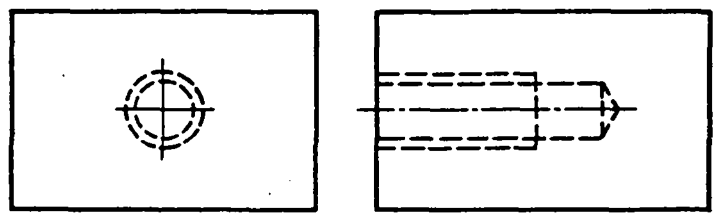
Right-handed thread (-RH)

5. For a tapped blind hole, the minor diameter must first be drilled and then the thread cut.



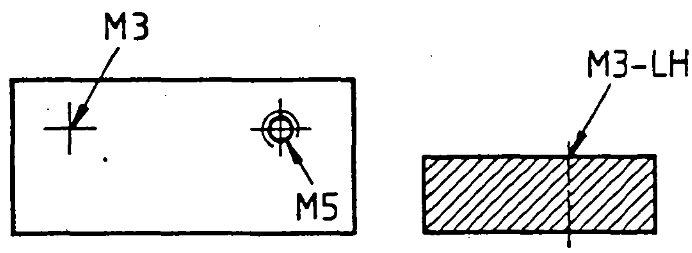
6. A thread can also be drawn concealed.

Tapped blind hole, front and side view



7. Simplified representation of small internal threads.

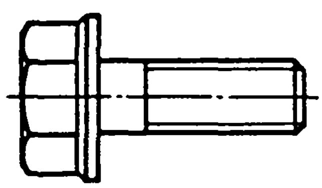
Nominal diameter ≦ 5 mm



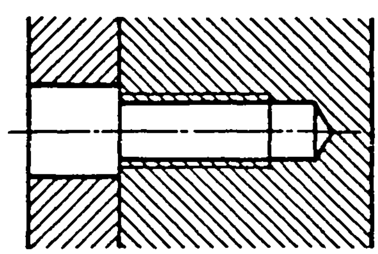
Screwed connections

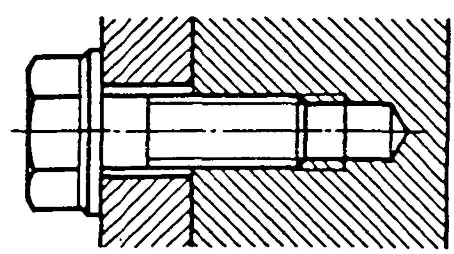
8. In the representation of screwed connections, the screws and nuts are not drawn.

Drawing of screw



Internal threads are only shown where they are not concealed by the bolt thread.



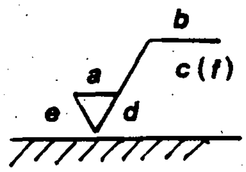


5.5 Rules for the indication of surface finishes

Information on the surface finish of a part is given by signs and additional notation, but only when absolutely necessary.

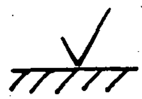
Data on surface finishes:

a) Roughness (arithmetically calculated average roughness R_a)
b) Manufacturing technique, surface treatment or coating
c) Reference length (mm)
d) Direction of grooves
e) Machining allowance (mm)
f) Roughness (e.g. peak-to-valley height, R_t)



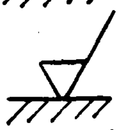
Position of lettering in relation to symbol

Basic symbol
2 lines (0.35 mm broad) of unequal length, at an angle of 60°. By itself this symbol usually has no significance.

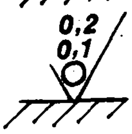


Production of surface:

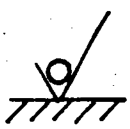
with any method, maximum admissible roughness R_a = 3.2 µm



by machining

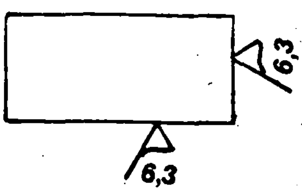


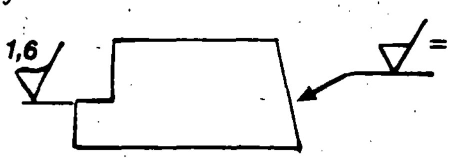
without machining; maximum value of roughness factor R_a = 0.2 µm, minimum 0.1 µm



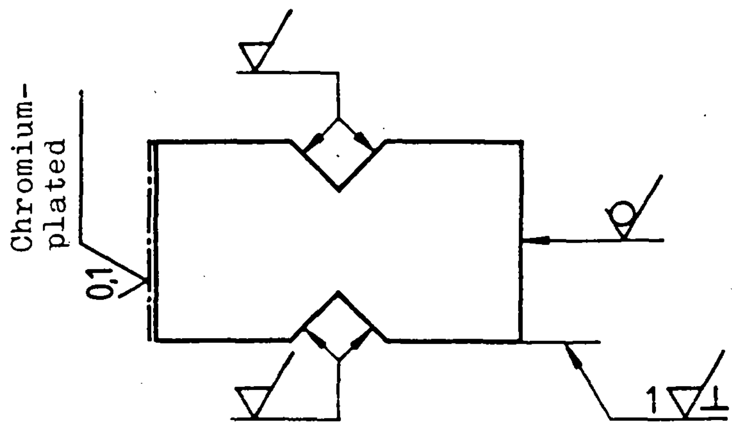
If the symbol refers to one production stage, it may stand alone. The surface should remain in the condition reached in the preceding stage.

1. The symbols are written on the broad solid lines representing the finished surfaces. 2. The roughness value must be legible from below or from the right. 3. Symbols may be connected to the surface by auxiliary or reference lines.

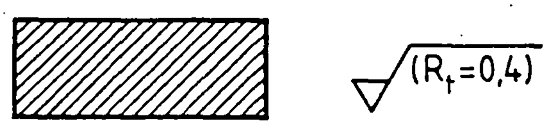




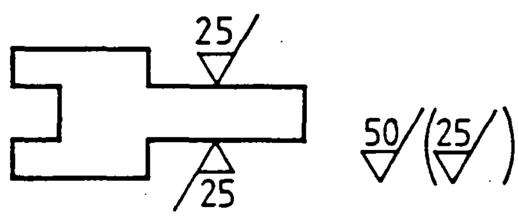
4. If the symbols contain other information apart from R_a, this must be legible from below or from the right.



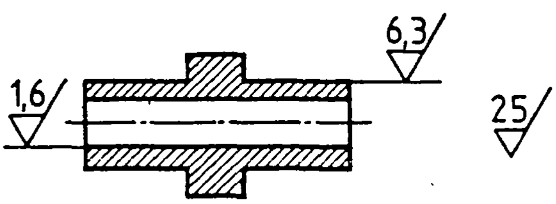
5. If all surfaces have the same finish, the symbol is entered at the side of the drawing.



6. If there is one main surface finish, the main symbol is entered at the side of the drawing. The other symbols are entered next to the appropriate surface, and are given in brackets after the main symbol (cf. also 7).

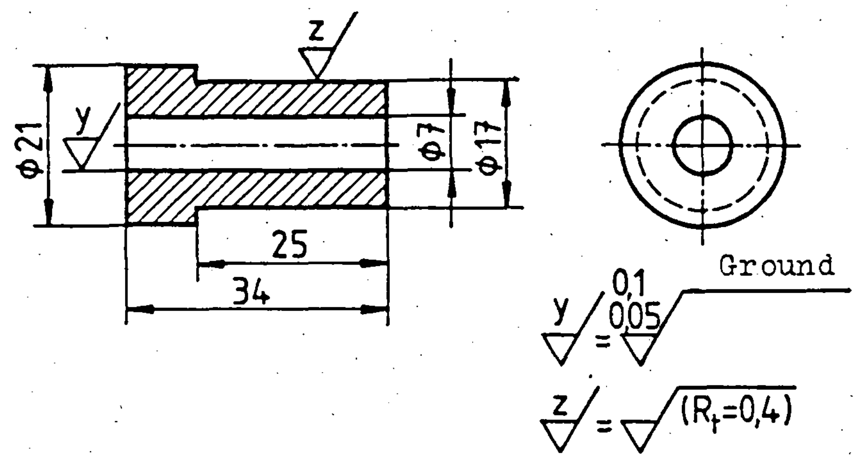


7. In the representation of cylindrical bodies, the symbols are entered only once, at the generator.



8. The symbol appears in the view in which the manufacturing dimension is given.

9. In the case of limited space, or repetition of data, complex information can also be given in simplified form.

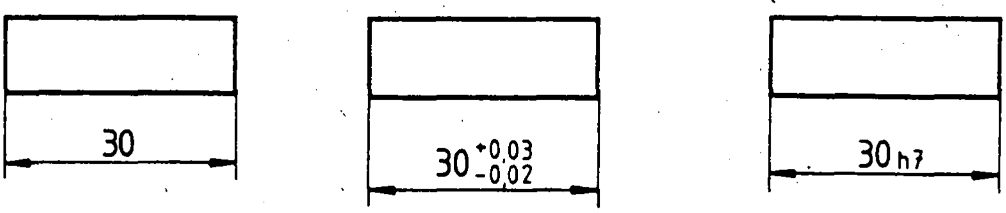


5.6 Rules for the indication of tolerances

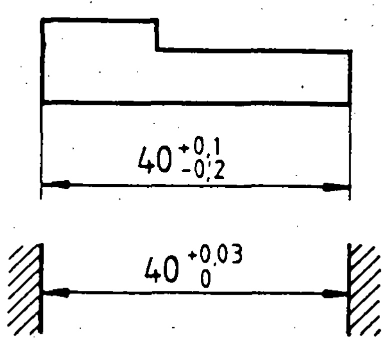
Absolute accuracy in the manufacture and testing of parts is not possible. Slight discrepancies between nominal and actual dimensions are therefore admissible.

Differentiation:

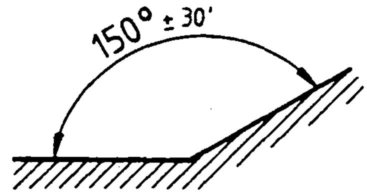
Dimension without indication of tolerance	Dimension with permissible deviations	Dimension with ISO abbreviation



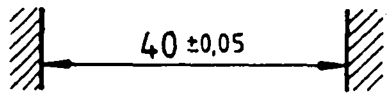
1. The upper tolerance figure should be higher and the lower tolerance figure lower than the dimension figure.



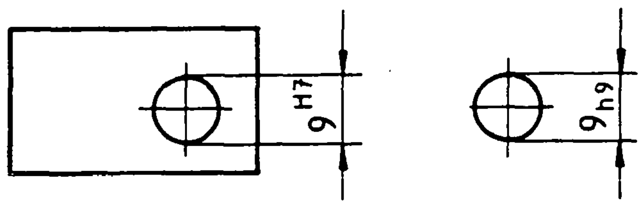
2. The lettering for the tolerance figures should not be smaller than 2.5 mm.



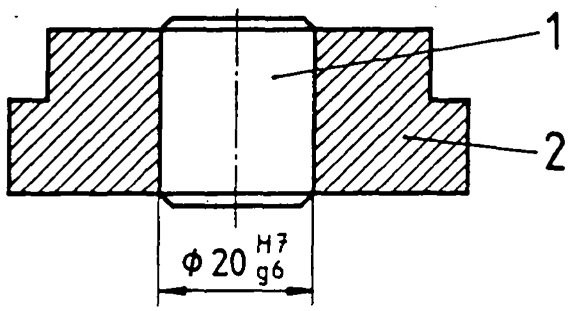
3. If the upper and lower allowances are the same, the number is written only once after the dimension figure.



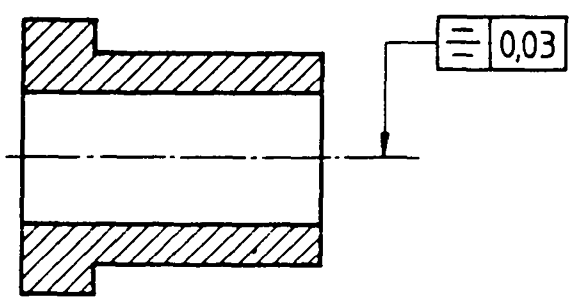
4. The ISO abbreviations are written after the dimension figure.



5. Where parts are assembled, the internal dimensions are written above the external dimensions.



6. Since it is not possible to produce parts which are geometrically perfect, tolerances of shape or position may also be given in certain cases, e.g. deviation from perfect symmetry.

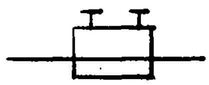
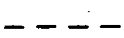
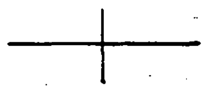
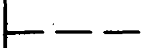


6 Representation of pipelines and other components of water-supply systems

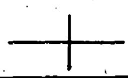
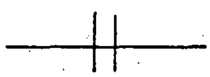
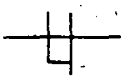
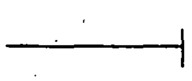
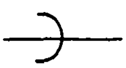
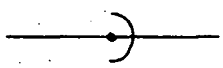
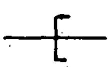
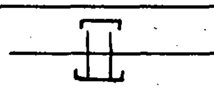
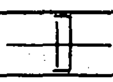
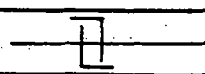
Pictograms

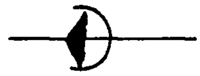
Pictograms are highly schematized depictions of pipes, valves and other parts in pipe lay-out and control plans. The pictograms can be shown in any position, corresponding to the direction taken by the pipes.

6.1 Pipes

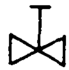
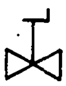
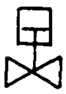
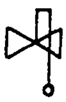
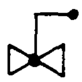
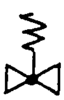
1.	Basic main (basic pictogram)		6.	Jacketed main	
2.	Control pulse main		7.	Heater	
3.	Differential pressure main		8.	Intersection of two mains without joint	
4.	Extension main		9.	Intersection of two mains with joint	
5.	Mobile main		10.	Branch	

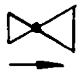
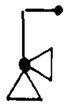
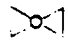
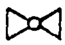
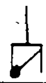
6.2 Joints

1.	Pipe joint (basic pictogram)		2.	Flange joint	
3.	Flange joint with blind hole ring		4.	Blind flange	
5.	Socket joint		6.	Ball socket joint	
7.	Slide-on socket joint		8.	Clamp (supported) joint	
9.	Screwed joint		10.	Coupling	

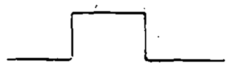
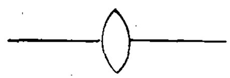
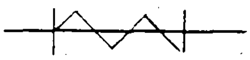
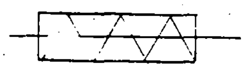
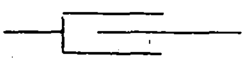
11.	Welded or soldered joint		12.	Welded socket joint	
13.	Welded ball socket joint		14.	Welded slide-in socket joint	
15.	Welded-in valve				

6.3 Valves

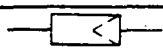
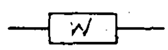
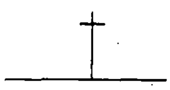
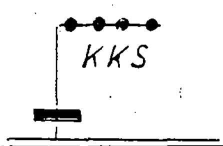
1.	Stop valve (basic pictogram)		2.	Stop valve closed	
3.	Stop valve open		4.	Stop valve with hand wheel	
5.	Stop valve with hand crank		6.	Power-driven stop valve	
7.	with piston drive		8.	with magneto drive	
9.	with motor drive		10.	with diaphragm control	
11.	with float control		12.	Control valve (basic pictogram)	
13.	Gate valve		14.	Weight-loaded safety gate valve	
15.	Spring-loaded safety gate valve		16.	Non-return gate valve, closeable	
17.	Non-return valve, not closeable		18.	Foot valve	

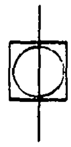
19.	Pressure-reducing valve		20.	Angle valve	
21.	Weight-loaded safety angle valve		22.	Non-return angle valve, closeable	
23.	Sluice valve		24.	Cock	
25.	Full-way cock		26.	Angle cock	
27.	Three-way cock		28.	Flap valve	
29.	Stop flap		30.	Throttle flap	
31.	Non-return flap		32.	Foot flap	

6.4 Equalizers

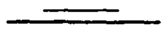
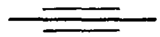
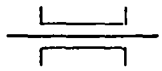
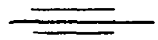
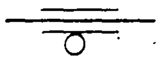
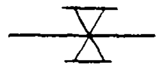
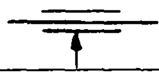
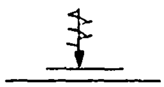
1.	Longitudinal equalizer		2.	U-bend equalizer	
3.	Lyre-type equalizer		4.	Lense-type equalizer	
5.	Expansion bellows		6.	Metal hose	
7.	Stuffing-box equalizer				

6.5 Accessories

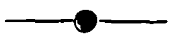
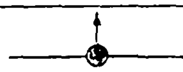
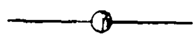
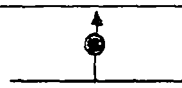
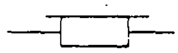
1. Strainer		2.	Water meter	
3. Wash-out with sluice valve		4.	Cathodic corrosion protection	

5.	Filter		6.	Air valve	
7.	Outflow funnel		8.	Through-flow inspection glass	

6.6 Pipe supports

1.	Pipe support (basic pictogram)		2.	Pipe sleeve bearing	
3.	Pipe sleeve bearing with guide		4.	Pipe sleeve bearing on rollers	
5.	Pipe sleeve bearing on balls		6.	Fixed point	
7.	standing		8.	suspended	
9.	Spring suspension		10.	Spring support	
11.	Compensating support				

6.7 Hydrants

	Underground	Above ground	Garden
On the pipe			
Next to the pipe			
To one side of the pipe			
Hydrant in manhole		Pipe cleanout	

7 Pipe lay-out plans

Pipes are represented by solid lines. The nominal diameter is indicated by the width of the line, which is not necessarily to scale, and entered above the pipe.

The following line widths (in mm) are recommended:

Nominal diameter		Scale 1:500	Scale 1:1000 to 1:5000
100		0.5	0.25
100	150	0.7	0.35
150	250	1.0	0.5
250	400	1.4	0.7
400		2.0	1.0

On long pipelines, data is repeated as considered necessary. Boundaries of plots and streets should be under-stated, so that the pipe system is clearly recognizable on the plan. Buildings supplied from the system can be emphasized through shading or thicker contour lines.

Abbreviations used for types of water mains (German nomenclature):

ZW (Zubringerleitung) = Feeder main
HW (Hauptleitung) = Trunk main
VW (Versorgungsleitung) = Service main
AW (Anschlußleitung) = Communication pipe

Abbreviations for pipe materials (German nomenclature) are:

GG (Grauguß) = grey cast iron (cast iron with lamellar graphite)

GGG (duktiles Gußeisen) = ductile cast iron (cast iron with spherical graphite)

St (Stahl) = steel

AZ (Asbestzement)	= asbestos cement
Sb (Stahlbeton)	= reinforced concrete
Spb (Spannbeton)	= prestressed concrete
PEh (Polyäthylen hart)	= high-density polyethylene
PEw (Polyäthylen weich)	= low-density polyethylene
PVC (Polyvinylchlorid)	= polyvinyl chloride

If protective coatings are named, the following abbreviations are used in German:

External protection:

Ba (bituminöse Umhüllung)	= bituminous coating
dBa (doppelte bituminöse Umhüllung)	= double bituminous coating
Ka (Kunststoffumhüllung)	= plastics coating

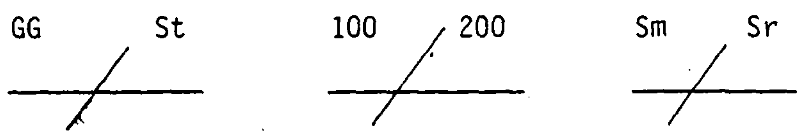
Internal protection:

Bi (bituminöse Auskleidung)	= bituminous lining
Zm (Zementmörtelauskleidung)	= cement mortar lining
Ki (Kunststoffauskleidung)	= plastics lining

The following abbreviations are used in German for the commonest types of pipe joints:

No letters added	= calked socket joint
Sr (Schraub-Muffen-Verbindung)	= screwed socket joint
Sm (Steck-Muffen-Verbindung)	= slide-in socket joint
Sw (Schweiß-Verbindung)	= welded joint
Grr (Gummi-Rollring-Verbindung)	= rubber O-ring joint
Stb (Stopfbuchs-Verbindung)	= stuffing-box joint
Kl (Klebemuffe)	= cemented socket joint
Km (Klemm-Verbindung)	= supported joint
Fl (Flansch-Verbindung)	= flange joint

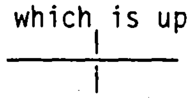
Transitions from one material or one diameter to another, or between two types of joint, are shown as follows:



Indications of the level of a water main apply optionally either to the upper or to the lower pipe edge in relation to m.s.l. Only one of the two options may normally be used on the same plan. If there is some reason for not observing this rule, the deviation must be clearly indicated.

The heights are written at right angles to the pipe and underlined. The line indicates the point in the lay-out plan to which the height refers.

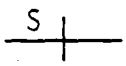
The thickness of the soil covering over pipes is given in metres, without "m", in brackets above the line representing the pipe.

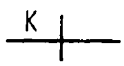
Where pipes intersect, the pipe which is uppermost is represented by a continuous line. 

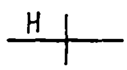
Any other pipes which do not belong to the pipe system are shown by a broken line: __ __ __ __

The pressures in water mains are, if required, noted above the drawn main, followed by the unit ("bars").

The following pictograms are also permissible for simplified representation of stop valves:

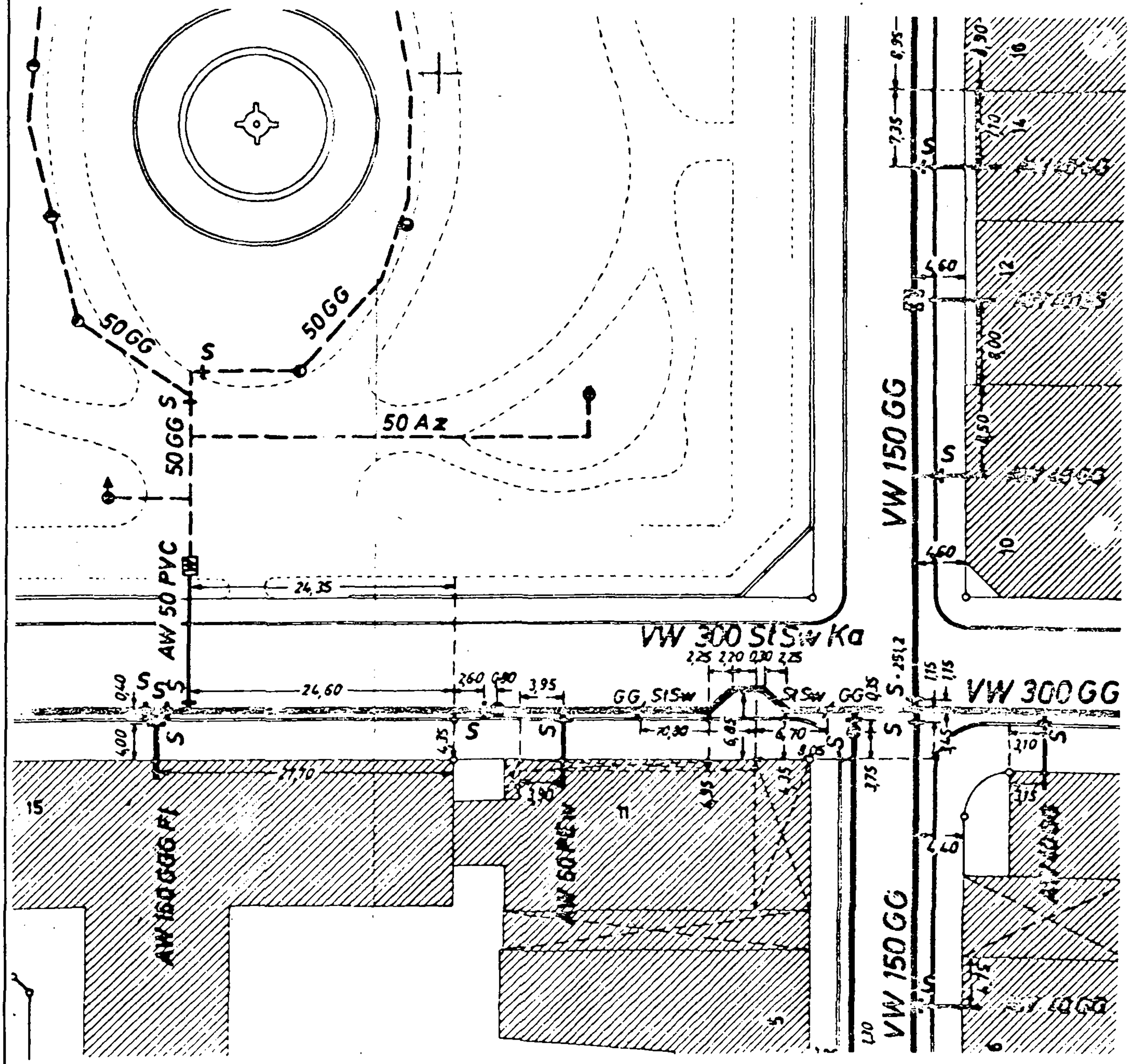
Sluice valve 

Flap valve 

Cock 

An extract from a pipe lay-out plan is shown on page 40.

Extract from a pipe lay-out plan



8 Bibliography

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Scholz-Grühn — Grundlehrgang Technisches
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The illustrations in section 5 were taken from this course.

DIN standards
DIN 2425
DIN 2429

Some passages of text were taken unaltered from the publications named above.

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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
2.3a 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

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